America's ZERO CARBON ACTION PLAN

The Zero Carbon Consortium

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3. INDUSTRIAL POLICY, EMPLOYMENT, AND JUST TRANSITION

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3.1 Introduction

This chapter of the Zero Carbon Action Plan focuses on achieving an equitable and just transition as an integral component of the overall U.S. decarbonization project. Of course, this decarbonization project will completely transform the ways that energy is produced and consumed in the United States. It will also initiate major changes more broadly throughout the U.S. economy and society.

The critical considerations that are examined in this chapter include the following. First, investments to build a clean energy economy will be a source of new job creation. But how many jobs are likely to be created? And what policies can be enacted to raise the proportion of good-quality jobs resulting from clean energy investments in terms of wages, benefits and workplace conditions? How can we also ensure that these new job opportunities are fully open to women and people of color? To date, women and communities of color are underrepresented in the existing U.S. energy sector as well as in the areas of employment that will expand through the clean energy investment project.

The contraction of the fossil fuel-dominant energy system will entail job losses. It will also produce hardships for communities whose well-being is currently dependent on the vibrancy of the fossil fuel industries. These negatively impacted workers and communities will require significant transitional support. Just transition policies are certainly justified according to any standard of fairness. But they are also a matter of strategic politics. Without such adjustment assistance programs operating at a major scale, the workers and communities facing retrenchment from the clean energy transition project will, predictably and understandably, fight to defend their communities and livelihoods. This in turn could create unacceptable obstacles in proceeding with effective climate stabilization policies.

The other major focus of this chapter examines the importance of narratives and other forms of public education and on-the-ground programs that will be needed to strengthen support for the clean energy transition. In fact, according to polling evidence, a large majority of the U.S. public already strongly supports a clean energy transition.

Yet, despite this widespread support, it remains the case that, to date, far too little has been accomplished in terms of moving the U.S. economy onto a viable climate stabilization path. It is therefore imperative to strengthen the extent of support around a transformative climate stabilization agenda.

The structure of this chapter is as follows. Following this introduction, Section 2 is titled "Job Creation through Clean Energy Investments". We estimate here that the number of jobs that will be generated between 2020 and 2050 by the *central scenario* developed in Chapter 2 of this plan, through which the U.S. economy will achieve net-zero CO_2 emissions by 2050. We estimate that the full set of clean energy supply investments and energy demand expenditures will generate an average of between about 4.2 – 4.6 million jobs per year between 2020 – 2050, depending on the extent to which the U.S. can reduce its reliance on imports in building its clean energy infrastructure. This level of job creation will equal between 2.4 – 2.6 percent of the projected labor force as of 2035—the midpoint between 2020 – 2050. The range, again, depends on the share of imports required in building out the clean energy economy. However, even with the low-end employment figure, the result will be that through the transition to a clean energy economy—and assuming all else remained equal—the average unemployment rate would fall from, say 5 percent to 2.6 percent, thereby injecting a major long-term boost to overall job opportunities.[i]

Still in Section 2, we then present a range of job quality indicators for the clean energy sectors in the current U.S. economy. It becomes clear that improving job quality standards in these new areas of employment needs to be established as a major priority. As will be discussed in Section 5, two major institutions for achieving higher job quality will be labor unions and effective job training programs. We also discuss in this section the importance of affirmative action programs to ensure that women and people and communities of color have equal access to these job opportunities.

Section 3 focuses on the contraction of the U.S. fossil fuel sectors and what will be needed to establish a just transition for the workers facing job losses. Here we estimate that the extent of job losses that will take place in two phases of the transition, 2020 – 2030 and 2031- 2050 respectively. For both phases, we estimate the number of jobs that will be lost and compare those figures with the number of workers who are likely to voluntarily retire at age 65. When considering these two sets of figures, the analysis shows that the net figure for job displacements – people who will not be retiring, but have lost their jobs and will need to be re-employed – is relatively modest year-to-year. Over 2021 – 2030, the total number of displaced workers will average about 12,000. Between 2031 – 2050, the figure does rise to an average of about 34,000 workers per year

For all of these workers, we propose a just transition policy package that includes five components: pension and reemployment guarantees, along with income, retraining and relocation support. Over 2021 – 2030, we estimate the total costs of the program to be about $1.2 billion per year. For the 2031 – 2050 period, we estimate the total average cost of these just transition policy measures at about $3.8 billion per year.

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i To be clear, we are *not* stating that these job creation figures are cumulative year-by-year—that, for example, the zero carbon program generates 4 million additional jobs in 2020, 8 million in 2021, 12 million in 2022 and so forth. Measuring job creation through clean energy investments in such a cumulative pattern produces figures that are out of scale with the size of the U.S. labor market and the level of annual overall economic activity (GDP). We discuss the distinction between measuring 'jobs-per-year' versus cumulative job years in Section 3.2.2.

Thus, even over the more costly phase of the fossil fuel industry contraction between 2031 – 2050, the total costs of the just transition program will amount to less than one one-hundredth of 1 percent of average U.S. GDP over these years. It is also important to compare this figure of approximately 34,000 fossil fuel industry workers being displaced annually per year over 2031 – 2050 with the average level of increased employment of roughly 4 million jobs that will result through the U.S. clean energy transition.

Section 4 focuses on communities that are presently heavily dependent on fossil fuel-based industries. We first show that fossil fuel production in the U.S., both coal as well as oil and gas, is highly concentrated geographically in a small number of states, and even a small number of communities within these relatively few states. The long-term phase-down in the fossil fuel industry will be felt most acutely in these states and communities. Most of the rest of the country is likely to experience negative effects to a much lesser degree, if at all. Focusing therefore on the heavily impacted communities, we discuss experiences and policy proposals in two main areas—land reclamation and repurposing of what are now sites of fossil fuel production activity. We draw on a range of experiences in the U.S. as well as the successful repurposing initiatives that have been operating for decades in Germany's Ruhr Valley, what had been the country's primary coal-producing region.

Section 5, "Good Quality and Equal Access to Clean Energy Jobs" discusses the role of labor unions and job training programs for raising the job-quality level in the expanding clean energy sectors. It also discusses the importance of effective affirmative action programs to ensure that women and people and communities of color have equal access to these expanding employment opportunities. Evidence shows how important these policy tools have been in different settings and under a variety of circumstances. A review of evidence from surveys of clean energy business managers report that, to a significant degree, firms are facing difficulties in finding well-qualified people to fill their job openings. Providing effective training opportunities is therefore critical for successfully expanding the clean energy sectors at the scale required.

Section 6 is titled "Building Support for Clean Energy Transition through Narratives, Education and Community Engagement." To begin with, as of 2019, over two-thirds of adults think that the Federal Government is doing "too little to reduce the effects of global climate change," and 77 percent think that "developing alternative energy" is a more important priority than "expanding fossil fuels." Yet it is clear that this level of support still needs to be broadened and strengthened. In this section a range of approaches and activities are discussed at the level of individual narratives, educational projects and practical support programs for households and communities. A macro-level narrative will animate this chapter as well as the Zero Carbon Action Plan more generally.

One model of how to advance just transition policies at the state level is currently underway in Colorado. To date, it is focused on the state's coal industry, but the framework could be readily generalized to its much larger oil and gas industry as well. The preliminary draft of the coal transition program was published in August 2020, with the final draft due by the end of 2020.

The program focuses on three areas: the transition for coal workers and coal communities respectively, and the fiscal requirements to support generous support for both the workers and communities that will experience displacement.

The main features of each of these areas include the following[1]:

Workers transition. It develops a package of training, job search, and relocation support services. It also provides temporary income and benefit assistance, including a wage and health differential benefit for most workers.

Community transition. It will assist affected communities with the creation of local transition plans that pivot from resource extraction to new industry sectors that provide living wages and an adequate tax base. It will include investments in local physical and community infrastructure to maintain and improve quality of life and critical services, and a state-wide investment fund focused on making investments in coal transition communities.

Fiscal issues. Commit to continue support for essential services and infrastructure, and support efforts to reinvest in these communities to produce utility-scale renewable energy projects.

Hansen, Bazilian, and Medlock (2019) summarize the approach being developed in the Colorado program as:

> Setting a precedent and model for other labor transitions as it includes specific requirements for utility workforce transition plans to be put in place. In addition, benefits to workers (such as wage differential benefits and training programs) and community grants form two pillars that are essential in recognizing the implications of removing jobs from communities that are dealing with economic malaise.[ii]

As it proceeds, the Colorado just transition project should provide important lessons for how to advance this agenda more broadly throughout the United States.

3.2 Job Creation through Clean Energy Investments

This section estimates the employment effects of advancing the clean energy investment program developed by Jim Williams and Ryan Jones, as summarized in Chapter 2 of this volume. Their model includes seven different U.S. energy system scenarios between 2020 – 2050. The baseline *reference scenario* is based on the Department of Energy's long-term forecast, the Annual Energy Outlook. According to the model specification under this scenario, CO_2 emissions in the United States will decline by only 23 percent between 2020 and 2050, from 5.20 to 4.02 billion tons. Working off of this *reference scenario*, the model then develops six alternative U.S. energy system scenarios between 2020 – 2050. Through each of these alternative scenarios, CO_2 emissions in the U.S. will fall to zero by 2050. In this chapter, we focus on what Williams and Jones term their *central scenario* through which the U.S. achieves zero CO_2 emission in 2050 at the lowest net cost.

ii Two more general recent studies on just transitions are, Henry, Bazilian and Markusen (2020) "Just Transitions: Histories and Futures in a post-COVID World," and Carley and Konisky (2020) "The Justice and Equity Implications of the Clean Energy Transition." Pollin et al. (2019) presents a detailed just transition program for Colorado that incorporates the state's oil and gas as well as its coal industries.

For estimating the total level spending on both the supply and demand sides of the U.S. energy system, we therefore calculate the difference in spending levels between the *central scenario* and the *reference scenario*. This difference in spending between the *central* and *reference scenarios* represents the net increase in spending required to bring CO_2 emissions in the U.S. economy down from 4 billion tons to zero as of 2050. On average over 2020 – 2050, total net expenditures within the *central scenario* includes $389 billion per year on investments to expand the supply of both clean renewable energy sources, including solar, wind, geothermal, and hydro power, as well as other low- to zero CO_2-emitting technologies, including nuclear power, biomass, and carbon sequestration. It also includes $160 billion per year to purchase a wide range of products that operate through consuming energy or "energy demand expenditures". These include electric vehicles, heating and cooling systems, and refrigeration equipment.[iii] The average overall spending total for both energy supply investments and energy demand expenditures therefore comes to $551 billion per year between 2020 – 2050. This is equal to about 1.7 percent of U.S. GDP at its midpoint between 2020 – 2050, assuming that the U.S. economy grows at an average annual rate of 2.2 percent over this 30-year period.

Working from these budgetary figures, the amount of jobs is estimated that will be created as a result of the spending amounts that the model in Chapter 2 allocates to all categories in the areas of both energy supply and demand.

After estimating the number of jobs that these energy supply and demand expenditures will generate, we then consider indicators of the quality of these jobs. These quality indicators include average compensation levels, health care coverage, retirement plans, and union membership. We also provide data profiling the types of workers who are employed at present in the job areas that will be created by the energy supply and demand expenditures, including evidence on both educational credentials of these workers as well as their racial and gender composition. We then report on the prevalent types of jobs that will be generated by these energy efficiency and clean renewable energy investments.

Before proceeding with presenting job creation estimates, the following section will first briefly describe the methodology used to generate the results.[iv] A fuller discussion of our methodology is provided in Appendix 6.2.[2]

3.2.1 Methodological Issues in Estimating Employment Creation

Our employment estimates are figures are generated directly with data from national surveys of public and private economic enterprises within the U.S. and organized systematically within the official U.S. input-output (I-O) model. The "inputs" within this model are all the employees, materials, land, energy and other products that are utilized in public and private enterprises within the U.S. to create goods and services. The "outputs" are the goods and services themselves that result from these activities that are then made available to households, private businesses and governments as consumers within both domestic and global markets.

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iii We provide a full listing of all of the Williams, Jones and Farbes model spending categories in the Appendix.

iv The October 2020 SDSN paper, "Conceptualizing Employment Pathways to Decarbonize the U.S. Economy," presents another methodological perspective on analyzing the employment issues associated with a U.S. clean energy transition project. The approach developed by SDSN is largely complementary to that utilized here.

Within the given structure of the U.S. economy, these figures from the input-output model provide the most accurate evidence available as to what happens within private and public enterprises when they produce the economy's goods and services. In particular, these data enable researchers to observe how many workers were hired to produce a given set of products or services, and what kinds of materials were purchased in the process.

Here is one specific example of how our methodology works. If we invest an additional $1 billion in building electric vehicles, what will be all the activities undertaken to produce these vehicles? How much of the $1 billion will be spent on hiring workers, how much will be spent on non-labor inputs, including materials, energy costs, and maintaining factory buildings, and how much will be left over for business profits? Moreover, when businesses spend on non-labor inputs, what are the employment effects through giving orders to suppliers, such as glass manufacturers or trucking companies?

We also ask this same set of questions about investment projects in renewable energy as well as spending on operations within the non-renewable energy sectors. For example, to produce $1 billion worth of wind energy productive capacity, how many workers will need to be employed, and how much money will need to be spent on non-labor inputs? Through this approach, the analysis is able to provide observations as to the potential job effects of alternative energy investment and spending strategies at a level of detail that is not available through any alternative approach.

3.2.2 Direct, Indirect and Induced Job Creation

Spending money in any area of any economy, including the U.S. economy, will create jobs, since people are needed to produce any good or service that the economy supplies. This is true regardless of whether the spending is done by private businesses, households, or government entities. At the same time, for a given amount of spending within the economy, for example, $1 billion, there are differences in the relative levels of job creation through spending that $1 billion in alternative ways. Again, this is true regardless of whether the spending is done by households, private businesses or public sector enterprises.

There are three sources of job creation associated with any expansion of spending—direct, indirect, and induced effects. For purposes of illustration, consider these categories in terms of investments in manufacturing electric cars or building wind turbines:

- **Direct effects**—the jobs created, for example, by manufacturing electric vehicles or building wind turbines;
- **Indirect effects**—the jobs associated with industries that supply intermediate goods for the electric vehicles or wind turbines, such as glass, steel, and transportation;
- **Induced effects**—the expansion of employment that results when people who are paid in the glass, steel, or transportation industries spend the money they have earned on other products in the economy. These are the multiplier effects within a standard macroeconomic model.

This study reports on all three employment channels – direct, indirect, and induced job creation. It is important to note that estimating induced effects – i.e., multiplier effects – within I-O models is much less reliable than the direct and indirect effects. In addition, induced effects derived from alternative areas of spending within a national economy are likely to be comparable to one another.

Within the categories of direct plus indirect job creation, how is it that spending a given amount of money in one set of activities in the economy could generate more employment than other activities? As a matter of simple arithmetic, there are only three possibilities. These are:

- **Labor Intensity.** When proportionally more money of a given overall amount of funds is spent on hiring people, as opposed to spending on machinery, buildings, energy, land, and other inputs, then spending this given amount of overall funds will create relatively more jobs.
- **Compensation per worker.** If $1 billion in total is spent on employing workers in a given year on a project, and each employee earns $1 million per year working on that project, then only 1,000 jobs are created through spending this $1 billion. However, if, at another enterprise, the average pay is $50,000 per year, then the same $1 billion devoted to employing workers will generate 20,000 jobs.
- **Domestic content.** When a given amount of money is spent in either the areas of energy supply or demand, some of the spending will occur outside of the U.S. economy. Of course, U.S. job creation will increase as the relative share of domestically-produced goods and services rises. Through the input/output model, one can observe the level of job creation at existing domestic content levels; it can also estimate how much overall job creation will increase through assuming an increase in the domestic content share, resulting, for example, from active industrial policies. In what follows, we report job creation levels both with existing domestic content ratios and through assuming that U.S. domestic content is able to increase to 100 percent in the full set of supply and demand activities.

Time Dimension in Measuring Job Creation

Jobs-per-year vs. job years. Any type of spending activity creates employment over a given amount of time. To understand the impact on jobs of a given spending activity, one must therefore incorporate a time dimension into the measurement of employment creation. For example, a program that creates 100 jobs that last for only one year needs to be distinguished from another program that creates 100 jobs that continue for 10 years each. It is important to keep this time dimension in mind in any assessment of the impact on job creation of any clean energy investment activity.

There are two straightforward ways in which one can express such distinctions. One is through measuring *job years*. This measures cumulative job creation of the total number of years that jobs are being generated. Thus, an activity that produces 100 jobs for 1 year would create 100 cumulative *job years*. Similarly, an activity that produces 100 jobs each year for 30 years would generate 3,000 *job years*.

The other way to report the same labor market activity is in terms of jobs-per-year. Through this measure, one is able to show the year-to-year breakdown of the overall level of job creation. Thus, with the 30-year program used in the example, it could be expressed as creating 100 jobs per year, every year, for the 30-year time period.

This jobs-per-year measure is most appropriate for the purposes of this study, in which the focus is measuring the impact on employment opportunities of clean energy investments. The reason that jobs-per-year is a better metric than cumulative *job years* is because the impact of any new investment, whether on clean energy or anything else, will be felt within a given set of labor market conditions at a point in time.

Reporting cumulative job creation figures over multiple years prevents scaling the impact of investments on job markets at a given point in time. For example, if clean energy investments create 5 million jobs in a given year, one can scale that to the size of the U.S. labor market in that year. At present, 143 million people are employed in the U.S. Adding 5 million jobs would therefore amount to an increase in employment of about 3.5 percentage points.

If we then assume that the clean energy investments continue for 10 years at the same scale, that would mean 5 million jobs per year would be created through these investments. That would continue to maintain overall employment in the U.S. at a level that is 3.5 percent greater than it would have been without the injection of clean energy investments (after allowing also for the natural growth of the U.S. labor market). However, if this employment impact is measured in terms of cumulative job creation, the 31 years' worth of investment would, by this measure, amount to over 150 million jobs. It is misleading to compare that cumulative job creation figure to the total of 143 million jobs in the U.S. at any specific point in time (e.g., 2021). In order to scale the cumulative job creation figure of 150 million, the appropriate comparison would be with the cumulative job figures for the whole U.S. economy over 31 years. But this cumulative jobs figure is not a particularly clear or useful way to understand labor market conditions at any given point in time.

Incorporating Labor Productivity Growth over the 31-Year Investment Cycle

The figures we use for the input-output tables are based on the technologies that are prevalent at present for undertaking these clean energy investments. Yet we are estimating job creation through clean energy investments that will occur over a 31-year cycle between 2020 - 2050. The relevant production technologies will certainly change over this 31-year period, so that a different mixture of inputs may be used to produce a given output.

For example, new technologies are likely to emerge, making other technologies obsolete. Certain inputs could also become more scarce, and, as result, firms may substitute other less expensive goods and services to save on costs. The production process overall could also become more efficient, so that fewer inputs are needed to produce a given amount of output. Energy efficiency investments do themselves produce a change in production processes (i.e., a reduction in the use of energy inputs to generate a given level of output). In short, the input-output relationships in any given economy – including its employment effects of clean energy investments – are likely to look different in 2035 or 2050 relative to the present.

Pollin et al. have addressed this issue in detail (e.g., 2015, pp. 133 - 144).[3] For the purposes of the present discussion, a simple assumption is made: that average labor productivity in clean energy investments rises by one percent per year throughout the full 2020 – 2050 period.

3.2.3 Job Creation Estimates

Tables 3.1 – 3.5 report on our job creation estimates generated by the Chapter 2 *central scenario* for reaching a net-zero emissions U.S. economy by 2050. Two overall sets of figures are reported for both the energy supply investments and the energy demand expenditures – first, job creation per $1 million in expenditure, then, job creation given the average annual level of spending incorporated into the Chapter 2 model (i.e., $389 billion per year in net energy supply investments and $163 billion per year in net energy demand expenditures). We first report figures for direct and indirect jobs, along with the totals for these main job categories. We then include figures on induced jobs, and show total job creation when induced jobs are added to figures for direct and indirect jobs.

Further, as noted above, job creation estimates are presented, under two alternative cases: first, that U.S. domestic content shares remain at their existing levels, then, second, that domestic content shares rise to 100 percent for all activities. Examining these two alternative scenarios for domestic content on both supply and demand-based energy-system spending enables us to observe the impact on employment through implementing effective U.S. industrial policies targeted at the emerging clean energy economy.

In Tables 3.1A/3.1B and 3.2A/2B, we present our estimates as to the job creation effects generated by the full range of energy supply projects. These include clean renewables, transmission and storage; fossil fuels; additional supply technologies, including nuclear, carbon sequestration and biomass; and a grouping of difficult to categorize "other" investments.[v] Starting in Table 3.1A with the figures at existing domestic content levels, we see that the extent of direct plus indirect jobs ranges from 2.4 jobs per $1 million in spending for transmission/storage to 8.5 for additional supply technologies. Adding induced jobs brings the range to between 5.1 – 14.2 jobs per $1 million in spending.

Of course, employment per $1 million in spending rises, by assuming that domestic content will rise to 100 percent. Thus, with the transmission/storage investment category, jobs per $1 million rises from 2.4 to 3.0, a 25 percent increase in job creation. The increases in employment in the other supply investment categories range between 10 – 14 percent.

v Our energy supply investment "other" category includes electric boilers, hydrogen blend, industrial CO_2 capital, other boilers, steam production, as well as what are termed "demand response" and "demand-side costs" categories in the Williams, Jones and Farbes model in Chapter 2.

Table 3.1. Job Creation through Energy Supply Investments
Job Creation per $1 million in spending

3.1A) Figures at Existing U.S. Domestic Content Levels

Investment Area	Direct Jobs	Indirect Jobs	Direct Jobs+ Indirect Jobs	Induced Jobs	Direct Jobs + Indirect Jobs + Induced Jobs
Clean renewables	2.8	3.0	5.9	4.4	10.2
Transmission/ storage	1.0	1.4	2.4	2.8	5.1
Additional supply technologies	5.5	2.9	8.5	5.7	14.2
Fossil fuels	1.6	2.7	4.4	4.2	8.5
Other investments	3.3	2.8	6.1	4.7	10.8

3.1B) Figures through Raising U.S. Domestic Content to 100 percent

Investment Area	Direct Jobs	Indirect Jobs	Direct Jobs+ Indirect Jobs	Induced Jobs	Direct Jobs + Indirect Jobs + Induced Jobs
Clean renewables	3.3	3.2	6.5	4.4	10.9
Transmission/ storage	1.0	2.0	3.0	2.8	5.7
Additional supply technologies	6.6	3.1	9.7	5.8	15.5
Fossil fuels	2.0	2.9	4.9	4.3	9.2
Other investments	3.8	3.0	6.8	4.8	11.6

Source: IMPLAN 3.0. Note: These jobs created per $1 million investments figures are based on net *positive* investments only, i.e., *central scenario* investments minus *reference scenario* investments, with net negative investments set to zero.

Based on these proportions, Table 3.2 shows the levels of job creation in the U.S. associated with $389 billion in average annual spending on these energy supply investments between 2020 – 2050. Again we first show our results assuming existing domestic content levels. We then assume domestic content rises to 100 percent. In this case, the individual categories of net investment spending include $164 billion for clean renewables, $48 billion for transmission/storage, and $39 billion for additional supply technologies. In addition, the figure for fossil fuel investments is a net negative $28 billion, reflecting the fact that fossil fuel investments fall in the Chapter 2 *central scenario* relative to their *reference scenario*. The analysis also shows that the largest investment area is the “other” category. This is not surprising, since it is capturing a wide range of technologies within this catch-all grouping.

Within these budgetary allocations, we see first in Table 3.2A, assuming existing domestic content levels, that total direct plus indirect job creation generated in the U.S. by this large-scale expansion in energy supply expenditures will amount to an average of about 946,000 direct jobs and 860,000 indirect jobs per year between 2020 – 2050. This totals to 1.8 million direct and indirect jobs. We also estimate that, as an average between 2020 – 2050, an additional 1.4 million induced jobs will be generated by these investments. This brings the total of direct, indirect and induced jobs generated by net energy supply investments to 3.2 million jobs.

Table 3.2B then shows these same calculations under the assumption that U.S. domestic content rises from existing levels to 100 percent for all activities. With domestic content at 100 percent, direct job creation through supply investments rises to 1.1 million and indirect jobs rise to 942,000, for a total of 2.1 million jobs. With induced jobs, the total rises to 3.5 million jobs after assuming domestic content rises to 100 percent.

Table 3.2 Average Number of Jobs Created Annually through Energy Supply Expenditures Estimates Adjusted for Increasing Labor Productivity (one percent annually), 2020-2050

3.2A) Figures at Existing U.S. Domestic Content Levels

Investment Area	Average Annual Budget Figure	Direct Jobs	Indirect Jobs	Direct Jobs+ Indirect Jobs	Induced Jobs	Direct Jobs + Indirect Jobs + Induced Jobs
Clean renewables	$164.1 billion	372,505	396,385	773,733	575,774	1.3 million
Transmission/ storage	$48.3 billion	36,413	54,071	90,484	106,276	196,493
Additional supply technologies	$39.3 billion	170,166	89,819	260,640	175,410	436,318
Fossil fuels	-$27.5 billion	-50,371	-51,434	-102,376	-104,727	-206,318
Other investments	$164.5 billion	435,372	371,228	806,618	621,294	1.4 million
TOTAL	$388.7 billion	964,085	860,069	1.8 million	1.4 million	3.2 million

3.2B) Figures through Raising U.S. Domestic Content to 100 percent

Investment Area	Average Annual Budget Figure	Direct Jobs	Indirect Jobs	Direct Jobs+ Indirect Jobs	Induced Jobs	Direct Jobs + Indirect Jobs + Induced Jobs
Clean renewables	$164.1 billion	436,402	427,674	864,075	576,911	1.4 million
Transmission/storage	$48.3 billion	37,746	75,726	113,472	106,542	220,014
Additional supply technologies	$39.3 billion	203,899	95,148	299,047	178,706	477,754
Fossil fuels	-$27.5 billion	-54,600	-55,552	-110,152	-106,383	-216,534
Other investments	$164.5 billion	503,014	398,617	901,631	635,986	1.5 million
TOTAL	$388.7 billion	1.1 million	941,612	2.1 million	1.4 million	3.5 million

Sources: IMPLAN 3.0. Budgetary figures from Williams, Jones and Farbes (2020) model in Chapter 2. Note: Investments spending and jobs numbers in this table are based on net investments, allowing for both net *positive* and net *negative* investments.

Tables 3.3 and 3.4 then present comparable estimates for the energy demand expenditures in the Chapter 2 *central scenario*. We have grouped this full set of projects into 10 categories. They are: vehicles, heating/ventilation/air conditioning (HVAC), manufacturing, other commercial and residential spending, construction, appliances, refrigeration, mining, agriculture and lighting.[vi] As Table 3.3A shows, direct plus indirect job creation per $1 million in spending with existing domestic content levels range between 4.4 jobs for vehicles and mining to 17.1 for agriculture. Job creation then rises by about 16 percent for vehicles and mining under the 100 percent domestic content assumption and by 11 percent with agriculture.

vi The "other" commercial and residential category of efficiency investments is taken directly from the Williams, Jones and Farbes model in Chapter 2—or, more precisely, this category combines the "commercial other" and "residential other" categories within the Chapter 2 model.

Table 3.3 Job Creation through Energy Demand Expenditures, by Subsectors and Technology, Job creation per $1 million in spending

3.3A) Figures at Existing U.S. Domestic Content Levels

Investment Area	Direct Jobs	Indirect Jobs	Direct Jobs+ Indirect Jobs	Induced Jobs	Direct Jobs + Indirect Jobs + Induced Jobs
Vehicles	1.1	3.4	4.4	3.5	8.0
HVAC	2.9	3.3	6.2	4.3	10.5
Manufacturing	2.1	3.8	5.8	3.8	9.7
Other commercial and residential	3.4	3.4	6.8	4.6	11.4
Construction	3.8	3.8	7.6	4.4	12.0
Appliances	1.8	3.4	5.3	3.8	9.1
Refrigeration	4.1	3.5	7.5	4.9	12.5
Mining	1.7	2.7	4.4	3.4	7.7
Agriculture	12.7	4.4	17.1	4.3	21.4
Lighting	2.8	3.6	6.4	4.5	11.0

3.3B) Figures through Raising U.S. Domestic Content to 100 percent

Investment Area	Direct Jobs	Indirect Jobs	Direct Jobs+ Indirect Jobs	Induced Jobs	Direct Jobs + Indirect Jobs + Induced Jobs
Vehicles	1.5	3.7	5.2	3.5	8.8
HVAC	3.6	3.5	7.1	4.4	11.5
Manufacturing	2.9	4.3	7.2	4.3	11.5
Other commercial and residential	3.8	3.7	7.4	4.7	12.1
Construction	3.9	4.0	7.9	4.4	12.3
Appliances	2.2	3.7	5.9	3.8	9.8
Refrigeration	4.5	3.7	8.1	5.0	13.1
Mining	2.3	2.8	5.1	3.4	8.5
Agriculture	14.1	4.9	19.0	4.8	23.8
Lighting	3.4	3.8	7.2	4.6	11.9

Source: IMPLAN 3.0. Note: These jobs created per $1 million in spending are based on net *positive* spending figures only, i.e., *central* minus *reference scenario* spending amounts, with net negative spending levels set to zero. Cost figures by technologies are not always available.

Table 3.4 shows the level of job creation through spending an average of nearly $163 billion per year on the full set of these projects between 2020 and 2050. In column 1 of Table 3.4A, we show the spending breakdowns by spending area assuming existing domestic content levels. As we see, of the full $163 billion average annual net spending figure – *central scenario* minus *reference scenario* spending – the largest areas of net expenditures include (with rounding): $80 billion on clean energy vehicles, $32 billion on high-efficiency HVAC systems and $17 billion on manufacturing equipment. These three spending categories therefore account for nearly 80 percent of total net demand expenditures.[vii]

The result of the demand expenditures at this level, and with existing domestic content levels, will be the creation of an average of about 312,000 direct jobs and 214,000 indirect jobs, for an average between 2020 and 2050 of about 530,000 direct plus indirect jobs. Including induced jobs adds another 412,000 jobs per year to the total figure. Assuming existing domestic content levels remain intact, this brings the total net job creation figure for the full set of energy demand expenditures, including induced jobs to about 980,000, as an annual average figure between 2020 – 2050.

In Table 3.4B, when we assume that domestic content rises to 100 percent, direct and indirect job creation through demand expenditures rises to about 630,000. Total job creation rises to 1.1 million when we also include induced jobs. That amounts to about a 12 percent increase in employment on the demand side through moving from existing domestic content levels to 100 percent domestic content.

Table 3.4 Average Number of Jobs Created Annually through Energy Demand Expenditures, by Subsectors and Technology, Figures Adjusted for Increasing Labor Productivity (one percent annually), 2020-2050

3.4A) Figures at Existing U.S. Domestic Content Levels

Investment Area	Average Annual Expenditure	Direct Jobs	Indirect Jobs	Direct Jobs+ Indirect Jobs	Induced Jobs	Direct Jobs + Indirect Jobs + Induced Jobs
Vehicles	$79.8 billion	102,902	-27,674	77,128	121,493	234,874
HVAC	$32.4 billion	84,799	90,711	177,470	115,746	293,449
Manufacturing	$16.9 billion	29,221	52,988	81,748	53,243	135,719
Other commercial and residential	$15.3 billion	42,408	43,236	85,644	57,522	143,166
Construction	$10.9 billion	34,950	34,458	69,253	40,029	109,438
Appliances	$3.1 billion	4,536	8,919	13,648	10,006	23,450
Refrigeration	$2.8 billion	7,126	8,044	15,171	10,093	25,385
Mining	$1.6 billion	2,194	3,544	5,738	4,391	10,095
Agriculture	$542.6 million	5,581	1,934	7,515	1,890	9,404
Lighting	-$739.5 million	-1,500	-2,012	-3,512	-2,532	-6,062
TOTAL	**$162.6 billion**	**312,217**	**214,147**	**529,801**	**411,880**	**978,919**

vii The negative figures in these tables represent cases in which spending in the Chapter 2 William and Jones *central scenario* is less than that in their reference scenario.

3.4B) Figures through Raising U.S. Domestic Content to 100 percent

Investment Area	Average Annual Expenditure	Direct Jobs	Indirect Jobs	Direct Jobs+ Indirect Jobs	Induced Jobs	Direct Jobs + Indirect Jobs + Induced Jobs
Vehicles	$79.8 billion	174,932	-46,385	128,546	127,782	256,328
HVAC	$32.4 billion	97,117	97,578	194,695	117,639	312,333
Manufacturing	$16.9 billion	40,382	60,238	100,620	60,670	161,290
Other commercial and residential	$15.3 billion	47,913	46,534	93,664	58,780	152,753
Construction	$10.9 billion	35,698	36,108	71,806	40,184	111,991
Appliances	$3.1 billion	5,722	9,675	15,397	10,053	25,451
Refrigeration	$2.8 billion	8,058	8,511	16,569	10,326	26,895
Mining	$1.6 billion	2,974	3,708	6,683	4,489	11,171
Agriculture	$542.6 million	6,196	2,153	8,349	2,109	10,459
Lighting	-$739.5 million	-1,874	-2,124	-3,998	-2,588	-6,586
TOTAL	**$162.6 billion**	**417,119**	**215,996**	**632,331**	**429,444**	**1.1 million**

Source: IMPLAN 3.0. Budgetary figures from Williams, Jones and Farbes (2020). Note: Expenditure and jobs numbers in this table are net figures, allowing for both net positive and net negative spending levels based on differences between the *central* and *reference scenarios*.

Table 3.5 brings together our job creation estimates for both the energy supply investments and energy demand expenditures, resulting from spending an average of $551 billion per year from 2020 – 2050. We show total figures for direct plus indirect jobs only, then we also show the total when induced jobs are included. As with Tables 3.1 - 3.4, we first present figures generated by assuming existing domestic content levels, then report our estimates through assuming domestic content rises to 100 percent.

Table 3.5 Average Annual Net Job Creation through Combined Energy Supply and Energy Demand Expenditure Program, 2020 – 2050, Assumption: Current Levels of Domestic Content

	Number of Direct and Indirect Jobs Created		**Number of Direct, Indirect and Induced Jobs Created**	
	Jobs Created at Existing Domestic Content Levels	**Jobs Created at 100% Domestic Content**	**Jobs Created at Existing Domestic Content Levels**	**Jobs Created at 100% Domestic Content**
1) $388.7 billion in net average annual energy supply investments	1.8 million	2.1 million	3.2 million	3.5 million
2) $162.6 billion in net average annual energy efficiency expenditures	529,801	632,331	978,919	1.1 million
3) $551.3 billion in net average annual combined expenditures	2.3 million	2.7 million	4.2 million	4.6 million
4) Total net job creation as share of projected 2035 labor force *(projection is 175 million U.S. workforce in 2035)*	1.3%	1.5%	2.4%	2.6%

Sources: Tables 3.1 – 3.4. U.S. 2035 workforce projection is an extension of the U.S. Bureau of Labor Statistics projection through 2028, which assumes a 0.5 percent average annual labor force growth rate: https://www.bls.gov/news.release/pdf/ecopro.pdf

In row 3 of Table 3.5 the total average direct and indirect job creation between 2020 – 2050 –including jobs generated on both the supply and demand-sides of the energy transformation – is 2.3 million assuming existing domestic content levels, and 2.7 million, assuming domestic content rises to 100 percent.

Through adding induced jobs, the average annual job creation figures then rise, with existing domestic content levels, to 4.2 million, and to 4.6 million through assuming 100 percent domestic content. As seen in Table 3.5, this level of direct and indirect job creation would amount to between about 1.3 – 1.5 percent of the likely total labor force in the U.S. as of 2035. When induced jobs are included in the total, the figure rises to between 2.4 – 2.6 percent of the 2035 labor force. In addition, pushing U.S. domestic content to 100 percent in all of these supply and demand spending areas will produce an average of an additional 400,000 jobs per year between 2020 – 2050 relative to maintaining existing domestic content levels intact.

Indicators of Job Quality

In Table 3.6 - 3.9, we provide some basic measures of job quality for the direct jobs in the core areas that will be generated through both the energy supply investments and energy efficiency expenditures within the Chapter 2 *central scenario*. These basic indicators include: (1) average total compensation (including wages plus benefits); (2) the percentage of workers receiving health insurance coverage through their employer; (3) the percentage having retirement plans through their employers; and (4) the percentage that are union members. These figures are first presented for the energy supply investments in Tables 3.6 and 3.7, then for the energy demand expenditures in Tables 3.8 and 3.9.

Table 3.6 Indicators of Job Quality in Primary Energy Supply Investment Areas: Direct Jobs Only

	1. Clean renewables	2. Additional supply technologies	4. Transmission / Storage
Average total compensation	$83,000	$76,600	$139,700
Health Insurance coverage, percentage	56.7%	48.0%	72.9%
Retirement Plans, percentage	39.3%	31.7%	61.3%
Union membership, percentage	9.0%	9.1%	22.7%

Source: CPS 2018-2019

Table 3.7 Educational Credentials and Race/Gender Composition of Workers in Primary Energy Supply Investment Areas: Direct Jobs Only

	1. Clean renewables	2. Additional supply technologies	3. Transmission / Storage
Share with high school degree or less	43.0%	46.1%	31.1%
Share with some college or Associate degree	24.8%	30.1%	29.9%
Share with Bachelor's degree or higher	32.3%	23.8%	39.0%
Racial and Gender Composition of workforce			
Percent People and communities of color	33.7%	34.1%	26.2%
Percent Female	20.5%	19.4%	20.6%

Source: CPS 2018-2019

Energy Supply Investments and Job Quality

The analysis focuses on three core areas of direct job creation through energy supply investments: renewables, other non-renewables, and transmission storage. As the average compensation figures are fairly close in the two energy supply areas, at $83,000 for clean renewables and $77,000 for additional supply technologies. But workers in the transmission/storage areas are earning much higher pay on average, at nearly $140,000.

In terms of the provision of employer-sponsored health care, the workers in the transmission/storage sector are, as with their compensation, better off than workers in the other sectors. Nearly 73 percent of these workers are receiving health care through their employers. By contrast, between 48 – 57 percent of workers in the renewables and additional supply technology sectors are getting employer-based health insurance.

A similar pattern holds with retirement plans, as well as with unionization rates. Over 60 percent of workers in transmission/storage receive pensions from their jobs, while between 32 – 39 percent have employer-based pensions in the two other areas. Nearly 23 percent of workers in transmission/storage are union members, while only about 9 are union members in the other supply side investment areas.

Educational Credentials and Race/Gender Composition

In Table 3.7, we present data on both the educational credentials for workers in the three core energy supply investment categories as well as the race and gender composition of these workers. The analysis focuses here only on the workers who are employed *directly* through these investments.

Educational Credentials

With respect to educational credentials, we categorize all workers according to three educational credential groupings: (1) shares with high school degrees or less; (2) shares with some college or Associate degrees; and (3) shares with Bachelor's degree or higher.

As Table 3.7 shows, we see a similar pattern with the results on compensation and benefits. That is, the workers in transmission/storage have higher credentials, with nearly 40 percent having Bachelor's degrees or higher. In the other three supply-side categories between 43 – 46 percent have high school diplomas or less.

Also, in terms of the share of workers who are people of color, roughly one-third of workers in all of the supply-side investment areas are people of color, with the one exception of the transmission/storage investment area. In this case, the share of workers from communities of color is significantly lower, at 26 percent.

Women are underrepresented across the board—holding only about 20 percent of the jobs in these three core investment areas.

Energy demand expenditures and job quality

Starting with compensation figures, Table 3.8 shows that the averages for the energy demand expenditures range between roughly $70,000 per year for workers in the HVAC and refrigeration categories, rising to an average of $83,000 for workers employed in the clean vehicles category.

Table 3.8 Indicators of Job Quality in Primary Energy Demand Spending Areas: Direct Jobs Only

	1. Vehicles	**2. HVAC**	**3. Refrigeration**
Average total compensation	$82,600	$72,500	$69,600
Health Insurance coverage, percentage	73.8%	57.7%	48.3%
Retirement Plans, percentage	49.2%	39.3%	32.7%
Union membership, percentage	13.2%	9.9%	11.7%

Source: CPS 2018-2019

There is significant variation between workers in these three energy demand areas in terms of receiving health insurance through their employers. At the low end, about 48 percent of workers in the refrigeration category receive employer-based health insurance, while nearly 74 percent of workers in the vehicles category receive it.

The range of coverage with respect to private retirement plans is narrower than with health insurance. The low-end figures are with workers in the areas of refrigeration, in which only about 33 percent of workers have employer-based retirement plans. The figure is close to 50 percent for workers employed in the vehicles category. The figures on union coverage are broadly consistent at low levels, ranging between about ten percent for workers in the lighting and HVAC categories up to 13 percent for those in vehicles.

Educational credentials and race/gender composition

In Table 3.9, we present data on both the educational credentials for workers in the three core energy efficiency expenditure categories of vehicles, HVAC, and refrigeration, as well as the race and gender composition of these workers. Again, the analysis focuses here only on the workers who are employed directly through these investments.

Table 3.9 Educational Credentials and Race/Gender Composition of Workers Primary Energy Demand Spending Areas: Direct Jobs Only

	1. Vehicles	**2. HVAC**	**3. Refrigeration**
Share with high school degree or less	43.1%	48.6%	53.3%
Share with some college or Associate degree	29.4%	29.2%	27.6%
Share with Bachelor's degree or higher	27.4%	22.2%	19.0%
Racial and Gender Composition of Workforce			
Percent People and communities of color	35.4%	33.2%	36.5%
Percent Female	25.7%	17.3%	13.8%

Source: CPS 2018-2019

Educational credentials

As Table 3.9 shows, the distribution of educational credentials is fairly consistent across the major energy demand spending categories. Thus, the range of workers with high school degrees or less varies from a low of 43 percent for workers employed in the vehicles category to 53 percent in refrigeration. Similarly, the share of workers with Bachelor's degrees or higher ranges from a low of 1 percent in refrigeration to 27 percent in the vehicles category.

Race and gender composition

It is clear from the figures in Table 3.9 that, at present, the jobs created by energy demand expenditures are held mainly by white male workers. At the same time, the share of jobs held by workers from communities of color are somewhat higher than their 28 percent representation throughout the U.S. workforce in general. The range of workers from communities of color is narrow across the energy demand spending categories, between 33 and 37 percent. With respect to gender composition, women are under-represented across all sectors. The share of female employment is between 14 – 26 percent,[viii] even while women make up 46 percent of the U.S. workforce.[4]

viii According to the U.S. Census, 28 percent of U.S.'s labor force was non-White and/or Hispanic/Latino in 2017. The U.S. Department of Local Affairs estimates that 46 percent of U.S.'s labor force is female.

Prevalent Job Types with Clean Energy Investments

In addition to these average results across the various energy supply investment and energy demand expenditure areas, it is important to consider the range of the types of jobs that will be generated in each of the specified areas. To provide a picture of this range of jobs, in the Appendix, we present tables that report on the job categories in all of the investment and expenditure areas. It is difficult to summarize the detailed data on job categories presented in these tables, but the overall point is clear. That is, investing to build a clean energy economy will produce new employment opportunities at all levels of the U.S. economy. New job opportunities will open for, among other occupations, carpenters, machinists, environmental scientists, secretaries, accountants, truck drivers, roofers and agricultural laborers, as well as well as a full range of managerial occupations. It is important to note that this broad range of new opportunities will be available for workers in the U.S. that will have been displaced by the contraction of the fossil fuel industry activities.

3.3 Job Contraction and Just Transition for Workers in Fossil Fuel Industries[5]

The economic transition model developed by Williams and Jones in Chapter 2 describes a detailed pathway for achieving a net-zero U.S. economy by 2050.[ix] Of course, a critical feature of that project will entail a dramatic contraction in the production and consumption of oil, coal, and natural gas as U.S. energy sources. As of 2018, energy supplied by these fossil fuel sources accounted for about 80 percent of all U.S. energy consumption. Moreover, on a net basis, about 96 percent of the fossil fuel energy consumed in the U.S. in 2018 came from U.S. domestic production activity.[6] It therefore follows that the large-scale contraction of the U.S. oil, gas and coal industries will generate major job losses for workers currently employed in these and related industries. The contraction of the U.S. fossil fuel industry will also generate substantial negative impacts on communities which are currently dependent on the fossil fuel economy in terms of jobs, local business activity, and tax revenues to fund schools, health care facilities, infrastructure and other community institutions.

Within the framework of the model in Chapter 2, the rates at which the oil, natural gas and coal industry will contract vary significantly. Table 3.10 summarizes the respective rates of contraction for the three sectors. Specifically, as seen in the Chapter 2 model, the U.S. oil industry contracts by 20 percent between 2020 – 2030 and by 95 percent between 2031 – 2050. The natural gas industry does not contract at all between 2020 – 2030, but declines by 75 percent between 2031 – 2050. Finally, within the Chapter 2 model, the coal industry is phased out entirely and permanently between 2021 – 2030.

ix This section and Section 4 draws substantially from Pollin and Callaci, (2018) and subsequent follow-up projects, including Pollin et al. (2019).

Table 3.10. Assumptions on Contraction Rates for U.S. Fossil Fuel Sectors: Contractions as of 2030 and 2050. Baseline Employment Figures from 2018

	2030	2050
Oil	- 20%	- 95%
Natural Gas	No contraction	- 75%
Coal	100%	100%

Source: Williams, Jones and Farbes (2020).

In this section, we first consider these impacts on workers in the fossil fuel industry. We also develop a just transition program to support workers who will be facing displacement as a result of the fossil fuel industry contraction. The next section examines this issue with respect to communities, focusing on communities facing high impacts from the fossil fuel industry contraction. We then consider a range of just transition measures to support these heavily-impacted communities.

3.3.1 Job Losses for Fossil Fuel Industry Workers

In principle, there are 15 industries that would likely be heavily affected by a significant cut in U.S. fossil fuel consumption and production. Of course, the first two would be oil and gas extraction and coal mining themselves. There are also 13 ancillary industries that would be impacted. The first two would be support activities for both oil/gas extraction and coal mining. The 11 additional industries that would be impacted are: gas stations; natural gas distribution; drilling oil and gas wells; wholesale petroleum and petroleum products; fossil fuel electric power generation; pipeline transport; pipeline construction; oil and gas field machinery and equipment manufacturing; other petroleum and coal products manufacturing; and mining machinery and equipment manufacturing.

Table 3.11 lists all of these industries, and the level of direct employment in each of them as of 2018. The total direct employment from all of these industries is at 2.5 million as of 2018, 1.7 percent of the U.S. labor force. The largest source of employment among all of these industries was gas stations, with 765,718 total employment, more than 30 percent of total employment. Oil and gas extraction is the next largest employer, with 636,449 jobs, amounting to another 25 percent of all the fossil fuel industry related jobs. Support activities for oil and gas employ another 129,593, or 15 percent of the total for all fossil fuel-based industries. These largest 3 employers therefore account for around 70 percent of all the jobs tied to fossil fuels.

Table 3.11 Number of Workers in U.S. Employed in Fossil Fuel-Based Industries, 2018

Industry	**2018 Employment Levels**
Gas Stations	765,718
Oil and Gas Extraction	636,449
Support Activities for Oil/Gas	369,646
Natural Gas Distribution	129,593
Drilling Oil and Gas Wells	117,529
Wholesale -Petroleum and petroleum products	114,266
Fossil Fuel Electric Power Generation	98,604
Petroleum Refining	72,495
Coal Mining	55,988
Pipeline Transport	54,285
Support Activities for Coal	38,368
Pipeline Construction	36,690
Oil and Gas Field Machinery and Equipment Manufacturing	29,891
All other petroleum and coal products manufacturing	5,802
Mining Machinery and Equipment Manufacturing	5,133
Fossil Fuel Industry Total	2,530,459
Total Fossil Fuel Employment as Share of U.S. Employment *(U.S. 2018 employment = 148,891,000)*	1.7%

Sources: IMPLAN, 3.0, U.S. Department of Labor.

Among the other industries listed, the total direct employment in coal mining is at about 56,000 as of 2018. Total coal mining employment therefore amounted to only 0.04 percent of all employment in the U.S. in 2018. Even when we add another 38,368 for coal industry support activities, the total still amounts to less than 1/10th of one percent of overall U.S. employment. These figures offer valuable perspective, conveying that the resources that will be required to mount a just transition for these coal industry-related workers should be negligible relative to the size of the overall U.S. labor force.

Treatment of Indirect and Induced Employment Effects

We should note that the ancillary fossil fuel-based industries listed in Table 3.11 approximately match up with the industries in which *indirect employment* occurs resulting through fossil fuel sector production, as defined in the input-output tables, and as we have describe above. In estimating the number of workers who would require some form of support through a just transition program, it is more accurate to focus on the direct employment figures for these 13 ancillary fossil fuel industries as opposed to utilizing the indirect employment data from the input-output tables.

For our purposes of developing a just transition program, we are able to incorporate important details on employment conditions in these 13 ancillary industries by working with the available employment data on the specific industries as opposed to relying on a single generic category of indirect employment for the oil/gas and coal industries. At the same time, for the purposes of drawing comparisons with the figures presented above on employment creation through clean energy investments, it is useful to keep in mind that the figures reported here on ancillary employment relative to the oil/gas and coal industries are the equivalent of the indirect employment figures reported in the clean energy industries.

In drawing out the comparison between employment impacts of clean energy investments versus employment losses through the fossil fuel industry contraction, one should also consider the relative size of the induced employment effects of the fossil fuel industry contraction, as has been described in the employment effect above. As noted above, induced employment effects refer to the expansion of employment that results when people in any given industry – such as clean energy or fossil fuels – spend money to buy goods and services. This increases overall demand in the economy, which means more people are hired into jobs to meet this increased demand. It follows that the loss of incomes through a contraction of employment will create a negative induced employment effect. People will have less money to spend, overall demand for goods and services will contract, and therefore the demand for workers will decline correspondingly. However, because of the way we propose to implement a just transition program for fossil fuel-related industry workers throughout the U.S., there will be no loss of income for fossil fuel-dependent workers in the country, even as the industry itself contracts. It follows that implementing the just transition program will mean that there will also be no induced employment losses in the U.S. labor market even as the fossil fuel industry itself contracts. This will become clear after we describe the features of the proposed just transition program. We therefore return to this issue briefly at the end of this just transition section

Characteristics of Fossil Fuel and Ancillary Industry Jobs

Table 3.12 provides basic figures on the characteristics of the jobs in fossil fuel-based industries. As the table shows, on average, these are relatively high-quality jobs. The average overall compensation level is $109,000. This figure is significantly higher than what was seen above for most of the main supply- and demand-side areas within the clean energy project. With the exception of transmission/storage, average compensation in these other clean energy activities ranged between $70,000 and $83,000.

Workers in these industries are also relatively well off in terms of the benefits they receive from their jobs. Over 75 percent of them receive health insurance from their jobs. This contrasts with the figures we saw above for the clean energy areas, where, again, with the exception of transmission/storage, the share of workers receiving health insurance from their employers ranged between 32 – 57 percent. Nearly 50 percent of workers in the fossil fuel-based sectors also receive pension retirement benefits. Union membership is at 8.8 percent. This is, of course, a low figure, but it is still somewhat higher than the average for the entire U.S. private sector, at only 6.2 percent.

Table 3.12 Characteristics of Workers Employed in Fossil Fuel-Based Sectors in U.S. 2021-2030

	Fossil Fuel-Based industries
Average total compensation	$109,400
Health insurance coverage	75.4%
Retirement benefits	48.6%
Union membership coverage	8.8%
Educational credentials	
Share with high school degree or less	40.0%
Share with some college or Associate degree	27.2%
Share with Bachelor's degree or higher	32.8%
Racial and gender composition of workforce	
Percent People and communities of color	29.2%
Percent Female workers	16.1%

Source: IMPLAN 3.0; CPS 2018-2019

Table 3.12 also reports figures on educational credential levels for workers in each of the 13 industries, as well the percentages of female workers and workers from communities of color. The jobs are distributed fairly evenly with respect to educational credentials, with 40 percent of workers having high school degrees or less, 27 percent having some college and 33 percent with Bachelor's degrees or higher. The share of female workers is quite low at 16 percent. People of color make up nearly 30 percent of the workforce. This is basically the same percentage of people of color in the U.S. overall.

We can gain further detailed information on the composition of the workforce in the fossil fuel-based industries in Table 3.13, in which all the job categories are listed in which 5 percent or more of the workforce is employed. The table shows the highest percentage of jobs, at 14.6 percent, are in various forms of management. Jobs in extraction is the next largest category of employment, at 14.3 percent of all jobs. The representative occupations in these jobs include earth drillers, oil and gas roustabouts, and derrick operators. Generally speaking, as with the areas of employment in clean energy, we see that employment in fossil fuels engages a wide range of workers. Some of them will have skills specific to the industry and will therefore face difficulties moving into new employment areas. The majority of the workers will have jobs that should be transferable to new employment opportunities, in the clean energy economy or elsewhere. More generally, any just transition program to support displaced workers in the U.S. fossil fuel related industries will need to be focused on the specific background and skills of each of the impacted workers. We now turn to considering the specific dimensions and features of such a just transition program.

Table 3.13 Prevalent Job Types in U.S. ’s Fossil Fuel-Based Sectors, 2021-2030 (Job Categories with 5 percent or more of employment)

Fossil Fuel-Based Sectors

Job Category	Percentage of Direct Jobs Lost	Representative Occupations
Management	14.6%	Financial managers; marketing managers; financial chief executives
Extraction	14.3%	Earth drillers; oil and gas roustabouts, derrick operators
Transportation and material moving	10.0%	Crane operators, industrial truck operators, pumping station operators
Construction	9.2%	Carpenters, pipelayers, construction equipment operators
Installation and maintenance	9.2%	Maintenance and repair workers; first-line supervisors, industrial machinery mechanics
Architecture and engineering	8.5%	Electrical engineers; mining and geological engineers; engineering technicians
Production	7.7%	Power plant operators, inspectors, welding workers
Office and administrative support	7.6%	Bookkeeping clerks, customer service representatives; secretaries

Source: IMPLAN 3.0; CPS 2018-2019

Estimating Annual Job Losses through Fossil Fuel Contraction

For designing effective just transition initiatives, the most relevant metric will be the rate at which workers are likely to be losing their jobs through the fossil fuel industry contraction. Working within the Chapter 2 model, these rates will differ significantly in the 13 fossil fuel-based industries. This is because the rates at which the oil, natural gas, and coal industries are projected to decline themselves differ significantly in the model.

Based on the varying rates of contraction in oil, natural gas, and coal, as shown in Table 3.10, we estimate in Table 3.14 the total number of jobs that will be lost in the various individual industries. We show these figures separately for the 2020 – 2030 and 2031 – 2050 periods. For both periods, the 10 industries are listed that will experience the most significant job losses. In both periods the largest number of job losses will be in oil and gas extraction. But the figure is relatively small for 2020 – 2030, at 63,645 relative to the 2031 – 2050 period, at 477,337. This disparity is due to the fact that in the 2020 – 2030 period, natural gas does not contract at all, while oil declines by only 20 percent. By contrast, in the 2031 – 2050 period, oil declines to only 5 percent of its 2019 level while natural gas falls by 75 percent. The analysis also shows that all 55,998 jobs in the coal mining sector as of 2018 will be lost by the end of the 2020 – 2030 period.

Table 3.14 Total Job Losses in Major Fossil Fuel-Based Industries, 2021 – 2030 and 2031 – 2050

A) 2021 – 2030 Job Losses

Oil and gas extraction	-63,645
Coal mining	-55,988
Fossil fuel electric power generation	-49,302
Support activities for coal mining	-38,368
Support activities for oil and gas operations	-36,965
Wholesale: Petroleum and petroleum products	-22,853
Petroleum refineries	-14,499
Drilling oil and gas wells	-11,753
Mining machinery and equipment manufacturing	-5,133
All other petroleum and coal products manufacturing	-3,481
Oil and Gas Field Machinery and Equipment Manufacturing	-2,989

B) 2031 – 2050 Job Losses

Oil and gas extraction	-477,337
Gas stations	-382,859
Support activities for oil and gas operations	-277,235
Natural gas distribution	-97,195
Drilling oil and gas wells	-88,147
Wholesale: Petroleum and petroleum products	-85,699
Petroleum refineries	-54,372
Pipeline transportation	-40,714
Fossil fuel electric power generation	-39,441
Pipeline construction	-27,518
Oil and Gas Field Machinery and Equipment Manufacturing	-22,419
All other petroleum and coal products manufacturing	-2,176

These Table 3.14 figures are useful as a first indicator of what will be entailed in designing effective just transition policies. However, by themselves, they do not convey the actual patterns in which workers are likely to experience job losses. To estimate this pattern more accurately, two further considerations need to be incorporated. These are: (1) whether the rate of contraction for any given industry will be steady or episodic; and (2) the rates at which older workers will move into retirement. Of course, workers moving into retirement will not require assistance in finding new jobs. However, it will be critical that the pension funds accrued by these older workers will be available to them in full as they move into retirement. We consider these issues in turn.

Steady versus Episodic Industry Contraction

The scope and cost of any set of just transition policies will depend heavily on whether the contraction is steady or episodic. Under a pattern of steady contraction, there will be uniform annual employment losses over both the 2020 – 2030 and 2031 – 2050 periods, with the steady rates determined by the overall level of industry contraction within the given time period. But it is not realistic to assume that the pattern of industry contraction will necessarily proceed at a steady rate. An alternative pattern would entail relatively large episodes of employment contraction, followed by periods in which no further employment losses are experienced. This type of pattern would occur if, for example, one or more relatively large firms were to undergo large-scale cutbacks at one point in time as the industry overall contracts, or even for such firms to shut down altogether.

The costs of a just transition will be much lower if the transition is able to proceed smoothly rather than through a series of episodes. One reason is that, under a smooth transition, the proportion of workers who will retire voluntarily in any given year will be predictable. This will enable the transition process to avoid having to provide support for a much larger share of workers. The share of workers requiring support would rise if several large businesses were to shut down abruptly and lay off their full work force at once, including both younger as well as older workers. Similarly, it will be easier to find new jobs for displaced workers if the pool of displaced workers at any given time is smaller.

For the purposes of our calculations, we proceed by assuming that the U.S. will successfully implement a relatively smooth contraction of its fossil fuel industries. This indeed would be one important feature of a well-designed and effectively implemented just transition program. As a practical matter, a relatively smooth transition should be workable as long as policymakers remain focused on that goal.

Estimating Attrition by Retirement and Job Displacement Rates

In Tables 3.15 and 3.16 respectively, we show figures on annual employment reductions in the U.S. fossil fuel-based industries over two periods, 2021 – 2030, and 2031 – 2050, that will result through a smooth contraction at the rates described in Table 3.10. That is, coal is phased-out entirely by 2030, while oil declines by 20 percent and natural gas remains intact over this initial period. Then, from 2031 – 2050, oil falls to 5 percent and natural gas falls to 25 percent of 2020 production levels.

We also then estimate the proportion of workers who will move into voluntary retirement at age 65, both by 2030 and by 2050. Once the share of workers who will move into voluntary retirement at age 65 is known, we can then estimate the number of workers who will be displaced through the industry-wide contraction.

Because the rates at which the coal industry is phased out in the Chapter 2 model is much faster than that for oil and gas, we report in Table 3.15 separate figures on contraction rates for the two industries between 2021 – 2030. Table 3.16 then reports figures on contraction rates for the oil and gas industry only, since coal will have been shut down as of 2030.

2021 – 2030 contraction

We begin in Table 3.15 with the total fossil fuel-based industry workforce of 2.5 million workers. Based on the respective contraction rates for the oil, natural gas and coal industries over 2020 – 2030, we estimate that total job losses will be about 305,000 workers over 2021 – 2030. Assuming a smooth pace of contraction, this amounts to an average rate of job losses of 30,500 per year.

Table 3.15 Attrition by Retirement and Job Displacement for Fossil Fuel Sector Workers in U.S., 2021-2030

	All Fossil Fuels	Coal Mining and Related Ancillary Industries	Oil and Gas Extraction and Related Ancillary Industries
1) Total workforce as of 2018	2,530,459	151,693	2,378,766
2) Job losses over 10-year transition, 2021-2030	304,977	151,693	153,284
3) Average annual job loss over 10-year production decline *(= row 2/10)*	30,498	15,169	15,328
4) Number of workers reaching 65 over 2021-2030 (=row 1 x % of workers 54 and over in 2019)	422,436* *(16.7% of all workers)*	38,530 *(25.4% of all workers)*	383,906* *(23.8% of all workers)*
5) Number of workers per year reaching 65 during 10-year transition period (=row 4/10)	42,244	3,853	38,391
6) Number of workers per year retiring voluntarily (80% of 65+ workers)	33,795	3,082	30,713
7) Number of workers requiring re-employment (= row 3 – row 6)	12,087	12,087	0

Source: The 80 percent retirement rate for workers over 65 derived from U.S. Bureau of Labor Statistics: https://www.bls.gov/cps/cpsaat03.htm. According to these BLS data, 20 percent of 65+ year-olds remain in the workforce. Note: *This figure does not include gas station industry workers who are 54 years and older in 2019. This is because it is assumed that the gas station sector will begin to contract until 2031.

As row 2 of the table shows, there will be a roughly equal number of job losses between 2021 – 2030 in coal, at 151,691 and oil/gas, at 153,284. But the big difference between the job losses for coal versus those for oil/gas is that the coal figure represents 100 percent of the industry's entire current workforce, while the oil/gas figure amounts to only 6.4 percent of its current workforce. As a result, with oil/gas, our estimate that nearly 31,000 workers will voluntarily retire every year from their industry jobs once they turn 65 is more than twice as large as the roughly 15,000 job losses per year. This means that, for the oil/gas industry, with voluntary retirements being roughly twice as large as the number of job losses within the industry, the total number of workers that will face displacement and requiring re-employment will be zero. However, all oil/gas industry workers that move into retirement will need to have their pensions fully guaranteed.

By contrast, with the coal industry, it is estimated that 3,082 workers per year will retire voluntarily at age 65 between 2021 – 2030. But with average annual job losses in coal at 15,169, this then means that 12,087 workers will experience displacement per year—i.e. their coal industry jobs will be lost and they will not be choosing to voluntarily retire. All of these roughly 12,000 workers per year will need to receive the full package of just transition support, including guaranteed re-employment, along with income, retraining, and relocation support. All of these workers, along with those who had voluntarily retired, will need to have their pension accounts fully guaranteed. We describe the details of the program below.

2031 – 2050 contraction

In Table 3.16, we now perform the same set of calculations for the contraction process over 2031 – 2050. In this case, the challenge of mounting a just transition will be more substantial since, by 2050, the oil industry will have been reduced to 5 percent of its 2018 employment level and the natural gas industry will have declined by 75 percent relative to 2018. Coal, again, will have been totally phased out by 2030. Table 3.16 shows the impact of the oil/coal contraction over 2031 – 2050.

Table 3.16 Attrition by Retirement and Job Displacement for Fossil Fuel Sector Workers in U.S., 2031-2050

	Oil and Gas Extraction and Related Ancillary Industries*
1) Total workforce as of 2030	2,225,482
2) Job losses over 20-year transition, 2031-2050	1,595,110
3) Average annual job loss over 20-year production decline *(= row 2/20)*	79,756
4) Number of workers reaching 65 over 2031-2050 (=row 1 x % of workers between 34 and 55 years in 2019)**	1,138,707 *(45% of all workers)*
5) Number of workers per year reaching 65 during 20-year transition period (=row 4/20)	56,935
6) Number of workers per year retiring voluntarily	45,548 *(80% of 65+ workers)*
7) Number of workers requiring re-employment (= row 3 – row 6)	34,207

Source: The 80 percent retirement rate for workers over 65 derived from U.S. Bureau of Labor Statistics: https://www.bls.gov/cps/cpsaat03.htm. According to these BLS data, 20 percent of 65+ year-olds remain in the workforce. Note: *As indicated in Table 3.15, coal mining and related ancillary industries will have 0 employment as of 2030. **This is an underestimate of the percent of workers reaching retirement age which assumes that all workers ages 55 and older as of 2019 will have retired and been replaced by young workers in industries, such as gas stations, that are not contracting during 2021-2030. However, such industries may, in fact, hire workers to replace retiring workers during 2021-2030 that are not young. If this occurs, then the percent of workers reaching retirement age during 2031-2050 would be larger than the 45 percent figures used.

As seen in Table 3.16, about 2.2 million workers will remain employed in the oil and natural gas industries as of 2030, after about 150,000 jobs will have been lost between 2021 - 2030. A bit less than 1.6 million jobs will then be lost over the 20-year transition from 2031 – 2050. This amounts to an annual rate of employment decline of about 80,000 jobs per year. At the same time, we estimate that about 57,000 workers will turn 65 each year during this 20-year transition period. With an 80 percent voluntary retirement rate among workers turning 65, this then means that about 45,500 workers over 65 will choose retirement. The net effect over 2031 – 2050 will be that 34,200 workers per year will become displaced. These 34,000 workers per year will require a full set of just transition support policies, including re-employment, retraining, and relocation support. This will be in addition to the pension guarantees that will have been put in place during the first 2021 – 2030 contraction phase.

3.3.2 Features of Just Transition Program

We describe here a just transition program for workers in the U.S. fossil fuel-based industries that includes five components:

- **Pension guarantees.** This form of support will be provided for all workers, those moving into retirement as well as those with ongoing accounts through their employers.
- **Employment guarantees.** These would be jobs provided through clean energy investments as well as public-sector employment more generally.
- **Wage insurance.** Displaced workers will be guaranteed three years of compensation at their new jobs that will at least equal their pay levels in their fossil fuel-based industry jobs.
- **Retraining support.** This would include two years of retraining, as needed for all displaced workers.
- **Relocation support.** Workers will be guaranteed a one-time payment of $75,000 to relocate, as needed. This assumes one-half of all displaced workers will require this support.

Table 3.17 lists this full set of policy proposals, along with proposed budgetary outlays per workers for each measure. Table 3.18 then shows our overall budget estimates for the income, retraining, and relocation support programs.

Table 3.17 Policy Package for Displaced Workers in U.S.

Fossil Fuel-Based Industries

Pension guarantees for workers (65+) voluntarily retiring	**Legal pension guarantees**
Employment guarantee	Jobs provided through clean energy and public infrastructure investment expansions
Wage insurance	Displaced workers guaranteed 3 years of total compensation at levels in fossil fuel-based jobs
Retraining support	2 years of retraining, as needed ($4,000 in tuition and fees, $2,000 in other expenses)
Relocation support	$75,000 for one-half of displaced workers

Source: American Association of Community Colleges, "DataPoints: Tuition and Fees," 6/18/2020, see: https://www.aacc.nche.edu/2020/06/18/datapoints-tuition-and-fees/.

Table 3.18 Total and Annual Average Costs for Just Transition Support for Displaced Fossil Fuel-Based Workers

A. Years: 2021-2030

Year	**Income support** *(3 years of support for 12,087 coal workers/ year)*	**Retraining support** *(2 years of support for 12,087 coal workers/ year)*	**Relocation support** *(1 year of support for 12,087 coal workers/ year)*	**Total** (= Cols. 1+2+3)
Total Costs	$11.9 billion	$1.5 billion	$4.5 billion	$17.9 billion
Average Annual Costs	$991.1 million *(12 years of support)*	$131.9 million *(11 years of support)*	$453.3 million *(10 years of support)*	$1.5 billion *(12 years of support)*

B. Time Period: 2031-2052

Year	**Income support** *(3 years of support for 34,207 oil and gas workers/year)*	**Retraining support** *(2 years of support for 34,207 oil and gas /year)*	**Relocation support** *(1 year of support for 34,207 oil and gas/ year)*	**Total** (= Cols. 1+2+3)
Total Costs	$49.1 billion	$8.2 billion	25.7 billion	$82.9 billion
Average Annual Costs	$2.2 billion *(22 years of support)*	$0.4 billion *(21 years of support*	$1.3 billion *(20 years of support)*	$3.8 billion *(22 years of support)*

Note: Appendix 6.4 presents detailed annual calculations.

Before reviewing these cost estimates, we should explain why we are assuming that the pension fund guarantee program should be able to operate on a modest budget, covering only administrative costs, under the auspices, for example, of the federal Pension Benefit Guarantee Corporation (PBGC). As the agency tasked with enforcing the pension guarantees for fossil fuel-based workers, the PBGC could enact regulations to prohibit fossil fuel-based companies from paying dividends or financing share buybacks until their pension funds have been brought to full funding and then maintained at that level. As needed, the PBGC could also consider placing liens on company assets when pension funds are underfunded. Through such measures, the pension funds for most of the affected workers can be protected through a regulatory intervention alone, without the government having to provide financial infusions to sustain the funds.

At the same time, it will be likely that one or more of the firms will experience serious financial crises in the future. Within the context of the Chapter 2 model, this will most immediately be the case for the coal companies, with phase downs for oil and natural gas occurring more gradually over 2031 – 2050. In fact, some coal companies operating throughout the U.S. do now already face critical conditions with their pension funds, due to cutbacks in U.S. coal demand. In addressing the ongoing crisis with coal industry pensions, the Obama administration had proposed in 2015 a measure to support the pensions, under its “Power Plus” program that aimed broadly to support coal communities and workers.[7]

This proposal was blocked in the U.S. Congress by the Republican majority. But the broader point is that the equivalent of such a measure will need to be included as a centerpiece for the U.S. just transition program. The costs of this intervention could nevertheless be minimized to the extent that the PBGC operates effectively as a regulator during the fossil fuel industry phase down.

For estimating the costs of the income, retraining, and relocation support programs, as shown in Table 3.17, the overall set of policies will run for two years beyond 2050, to 2052. This is because displaced workers will be receiving 3 years of income support and two years of retraining support, including those workers who are displaced in 2050 itself.

As seen in Table 3.18, total costs for 2021 will be $17.9 billion for 2021 – 2030 and $82.9 billion for 2031 – 2050. The full 2021 – 2050 costs will therefore be just over $100 billion. The average costs will amount to $1.5 billion per year over 2021 – 2030, including $991 million for income support, $132 million for retraining, and $453 million for relocation support. For 2031 – 2050, we estimate overall average costs to be $3.8 billion per year, with $2.2 billion in income support, $0.4 billion for retraining and $1.3 billion for relocation support. Appendix 6.4 presents the full set of calculations whose results we summarize in Table 3.18. Overall, even during the high-cost period of 2031 – 2050, the $3.8 billion per year amount to less than one one-hundredth of 1 percent of average U.S. GDP over 2031 – 2050, assuming the U.S. economy grows at 2.2 percent per year between the most recent actual data of 2019 and 2050.[x]

3.4 Just Transition for Fossil Fuel-Dependent Communities

Communities that are dependent on the fossil fuel industry will face formidable challenges adjusting to the decline of the industry. This will be true even if all workforce reductions can be managed through a combination of attrition by retirement along with job guarantees for younger workers facing layoffs, and if all pension fund obligations to retired fossil fuel workers are honored in full. It is therefore imperative that effective community support programs be included as a major element of an overall just transition program for U.S. fossil fuel workers.

In seeking to develop such a program, it is first necessary to recognize the extent to which fossil fuel production in the U.S. is concentrated geographically. Five states –Kentucky, Montana, Pennsylvania, West Virginia, and Wyoming – account for nearly 70 percent of all U.S. coal production. But even within these five states, coal industry jobs represent a low percentage of overall statewide employment. In fact, as seen in Table 3.19 only five states employ more than 4,000 people total in the coal industry – West Virginia, Kentucky, Pennsylvania, Wyoming, and Alabama. West Virginia has the highest share of coal employment, with the 14,146 coal industry workers representing 2.6 percent of the overall statewide workforce. In Wyoming, the 5,294 coal industry workers represented 2.5 percent of the state's overall workforce. As the table shows, these are the only two states in which coal industry jobs exceed one percent of overall statewide employment.

x Average U.S. GDP between 2031 and 2050 will be $35.3 trillion, assuming the U.S. economy grows at an average annual rate of 2.2 percent between 2019 and 2050.

Table 3.19 U.S. Coal Employment in States with 3,000 or More Employees, 2019

	Coal Employment	**Total State Employment**	**Coal as share of total Employment (%)**
West Virginia	14,136	553,604	2.6%
Kentucky	6,849	1,606,009	0.4%
Pennsylvania	5,568	5,248,989	0.1%
Wyoming	5,294	211,524	2.5%
Alabama	3,133	1,622,325	0.2%

Source. Quarterly Census of Employment and Wages from Bureau of Labor Statistics; https://www.bls.gov/cew/. Figures are for private employment.

In fact, coal production is further concentrated by county within these heavily-producing states. Four counties produce 52 percent of Kentucky's coal output, a single county produces 58 percent of Montana's output, two counties produce 77 percent of Pennsylvania's output, six counties produce two-thirds of West Virginia's output, and Campbell County alone in Wyoming itself produces 89 percent of that state's output.

The level of geographic concentration for U.S. oil and gas production is roughly equivalent to that for coal. The top three states in oil production – Texas, North Dakota, and New Mexico along with offshore federal waters – account for 76 percent of all U.S. production, with Texas by itself accounting for 41 percent. With natural gas, the top five producing states – Texas, Pennsylvania, Louisiana, Oklahoma and Ohio – account for 62 percent of total production, with Texas alone producing 22 percent.[8]

Table 3.20 lists the 7 states in which oil and gas employment reaches 15,000 or higher – Texas, Oklahoma, Louisiana, Colorado, New Mexico, North Dakota, and Pennsylvania. In terms of employment, as seen in Table 3.10, Texas has the largest number of employees, at 234,022, while Wyoming has the highest proportion, at 5.9 percent of total employment. In addition to Texas and Wyoming, seven other states have employment levels in oil and gas exceeding 1 percent of total statewide employment. These are Oklahoma, Louisiana, Colorado, New Mexico, North Dakota, Alaska, and West Virginia.

Table 3.20 U.S. Oil and Gas Extraction Employment in States with 15,000 or more Employees. 2019

	Oil and Gas		**Oil and Gas**
	Extraction Employment	Total State Employment	Share of Total Employment (%)
Texas	234,022	10,691,618	2.2%
Oklahoma	45,587	1,295,884	3.5%
Louisiana	33,563	1,611,229	2.1%
Colorado	24,070	2,308,090	1.0%
New Mexico	21,799	657,218	3.3%
North Dakota	19,311	351,482	5.4%
Pennsylvania	17,546	5,248,989	0.3%

Source. Quarterly Census of Employment and Wages from Bureau of Labor Statistics. https://data.bls.gov/cew/apps/data_views/data_views.htm#tab=About

The impact of a long-term phase-down in the fossil fuel industry will of course be felt most acutely in these states and counties where production is highly concentrated. Most of the rest of the country is likely to experience negative effects to a much lesser degree, if at all.

Large cities tied to the fossil fuel industry, such as Houston and Dallas, will unavoidably face big adjustments, similar to those experienced by major manufacturing cities such as Detroit and Pittsburgh over the past three decades. But smaller communities that are less diversified will experience still greater losses. Midland Texas, a city of 145,000 residents, had been relying on both traditional oil and gas extraction as well as more recent shale oil projects to generate about two-thirds of the city's overall economic activity.[9] As a result, Midland and its sister city Odessa boomed when oil prices were rising and the shale oil extraction industry were growing. For example, real earnings for fossil fuel workers in the area rose by an average of 22 percent between 2006 – 2014, due especially to the growth in shale oil extraction.[10] But the area then experienced a loss of about 13,000 jobs in 2015 – 7.5 percent[xi] of the area's overall workforce – when oil prices fell that year.[11] More recently, between January – April 2020, the area experienced nearly 37,000 job losses – over 18 percent of the area's total workforce – as global oil prices fell by over 70 percent. Without an effective transition program, this pattern of sharp decline will persist in this and similarly oil and gas dependent communities.[12]

The situation is, again, still worse for coal-dependent communities. For example, in Boone County, West Virginia, in 2009, 52 percent of all jobs were with the region's coal industry.[13] By 2019, that figure had fallen to 23 percent. In total, the coal industry employed about 3,600 people in Boone County in 2009. That figure fell to 737 as of 2019.[14] In 2019, reflecting this pattern of employment decline, county employees were asked to take 20 percent pay cuts.[15] Again, in the absence of a well-functioning transition program, this pattern will only become more severe in Boone County and similarly coal-dependent communities.

Experiences with Community Transition Projects

The U.S. can advance viable readjustment programs that are capable, at least, of significantly softening the blows to be faced by Midlands, Boone County, and many similarly-situated communities. The fact that U.S. fossil fuel production is so highly concentrated should make the task less difficult to accomplish, since there will be only a relatively small number of heavily impacted communities.

In addition, critically, the decline of the fossil fuel industry will be occurring in conjunction with the rapid expansion of the clean energy economy. This should provide a basic supportive foundation for advancing effective community transition policies, in ways similar to what has already been discussed in terms of providing job opportunities for younger displaced fossil fuel industry workers.

Within this broader clean energy investment program, policies can be designed so that regions and communities that are heavily dependent on fossil fuel industries will receive disproportionate support to advance regionally appropriate clean energy projects. For example, in a 2019 report, the Reclaiming Appalachia Coalition proposed projects in three areas for their region: solid waste, recycling, and sustainable management materials; technology; and recreation and ecotourism.[16]

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xi According to BLS figures, the Midland-Odessa Combined Statistical Area had 173,000 employed persons in January 2015, and 160,000 employed persons in January 2015. The decline of 13,000 is therefore a loss of 7.5 percent.

The Appalachian region could also receive extra support for upgrading the energy efficiency of their building stock and electrical grid transmission system. As another example, Texas and Wyoming could receive support to build wind energy production projects in their respective high-wind areas. One major project area for all fossil fuel dependent regions is, straightforwardly, to reclaim the land that has been damaged through mining and extraction operations.

Previous federal programs can serve as useful models on how to leverage this wave of clean energy investments to also support fossil-fuel dependent communities facing transition. There are both positive and negative lessons on which to build.

Reclamation

Reclamation of abandoned coal mines as well as oil and gas production sites is one major category of community reinvestment that should be pursued as the fossil fuel industry contracts. Moreover, the Federal Government already has extensive experience financing and managing reclamation projects, beginning with the passage of the Abandoned Mine Land (AML) program in 1977, as one part of the broader Surface Mine Control and Reclamation Act. The program has been funded through fees charged to U.S. mining companies, with the fees having been set as a percentage of market prices for coal. In the early years of the program, the fees amounted to about 1.6 percent of the average price of a ton of surface coal and 0.7 percent of underground coal. However, the fee rates have declined sharply over time, to less than half their initial value as of 2013. Since its inception, the program has generated around $9 billion in total fees.

As of the most recent Department of Interior figures, the program had reclaimed over $5.9 billion worth of damaged sites spanning roughly 800,000 acres.[17] But a 2015 study by Dixon and Bilbrey estimates that at least an additional $9.4 billion will be needed to remediate the approximately 6 million acres of land and waters that remain damaged through mining and abandonment.[18] In 2016, the Obama administration had proposed a Power Plus Plan through which $1 billion from the existing pool of AML funds would be disbursed, with about 1/3 of these funds targeted for the Central Appalachian states. These funds would have represented significant support. But this $1 billion budget would still have represented only about 10 percent of the nearly $10 billion Dixon and Bilbrey estimate will be needed to adequately remediate the roughly 6 million acres that remain damaged.

The Obama program was never enacted once Donald Trump assumed the presidency in January 2017. But the reclamation of the abandoned coal mines still needs to be accomplished.[19] Otherwise, the damaged 6 million acres will continue to face severe problems, including, as Dixon and Bilbery write, “landslides, the collapse of exposed highwalls, mine fires, subsidence caused by the deterioration of underground mines, water problems caused by abandoned mine pollution, and more”.[20] Dixon and Bilbery further argue that “these problems continue to markedly impede local economic development and threaten the livelihoods of citizens”.[21]

There are no comparable federal reclamation projects for abandoned oil and gas extraction production sites. However, in June 2020, the U.S. Congress began considering legislation to plug so-called orphaned[xii] oil and gas wells.[22]

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xii To be more precise, the term “orphan well” is an legal term that can be used for regulatory purposes by relevant federal or state-level regulators. Related terms are “marginal,” “inactive” and “idle” wells. Biven (forthcoming 2020) reviews these issues in detail.

Orphaned wells are abandoned oil and gas wells for which no viable responsible party can be located. Idle oil and gas wells emit pollutants into the air, including hydrogen sulfide and organic compounds that contribute to ground-level ozone.

The one-time owners of these wells earn revenues during the wells' productive lives. They then frequently file bankruptcy to shield assets from creditors and then "orphan" the wells. At that point, the costs and responsibility to decommission and plug the wells becomes a matter of public policy intervention.

The policy measure that was introduced into the House of Representatives in June 2020 was included in the $1.5 trillion Moving Forward Act.[23] This bill included $2 billion to support well-plugging programs. But this budgetary figure assumes that there are only about 57,000 orphaned wells around the country and that the average clean-up cost would be $24,000. By contrast, in 2018, the U.S. Environmental Protection Agency estimated the number of orphaned onshore wells to be between 2.3 and 3 million – that is, more than 30 times the number of wells estimated in the House bill.[24] The total number of orphaned wells has been increasing due to the recent global oil price collapse, and will increase further, of course, as the clean energy transition proceeds.[25] Moreover, a recent report on the costs of plugging orphaned wells in Ohio put this figure at $110,000, more than 4 times the amount included in the House bill. In short, plugging orphaned oil and gas wells should be recognized as a major reclamation project. It can also generate thousands of long-term jobs for former oil and gas field workers.

At the same time, while recognizing the imperative of reclamation projects, it is also important to not overstate their potential as an engine of long-run community development. For one thing, beyond the clean-up work itself, even when such projects are substantial, one cannot expect that a broader set of community-based development projects will inevitably emerge as spillover effects tied to the reclamation projects. In addition, reclamation projects are generally highly capital intensive. As such, on their own, they are not likely to produce large numbers of new job opportunities for workers laid off through declining fossil fuel production. It is therefore critical to also examine experiences and prospects for repurposing beyond reclamation in the current fossil fuel-dependent communities.

Repurposing

One important example of a federal government-directed repurposing project was the Worker and Community Transition program that operated through the Department of Energy from 1994 – 2004. Its mission was "to minimize the impacts on workers and communities caused by changing Department of Energy missions." This program, along with related initiatives, was targeted at 13 communities which had been heavily dependent on federal-government operated nuclear power and weapons facilities but subsequently faced retrenchment due to nuclear decommissioning.

The conditions faced by the nuclear power-dependent communities and the aims of the repurposing program for them have useful parallels with the challenges that will be faced by many fossil fuel dependent communities. To begin with, for security reasons, the nuclear facilities were located in rural areas. Most fossil fuel extraction sites are also in rural areas, as determined by the location of the fossil fuel deposits. As a result, in most cases, with both the nuclear weapons facilities and the fossil fuel production sites, the surrounding communities and economies became heavily dependent on these single activities.

Finally, both with the nuclear and fossil fuel-dependent communities, the opportunities are limited to directly repurpose much of the physical infrastructure in place[xiii], since that infrastructure was built to meet the specific needs of each of the industries.[26]

Operating with such constraints, the Worker and Community Transition program provided grants as well as other forms of assistance in order to promote diversification for these 13 nuclear energy-dependent communities and to maintain jobs or create new employment opportunities. The program targeted sites where job losses exceeded 100 workers in a single year. It encouraged voluntary separations, assisted workers in securing new employment, and provided basic benefits for a reasonable transition period. The program also provided local impact assistance and worked with local economic development planners to identify public and private funding and assist in creating new economic activities and replacement employment. Annual appropriations for the program totaled around $200 million in its initial years but became much smaller—in the range of $20 million – in the final years of operation.

Lynch and Kirshenberg, writing in the *Bulletin of the Energy Communities Alliance*, provide a generally favorable assessment of the program.[27] They conclude as follows:

> Surprisingly, the 13 communities, as a general rule have performed a remarkable role in attracting new replacement jobs and in cushioning the impact of the cutbacks at the Energy-weapons complex across the country … The community and worker adjustments to the 1992 – 2000 DOE site cutbacks have been strong and responsive, especially when compared with any other industrial adjustment programs during the same decade..[28]

The experience in Piketon, Ohio provides a good case study of how this program has operated in one community. Piketon had been the home of a plant producing weapons-grade uranium that closed in 2001. The workers in the plant were represented by the Oil Chemical and Atomic Workers union (OCAW) which merged in 1999 with the United Steel Workers. The union leadership was active in planning the plant's repurposing project. The closure could have been economically devastating for the region, but the Federal Government provided funding to clean up the 3,000 acre complex[xiv]. The clean-up operation began in 2002, and is scheduled to take 40 years to complete.[29] Currently 1,900 workers are employed decontaminating the site at a cost of $300-$400 million a year. The contractor hired to clean up the site employs union workers and the president of the USW local union is enthusiastic about the long-term prospects for the project and the site.[30]

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xiii With respect to repurposing the infrastructure around the nuclear sites, Lowrie et al. (1999) write that "much of federal investment leaves behind little usable on-site infrastructure to provide long-term economic benefits to a region. For instance, there are odd-shaped buildings, unusable waste management systems, and roads and railroads with inefficient locations. It is hard to convert resources for arms production to civilian uses because the technologies are significantly different and the workers skills are unique," (pp. 120 – 121).

xiv In May 2016 Congress legislated to maintain funding for the site.

Despite the positive achievements with projects such as Piketon, Lynch and Kirshenberg also note more generally that "The most serious problem facing the energy-impacted communities…was the lack of a basic regional economic development and industrial diversification capacity for most of the regions affected by the cutbacks…" A separate study by Lowrie et al. reaches the same conclusion.[31] They write:

> The community transition efforts thus far are inadequate, and the cleanup funds being distributed to the sites have become a substitute for adjustment to a post-Department of Energy world. Continued dependence on cleanup jobs at the sites rather than transitioning to a non-DOE economy will exact a toll on long-term economic sustainability (p. 121).

To address this problem directly, community assistance initiatives could encourage the formation of new clean energy businesses in the affected areas. One example of a successful diversification program was the repurposing of a nuclear test site in Nevada to what is now a solar proving ground. More than 25 miles of the former nuclear site are now used to demonstrate concentrated solar power technologies and help bring them to commercialization.[32]

Another important set of examples with community transition has been the integration of clean renewable energy sources – primarily wind and solar power – into Alaska's longstanding and extensive energy microgrid infrastructure. A microgrid is a localized power grid. Some are connected to larger traditional power grids, and can disconnect to operate autonomously, though not all have that capacity. Others, like most of the microgrids in Alaska, operate on their own, with no connection to a larger transmission system. More than 200 microgrid systems are operating in Alaska, mostly in the state's geographically remote areas, where it is difficult and expensive to connect to the closest available larger power grid.

Since the 1960s, these grids have been heavily reliant on diesel generators. But since around 2005, renewable energy has become an increasingly significant alternative to diesel fuel. As of 2015, the Alaska Center for Energy and Power described this development as follows:

> Over the past decade, investment in renewable energy generation has increased dramatically to meet a desire for energy independence and reduce the cost of delivered power. Today, more than 70 of Alaska's microgrids, which represent approximately 12 percent of renewably powered microgrids in the world, incorporate grid-scale renewable generation[xv], including small hydro, wind, geothermal, solar and biomass.[33]

The initial motivation for the transition from diesel to renewable energy was cost. Delivering diesel to Alaska's more remote areas can be extremely expensive, up to $1 per kilowatt hour of electricity. With wind and especially solar costs having fallen significantly over the past decade, they are capable of delivering electricity to the microgrids at significant cost savings.[xvi] But more generally, the development of renewable energy-powered microgrids in Alaska provides an innovative model for repurposing former fossil fuel based energy operations.

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xv For more detailed analyses of various aspects of the renewable energy transition in Alaska's microgrids, see the special November 2017 issue of the *Journal of Renewable and Sustainable Energy*, "Technology and Cost Reviews for Renewable Energy in Alaska: Sharing Our Experience and Know-How".

xvi Erin Whitney, the editor of the special issue of the *Journal of Renewable and Sustainable Energy*, writes in her preface that "the driving factor for renewable energy implementation in remote grids in Alaska is the reduction in the cost of energy" (see Whitney (2017)).

Among other features of this energy transition in Alaska is that the publicly-funded Alaska Network for Energy Education and Employment (ANEE) is providing training programs to enable local community residents to manage the renewable-based microgrid operations themselves.[34]

There are also important cases of successful repurposing projects in other countries. Most prominent has been the experience in Germany's Ruhr Valley, which has been the traditional home for its coal, steel and chemical industries. Since the 1990s, the region has advanced industrial policies to develop new clean energy industries.[xvii] As one important example of this repurposing project in the Ruhr region, RAG AG, a German coal-mining firm, is in the process of converting its Prosper-Haniel coal mine into a 200 megawatt pumped-storage hydroelectric reservoir that acts like a giant battery. The capacity is enough to power more than 400,000 homes in North-Rhine Westphalia.[xviii] In addition to hydroelectric power storage, the company is also erecting wind turbines on the top of tall waste heaps and installing solar panels on the slopes. Other firms in the region have branched into producing wind and water turbines. This regional transition project has succeeded through mobilizing the support of the large coal, steel and chemical companies and their suppliers, along with universities, trade unions and government support at all levels.

U.S. Defense Industry Conversion

With respect to the U.S. challenge specifically, it is important to keep in mind that the extent of the overall community displacement that will result through the clean energy transition will be no greater than what the U.S. experienced after the end of the Cold War. Between 1987 and 1996, 1.4 million jobs were lost overall in the defense and aerospace industries, a 40 percent decline.[35] San Diego and Philadelphia both lost around 50,000 jobs over this period[xix], representing declines in both cases of about 6 percent of their respective workforces.[36]

The Federal Government did advance substantial transition programs during this period, in particular through the Defense Reinvestment and Conversion Initiative. The total funding for the program amounted to more than $16.5 billion over the years 1993 to 1997 (i.e., about $4 billion per year). A 1999 study by Powers and Markusen found that these programs were adequate in terms of overall funding levels, at about $12,000 per displaced worker. Still, Powers and Markusen concluded that the program did not succeed in terms of supporting the well-being of the individual workers and their communities. This was because the transition policies were primarily focused on providing support for the defense industry contractors, through promoting mergers and the expansion of foreign weapons markets. The laid off workers often did not find the assistance necessary to make satisfactory job and career changes.

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xvii The general descriptions in this paragraph is based on Galgoczi (2014) and Dohmen and Schmid (2011) (see Bibliography).

xviii See, for example, Chow (2017) (see Bibliography).

xix Employment in Philadelphia in 1987 was 772,300, so employment loss was 6.5 percent Employment in San Diego that year was 851,000, so employment loss was 5.9 percent; BLS, Employment, Hours and Earnings—State and Metro Area, from the Current Employment Statistics, data can be queried via http://www.bls.gov/data/#employment (see "Databases, Tables & Calculators By Subject").

It is not realistic to expect that transitional programs will, in all cases, lead to developing new economic bases that support a region's previous level of population and community income. In some cases, the role of community assistance will be to enable communities, moving forward, to shrink to a size that a new economic base can support. Moreover, the Cold War conversion experience makes clear that mounting a federal transition program, even if it is well-funded, is not a solution in itself. As seen in some cases with repurposing nuclear waste sites and in the experiences in Germany's Ruhr Valley, the central challenge will be to effectively integrate transition programs with the coming wave of public and private investments in energy efficiency and clean renewable energy and the millions of new job opportunities generated by these investments.

3.5 Good Quality and Equal Access for Clean Energy Jobs

What is clear from the evidence we have reviewed is that large-scale job creation will certainly result in all regions of the U.S. economy through clean energy expenditures on both the supply and demand sides of this nationwide project, with budgetary levels in the range of about $500 billion per year on average between 2021 – 2030. But it is also clear that these will not necessarily all be good-quality jobs or that these newly-created jobs will be broadly accessible to all population cohorts within the overall U.S. labor force. As we have seen, average compensation varies widely in the various clean energy activities, from roughly $70,000 - $140,000, depending on the sector. Representation by women and people of color is also generally low, as is union membership.

It is critical that the large-scale expansion of employment opportunities that will result through clean energy investments actively address these concerns, to maximize the extent to which the jobs that are created will be good-quality jobs, and that these newly-created jobs are widely accessible to all population groups. This includes the workers who will have become displaced by the contraction of the U.S. fossil fuel industry. It also includes women and people of color, groups that, as we have seen, are now underrepresented in the main areas of clean energy employment.

To advance these two critical goals – an abundance of good quality jobs in the clean energy economy and wide access to these newly-created jobs – we consider now the role of three major tools for achieving these critical goals (i.e., labor unions, job training programs, and affirmative action policies).

3.5.1 Labor Unions and Labor Standards[xx]

The important role that can be played by unions in supporting high-quality employment in the clean energy economy becomes clear in comparing the respective recent experiences in the solar energy installation sectors in California and Arizona. The California sector operates within a framework of relatively strong unions and labor laws while these are both relatively weak in Arizona. A 2014 study by University of Utah economist Peter Phillips describes how these distinct institutional settings play out within the respective state-level solar installation labor markets. Phillips writes:

> Jobs building utility-scale solar electricity generating facilities are not inevitably good jobs paying decent wages and benefits and providing career training within construction. Under some labor market conditions, many solar farm jobs can be bad jobs paying low wages, with limited benefits or none at all, working for temporary labor agencies with no prospect for training, job rotation, or career development.
>
> In California, this low-road approach to utility-scale solar construction is uncommon for several reasons. First, when any federal funds are involved, the project is governed by federal prevailing wage regulations mandating that, for each occupation on the project, the wage in the local area that prevails for that occupation, based on Davis-Bacon surveys, must be paid.
>
> All states are covered by the federal Davis-Bacon Act, but in some states, such as Arizona, for some construction crafts, nonunion rates prevail in many counties, meaning that prevailing wage jobs can be paid low wages with limited benefits. In California, union strength has meant that in most cases on prevailing wage solar projects, workers will get paid good wages with good benefits. State right-to-work laws play a role in determining union strength. By undercutting union strength, Arizona's right-to-work law plays a role in determining the low-road practices found on some solar farm construction in that state. In contrast, California's resistance to right-to-work regulations reinforces federal Davis-Bacon wage mandates, thereby helping lead California's solar farm work along a high-road approach to construction.

3.5.2 Worker Training

In addition to the support for good clean energy industry jobs provided by unions and labor standards, it will also be critical that workers have access to high-quality training programs that will enable them to enter their new jobs with the skills they need to succeed. Without high-quality and accessible training opportunities, the likelihood increases that labor force quality standards will become compromised. The importance of providing high-quality training programs for workers entering the clean energy economy are reflected in a 2018 survey conducted jointly by the National Association of State Energy Officials (NASEO) and the Energy Futures Initiative (EFI), in which, among other questions, employers in clean energy sectors were asked whether they faced difficulties in hiring new workers. This survey found that a high proportion of clean energy employers are facing significant challenges in finding qualified people to hire.

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xx In our discussion, the term "union" refers only to the traditional definition of unions, i.e., an organization that has been certified under the provisions of the National Labor Relations Act to represent employees. For example, the Current Population Survey which provides the micro-data on job characteristics in this section, only asks about formal union membership. However, other labor organizations such as worker centers and worker collectives could also serve the same purpose as traditional unions. Worker centers frequently represent low-wage and immigrant workers and aim to achieve similar objectives as traditional unions—they are institutions through which workers and their communities can advocate collectively for their interests. For examples of such organizations, see: https://aflcio.org/what-unions-do/social-economic-justice/worker-centers, and https://www.epi.org/publication/bp159/.

We present the main results of this survey in Tables 3.21 and 3.22. We show the survey results in the three largest areas of clean energy employment to date in the U.S. – i.e., energy efficiency, in which 2018 employment was at 2.3 million; solar electricity, with 242,343 people employed; and wind electricity, with 111,166 people employed. We present figures for each clean energy sector broken out according to sub-sectors, including construction; professional/business services; manufacturing; wholesale trade, distribution and transport; utilities; and other services.

Table 3.21 Firms that Reported Hiring Difficulties in Solar, Wind, and Energy Efficiency Sectors

3.21A) Energy Efficiency; 2018 Employment = 2.3 million

		Firms Reporting Hiring Difficulties		
	2018 Employment Level	**Somewhat difficult**	**Very Difficult**	**All firms reporting difficulties**
Construction	1.30 million	32%	52%	84%
Professional/business services	484,481	21%	61%	82%
Manufacturing	321,581	14%	58%	72%
Wholesale trade, distribution, transport	180,339	24%	48%	72%
Other Services	42,881	40%	36%	76%

Source: *The 2019 U.S. Energy & Employment Report*, https://www.usenergyjobs.org/

3.21B) Solar Electric Power; 2018 Employment 242,343

		Firms Reporting Hiring Difficulties		
	2018 Employment Level	**Somewhat difficult**	**Very Difficult**	**All firms reporting difficulties**
Construction	177,320	54%	31%	85%
Professional/business Services	48,142	57%	16%	73%
Manufacturing	46,539	60%	18%	78%
Other services	32,937	54%	23%	77%
Wholesale trade, distribution, transport	26,759	73%	6%	79%
Utilities	3,295	31%	31%	62%

Source: The 2019 U.S. Energy & Employment Report, https://www.usenergyjobs.org/

3.21C) Wind Electric Power; 2018 Employment 111,166

		Firms Reporting Hiring Difficulties		
	2018 Employment Level	**Somewhat difficult**	**Very Difficult**	**All firms reporting difficulties**
Construction	36,706	58%	28%	86%
Professional/business services	27,058	66%	15%	81%
Manufacturing	26,490	53%	26%	79%
Wholesale trade, distribution, transport	11,783	77%	8%	85%
Utilities	6,231	50%	33%	83%
Other services	2,898	40%	33%	73%

Source: *The 2019 U.S. Energy & Employment Report*, https://www.usenergyjobs.org/

Table 3.22 Summary Figures: All Firms Reporting Hiring Difficulties in Energy Efficiency, Solar Electricity and Wind Electricity Sectors

	Energy Efficiency	**Solar Electricity**	**Wind Electricity**
Construction	84%	85%	86%
Professional/business services	82%	73%	81%
Manufacturing	72%	78%	79%
Wholesale trade, distribution, transport	72%	77%	85%
Utilities	---	79%	83%
Other services	76%	62%	73%

Source: *The 2019 U.S. Energy & Employment Report*, https://www.usenergyjobs.org/

In the energy efficiency sector, the largest source of employment by far is in construction, with 1.3 million out of the total employment of 2.3 million (i.e., 56 percent of total energy efficiency investment). As seen in Table 3.21A that fully 84 percent of employers reported difficulties in hiring workers, with 52 percent finding it “very difficult” to hire qualified workers.

The results are only moderately lower in the other sub-sectors within energy efficiency. Thus, manufacturing firms reported the lowest level of hiring difficulties, at 72 percent. We see in Tables 3.21 B and C, as well as in the summary Table 3.24, these patterns are similar in the solar and wind electricity sectors and sub-sectors as well.

The survey further found that “lack of experience, training or technical skills” was the most important reason that employers were facing difficulties in hiring workers. The other, less significant factors were location and a relatively small applicant pool.

The study's conclusion from these survey results is that "The need for technical training and certifications was also frequently cited, implying the need for expanded investments in workforce training and closer coordination between employers and the workforce training system".[37]

It is clear therefore that high-quality and accessible workforce training programs need to be included as an important component of the overall clean energy investment project in the U.S. Some crucial features of what would constitute such programs have been well described in recent research by Ellen Scully-Russ.[38]

Scully-Russ provides case study evidence on two successful clean energy training programs that operated in Vermont and Oregon respectively. The two programs were the Vermont Growing Renewable Energy/Efficiency Employment Network (Vermont GREEN) and Renewable Northwest (ReNW). Both programs received grants in 2010 of approximately $5 million from the U.S. Department of Labor to develop innovative training programs to support the development of green enterprises as well as raise job quality standards more generally in their respective regions. Paraphrasing Scully-Russ, the main features of these two program were as follows:

Vermont GREEN

Vermont GREEN supported the extensive, state-sponsored weatherization program. Homeowners living in low-income neighborhoods could apply for state funds to weatherize their homes. In turn, the state required homeowners to hire local contractors, who themselves had to hire local residents to perform this weatherization work. The state paid for the training and certification, while Vermont GREEN recruited the trainees and provided wraparound support services to ensure trainees succeed in the program and are placed in weatherization jobs.

Vermont GREEN worked with a network of community action agencies to offer extensive career counseling. Counselors help residents assess their interests and training needs, access relevant federal- and state-funded green training programs, and secure a job.

Vermont GREEN offered customized training services to meet the specific needs of green regional employers and union apprenticeship programs. Vermont GREEN paid for a portion of this training and leveraged this investment to help employers tap other public and private resources to pay for training. All customized training was required to result in an industry-recognized certificate. Vermont GREEN also worked to integrate a wide variety of resources to deliver workforce development programs throughout the state. The aim here was to help ensure that the effort was sustained beyond the grant period.

ReNW

ReNW also developed a three-pronged strategy, including the following:

Economic development strategy. To cultivate new markets in the renewable electricity industry for the area's small and mid-sized manufacturers, ReNW worked with providers to determine their needs for equipment and component parts, build a local supply chain, and upgrade the manufacturing workforce and production system.

Workforce development strategy. ReNW engaged regional Workforce Investment Boards (WIB) to recruit workers and refer them to jobs and/or training and certification programs. Area education providers provide the training either through degree-granting programs or customized training offered to individual employers.

Job placement strategy. ReNW counselors worked with green employers to place workers in green jobs. At least 13 employers in the ReNW network agreed to provide workers referred by ReNW counselors first consideration for all open positions.

In Scully-Russ's overall assessment, these two programs were both broadly successful in providing good-quality training experiences for both newly-hired workers as well as incumbent employees who needed to acquire new skills. However, she found that these programs were only partially successful in establishing that the clean energy sector jobs were consistently good-quality jobs (i.e., full-time positions at decent pay and benefits). She also found that while these programs did exert a positive impact on general labor market conditions in their respective regions, this impact overall was limited.

Scully-Russ concludes the case study with a more general set of "lessons learned" and "challenges/barriers." These include the following:

Lessons Learned

- Policy leaders and workforce practitioners can raise equity standards generally through leveraging public investments to move green employers to adopt a work system based on high quality and skill standards.
- Policy leaders and workforce practitioners can leverage public investments in the green economy to also enhance new workforce and certificate programs, both for the green economy specifically and more generally.
- Responsive and effective economic and workforce development strategies in the green sector must emerge from within local relationships and conditions.

Challenges/Barriers

- Local programs need to work effectively among each other, and within the specific context of existing labor market institutions.

New incentives and regulation requiring public agencies to work together in servicing industries, like the green sector, targeted for economic development may be required if the investments are to result in improvements to the public system.

- Traditional workforce planning, development strategies, and methods are ineffective in responding to the needs of emerging sectors and occupations and therefore thwart their development.

Workforce development plans that drive the preparation of the workforce are often based on analysis of a small number of supply and demand variables that do not account for the dynamic changes taking place in new and emerging industries. In addition, the conventional process is linear, sequential, and protracted; employers hand off an analysis of needs to educators who are then expected to respond with education and training to prepare the workforce.

In the cases of Vermont GREEN and ReNW, the parties departed from these conventions by accounting for more factors in the program development process and engaging in a highly interactive planning process. However, participants still expressed reservations that training investments were premature, jobs were not yet solidified, and needs were not well understood. It was broadly understood that that workforce development in this context was risky because there was little certainty that training would match the jobs as they emerged and that jobs would be there to employ trainees. New methods to synchronize the supply and demand in the labor market and to anticipate future needs in an ambiguous and uncertain context are therefore required.

How Much to Spend on Worker Training?

It is critical to consider the overall level of spending that needs to be committed to clean economy training programs throughout the U.S. Of course, these overall budgetary issues are complementary to the critical issues highlighted by Scully-Russ with respect to the design of individual programs and their local and regional impacts.

The U.S. government has recently operated an economy-wide clean energy job training program. This was the Energy Efficiency and Renewable Energy Training Program, which was initially one component of the 2007 Energy Independence and Security Act. The program was then funded as part of the 2009 American Recovery and Reinvestment Act – the Obama stimulus program. Over 2009 – 13, the funding allocated specifically for job training programs averaged $75 million per year.

The program supported the following: national training grants that were geographically distributed; state training grants; demonstration grants that prioritized for low-income population, termed the 'pathways out of poverty' demonstration program; and research on training needs and labor markets. The specific types of training programs included in this measure were: occupational skills training; safety and health training; basic skills and job readiness training; college training programs; internship programs; apprenticeship programs and skill upgrading and retraining. The funding allocations included at least 60 percent for the various training programs themselves, 20 percent for the 'pathways out of poverty' measures, and no more than 20 percent for labor market research.

Assessments of this program were mixed. A 2012 report from the U.S. Department of Labor[xxi] found that the program had been only partially successful in placing workers into jobs in clean energy sectors.[39] A 2013 study by an outside consulting group, IMPAQ International, reported that, according to the majority of program administrators, funding to support the programs was not available for a sufficiently long time to have been effective.[xxii] Two more recent studies, by Mundaca and Richter (2015) and Hughes (2018) respectively, supported the basic findings by the Department of Labor and IMPAQ International.[40]

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xxi The DOL study found, in particular, that "the impact of the Recovery Act Green Jobs training program has been limited in terms of reported employment outcomes…entered employment and retention results are far lower than planned" (p. 29; see BPA and SPRA (1994)).

xxii See also Bradley, Congressional Research Service (2013) and U.S. Government Accountability Office (2013) (both in the Bibliography), which were also mixed in their assessments.

It is clear that worker training programs do need to be revived at a major scale, in order to operate at a quality level sufficient to both support the clean energy investment agenda and to expand opportunities for workers to move into these new employment areas. Given that we are proposing that annual clean energy investments expand roughly 10-fold relative to the levels of 2010 – from around $50 billion to $500 billion per year – it would suggest, at least as an initial reference point, that worker training programs increase equivalently. This would imply an annual budget for worker training in the range of $750 million per year. More generally, it would imply a spending level at roughly 1.25 percent of overall annual clean energy investment spending in the U.S.

In practice, there is likely to be overlap between worker training programs and the separate programs tied to both community and worker adjustment. Nevertheless, for the purpose of not underestimating costs of important programs aimed at assisting workers and communities, we assume that the budget for clean energy worker training programs should be treated as distinct from and in addition to those for both community and workers adjustment.

Affirmative Action

As described above, women and people and communities of color are currently underrepresented in the range of job areas that make up the emerging U.S. clean energy economy. The composition of the current U.S. clean energy workforce is, first, predominantly male within all racial categories. But male non-whites still have far fewer positions in the sectors where the job quality is relatively high, such as Transmission and Storage.

This current imbalance of job opportunities for women and communities of color is driven, in particular, by the long-standing pattern of gender and racial discrimination in the U.S. construction industry. Currently, women make up only 3.5 percent of construction workers, even while women represent 47 percent of all employed workers. Similarly, Black workers make up 13 percent of all employed workers throughout the U.S. economy, but hold only eight percent of construction industry jobs.[xxiii] This is especially significant because a disproportionate share of overall employment creation through both energy supply and demand expenditures will be in construction. For example, construction employment accounts for 28 percent of the jobs created in the primary areas of clean renewable supply investments, including solar and wind energy; and 22 percent in the additional non-fossil fuel investment areas (i.e., nuclear, biomass and carbon sequestration).

To achieve an equitable representation of women and communities of color in the newly created clean energy economy jobs, it will be necessary to implement employment policies that both prohibit discriminatory behavior and require employers to develop positive affirmative action plans, especially in the construction industry. One of the most prominent examples of affirmative action policies is set out in federal policy through Executive Order 11246. EO11246 requires employers with large federal contracts or employers who receive significant federal assistance to work toward employment equity (i.e., "employment utilization goals") with regard to nonwhite and women workers. These requirements typically entail employers providing written affirmative action plans. The equity standards generally aim for employment shares for women and non-whites that reflect their overall shares within the given local labor market.[xxiv]

xxiii Authors' analysis of Current Population Survey basic monthly microdata, 2019.

xxiv The construction industry has proved to be a particularly challenging sector with respect to diversifying their workforce. EO11246 regulations has responded to this challenge by modifying the requirements for the construction industry. EO11246 sets a low utilization goal of 6.9 percent for women and federal construction

Employers who fail to meet these equity standards risk cancelation of their contracts, disqualification from bidding on future federal contracts, as well as legal action by the Equal Employment Opportunity Commission (EEOC).

The relevant research literature finds that this type of federal affirmative action policies has been effective, in particular, in raising employment opportunities for Black men. The evidence is more mixed for women.[xxv] Two factors have been critical in achieving successful results with these programs: (1) a high level of enforcement activity by the Office of Federal Contract Compliance Program (OFCCP); and (2) an expansion of job opportunities in the relevant labor market segments. In other words, not surprisingly, affirmative action policies are more successful: (1) when they are being effectively enforced; and (2) when employers are able to diversify their workforces through adding women and people of color as opposed to having these underrepresented groups replace existing cohorts of white male workers.[xxvi]

The experience with the Obama Administration's implementation of its 2009 economic stimulus program, aiming to counteract the 2007 – 2009 Great Recession, is instructive. The infrastructure spending program within the broader policy initiative – the American Recovery and Reinvestment Act – included a large expansion of federally-supported construction contracts. To ensure compliance by employers with the federal affirmative action standards, the Obama Administration expanded the budget and staffing for affirmative action enforcement at the Office of Federal Contract Compliance and increased the agency's focus on the construction industry. This combination of policy initiatives did achieve a measurable improvement in the diversity of the construction industry workforce.[41]

3.6 Building Support for Clean Energy Transition Through Narratives, Education and Community Engagement

To successfully advance a transition to a net-zero emissions economy over the next 30 years, it will be critical that this project be widespread and have deep support throughout U.S. society. At present, the level of support does already appear strong – a November 2019 Pew Research poll reported that 67 percent of U.S. adults think that the Federal Government is doing "too little to reduce the effects of global climate change," and 77 percent think that "developing alternative energy" is a more important priority than "expanding fossil fuels". In addition, 89 percent of adults "say that they make an effort to live in ways that protect the environment," though only 25 percent report that they do so "all of the time".[42]

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contractors are not required to produce written affirmative action plans but instead to make good faith efforts, as defined by the OFCCP, the agency that monitors contractor compliance.

xxv See for example Leonard (1984a) and (1984b); and Rodgers and Spriggs (1996) (in Bibliography).

xxvi To further strengthen such affirmative action initiatives, in particular in behalf of female workers, one specific initiative would be to increase support for the U.S. Department of Labor's Women in Apprenticeship and Non-Traditional Occupations program (WANTO; see: https://www.dol.gov/agencies/wb/grants/wanto-grants). This grant program funds organizations that 1) offer women pre-apprenticeship and training programs for the skills they need to succeed in occupations in which women are presently underrepresented; 2) provide training for employers, unions and workers in how to remove workplace barriers that cause women to leave such occupations; and 3) provide wrap-around support services such as mentoring services and childcare support.

Despite this widespread support, it remains the case that to date, far too little has been accomplished in terms of moving the U.S. economy onto a viable climate stabilization path. It is therefore imperative to strengthen the extent of support around a transformative climate stabilization agenda. This will entail creating effective narratives as to how the clean energy transition can proceed and communicating these narratives widely.

Toward this end, it is critical that the perspectives of a wide range of people, at all levels of society, be transmitted widely. Individual stories can help people to understand the problem and provide inspiration in terms of solutions and best practices. The organization Our Climate Voices is one important resource that brings together the perspectives of people throughout the society. Our Climate Voices describes its work as follows:

> Our mission is to humanize the climate disaster through storytelling, contribute to a shift in the climate change dialogue that puts the voices of those most impacted at the forefront of the conversation, and to connect people with ways to support the community-based climate solution-making work that frontline and vulnerable communities are already doing to combat climate change impacts.
>
> We believe that storytelling is an underutilized and vital tool in the fight for climate justice. First-hand narratives connect with people on an emotional level and raise the issue of climate change in people's hearts and minds. Stories are more memorable than facts and figures.
>
> We believe in the importance of listening to and learning from one another. Our Climate Voices storytellers provide a window into the daily ways that climate change affects us all. This global disaster is urgent and each of our communities is impacted. Our storytellers have insight and wisdom into how to envision a more equitable and sustainable world. Effective climate justice work strengthens not only environmental health, but also human livelihood.[43]

One dimension of the storytelling challenge is to strike the most effective balance between hope and fear. In recent years, both climate change activists and climate change deniers have often told stories that have been dominated by fear. Activists have focused on the threat of global ecological catastrophe, while deniers warn that America could 'return to the Stone Age' if radical environmentalists succeed in implementing their agenda. Unfortunately, as neuroscientists have shown[xxvii], intense threat perceptions impair humans' capacity for cognition, creativity, and collaboration – all of which are urgently needed to address this complex challenge.[44] Stories that conjure images of overwhelming threats – whether to the global environment or the U.S. economy – tend to polarize and paralyze their audiences. Conversely, unrealistically optimistic stories about the prospects for rapid decarbonization may result in disillusionment or cynicism if these promises cannot be met. Vivid narratives are essential for catalyzing effective action, but these narratives must be rooted in a realistic appraisal of the technological, economic, and political possibilities.[xxviii]

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xxvii See, for example, Landau-Wells and Saxe (2020).

xxviii This paragraph follows closely and quotes directly from a 7/3/20 private correspondence between Robert Pollin and Professor Mark Levinger of George Washington University.

Three organizations in Alaska provide effective case studies of how to offer education and support that will help individual people and communities to become engaged with the clean energy transformation project. Alaska Heat Smart focuses specifically on providing information and consulting services to help homeowners purchase heat pumps and install them in their homes.[45] They work especially in support of low-income families, informing homeowners that they can save between 40 – 70 percent over oil or electric heat through installing a heat pump, while also reducing the household's carbon footprint. At a very practical level, Alaska Heat Smart assists families in obtaining bids from contractors and in identifying financing options for heat pump installations. Renewable Juneau often works in conjunction with Heat Smart Alaska on converting homes to efficient heat pumps.[46] It also provides educational materials and support in making electric vehicle purchases. Renewable Juneau is also active more broadly in supporting policies that advance renewable energy in their region. The Renewable Energy Alaska Project operates a range of educational projects throughout the state.[47] These include the Alaska Network for Energy Education and Employment, which aims to support individual Alaskans in finding high-quality clean energy learning, training, and job opportunities. They also advocate in support of developing "green bank" funding programs that will lower the risks and costs of financing clean energy investments in the state.

At the level of individual and household behavior, the work of David Finnegan in creating Green Actioneers provides another valuable case study for advancing new modes of thinking in behalf of the clean energy transition project. In his Green Actioneers Workbook and website, Finnegan specifies 100 practical actions that families and individuals can take to "go green," starting with an energy audit for their homes. Finnegan writes that the book and website provide:

> Guidelines to improve the quality of the soil in their yards and throughout their communities, to improve the quality of their water and air, to attract beneficial insects not kill them with pesticides, to use much less electricity and water, to use EnergyStar appliances, to grow their own food in rooftop and porch gardens as well as their yards using natural fertilizers, to filter their own water, to take public transportation or drive electric, to install solar arrays backed up by wind energy RECs, to compost, to use natural cleansers and dispose of chemicals wisely, to reduce their use of plastic and shift from plastic to glass for food storage, and from paper to cloth for clean-ups, to seal their building "envelope" to reuse their own belongings, to repurpose fabric and recycle or reuse everything they can, to shop in thrift stores, to plant trees, to eat less meat, to avoid fast food and bring their lunch from home, to avoid flying and work from home if possible, among over 100 "Green Actions."

Finnegan also writes that his list of Green Actions will grow through communications he will develop with consumers.[xxix]

xxix The quotes from Finnegan and the overall description of his project are taken from private correspondence on 3/9/20 and 4/3/20 with Robert Pollin.

In addition to the critical interventions at the level of individual narratives, educational projects and highly practical support programs, it is equally important to be able to project a credible macro-level narrative capable of bringing together these micro-level initiatives. By way of summary, the macro-level narrative that animates this chapter on Equitable and Just Transition, as well as the Zero Carbon Action Plan more generally, includes the following themes:

- Driving U.S. and global CO_2 emissions to net-zero by 2050 is an ecological imperative.
- Undertaking the myriad of investments that can create a clean energy economy should create large scale expansion of job opportunities as well as new business opportunities.
- If managed effectively, building a clean energy economy will not entail increased costs for consumers. This is because, on average, the costs of delivering energy through clean renewable sources is already at cost parity with fossil fuels, and those costs are on a long-term downward trajectory. Moreover, by definition, raising efficiency standards in buildings, transportation systems and industrial machinery will entail energy savings and lower energy costs.
- Building a clean energy economy can serve as a framework for advancing greater social equality.
- Creating a clean energy economy will create losers. As we have focused in this chapter, this includes workers and communities whose livelihoods are presently dependent on the fossil fuel-based economy. Providing a just transition for these workers and communities must be a central focus of the overall clean energy transition project.
- The other major group that will be losers in the clean energy transition are, of course, the companies, public and private, which now own and manage the world's fossil fuel energy assets. This chapter has not focused on a transition program for the fossil fuel companies and their owners.[xxx] The broad point is nevertheless clear enough: the fossil fuel industry will have to experience near-total demise over the next three decades. There is no choice in the matter if we take seriously, as we must, the research produced by climate scientists.

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xxx See, for example, Pollin (2015) (in Bibliography).

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