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THE ECONOMICS OF JUST TRANSITION: A FRAMEWORK FOR SUPPORTING FOSSIL FUEL-DEPENDENT WORKERS AND COMMUNITIES IN THE UNITED STATES

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ABSTRACT: *We develop a Just Transition framework for U.S. workers and communities that are currently dependent on domestic fossil fuel production. Our rough high-end estimate for such a program is a relatively modest $600 million per year. This level of funding would pay for 1) income, retraining and relocation support for workers facing retrenchments; 2) guaranteeing the pensions for workers in the affected industries; and 3) mounting effective transition programs for what are now fossil-fuel dependent communities. The paper first summarizes the evidence on how much the U.S. fossil fuel industry will need to contract to achieve CO_2 emissions reduction targets consistent with the global targets established by the Intergovernmental Panel on Climate Change (IPCC). We then consider the impact of fossil fuel cutbacks on five ancillary U.S. industries, including support activities for coal and oil/gas as well as oil refining, electric power generation, and natural gas distribution. Section 3 presents estimates on job cuts that will occur in the fossil fuel and ancillary industries due to U.S. fossil fuel production cutbacks. Combining all fossil fuel and ancillary industries, we show that fully 83 percent of the job losses can be covered through attrition-by-retirement. To address the remaining 17 percent of job losses through fossil fuel industry cutbacks, we propose reemployment guarantees in the growing clean energy industries for displaced workers. As part of this job guarantee program, we estimate the costs of three provisions for the displaced workers: 100 percent compensation insurance for five years; retraining; and relocation support. Section 4 reviews the status of pension programs in the fossil fuel and ancillary industries and propose measures to maintain these pension programs at full funding into the future. Section 5 examines measures to support communities that are presently heavily dependent on the U.S. fossil fuel industry. The concluding section 6 brings together our cost estimates for the three components of our Just Transition program.*

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1. INTRODUCTION

The December 2015 Climate Summit in Paris established an official global consensus as to the imperative of controlling climate change. What was not achieved at the conference was an agreed-upon action agenda that is capable of accomplishing this end.[1] Nevertheless, in broad terms, there is little ambiguity as to what are the two most important actions needed for stabilizing the climate. First, the world must dramatically cut its reliance on oil, coal and natural gas to produce energy. This is because carbon dioxide (CO_2) emissions generated through burning fossil fuels, as well as methane and nitrous oxide emissions generated in producing fossil fuel energy, are responsible for about 75 percent of all greenhouse gas emissions that are causing climate change.[2] Second, as the alternative to fossil fuel consumption, again on a global scale, we must massively expand investments in energy efficiency and clean renewable energy sources--solar, wind, geothermal, low-emissions bioenergy, and small-scale hydro power.

Both parts of this climate stabilization program will produce large-scale impacts on the employment opportunities for working people as well as the communities in which they live. The investments in efficiency and clean renewables will generate millions of new jobs. But workers and communities whose livelihoods depend on the fossil fuel industry will unavoidably experience losses in the clean energy transition. Unless strong policies are advanced to support these workers, they will face layoffs, falling incomes, and declining public-sector budgets to support schools, health clinics, and public safety. This in turn will increase political resistance to any effective climate stabilization program.

It follows that the global climate stabilization project must unequivocally commit to providing generous transitional support for workers and communities that are currently dependent on the fossil fuel industry. The late U.S. labor leader and environmental visionary Tony Mazzocchi pioneered thinking on what is now termed a "Just Transition" for these workers and communities. As Mazzocchi wrote as early as 1993: "Paying people to make the transition from one kind of economy to another is not welfare. Those who work with toxic materials on a daily basis…in order to provide the world with the energy and the materials it needs deserve a helping hand to make a new start in life."[3]

We develop here a basic Just Transition framework for U.S. workers and the communities in which they live. Our rough high-end estimate for such a program is a relatively modest $600 million per year. This equals 1.2 percent of the roughly $50 billion per year in new

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[1] See, e.g., Watson et al. (2016), *The Truth about Climate Change*. The authors state that current pledges under the Paris agreement are "far from sufficient to put the world on a pathway to meet the 2°C target,"—i.e. to stabilize the global mean temperature at 2°C above pre-industrial levels. According to Watson et al. and a broad range of other climate scientists, this 2°C target is itself considered to be only a minimally acceptable goal for accomplishing climate stabilization.

[2] http://wdi.worldbank.org/table/3.9

[3] Mazzocchi (1993). For a valuable more recent examination of the Just Transition concept, see the 2016 joint propect of the Labor Network for Sustainability and Strategic Practice Grassroots Policy Project. This study reviews the history of the term, the contributions by Mazzocchi and others, and also reviews current discussions on how to convert the concept into viable policies.

public investment that will be needed to advance a successful overall U.S. climate stabilization program. As we show, this level of funding would pay for 1) income, retraining and relocation support for workers facing retrenchments; 2) guaranteeing the pensions for workers in the affected industries; and 3) mounting effective transition programs for what are now fossil-fuel dependent communities.

One reason that the costs for this program can be kept relatively modest is precisely because the fossil fuel industry cutbacks will be occurring in conjunction with the growth of the clean energy industry—i.e. large-scale investments in energy efficiency and clean renewable energy production. This is critical because, among other factors, within the U.S. economy, the number of jobs generated by clean energy investments will be much larger than the jobs that will be lost through fossil fuel industry retrenchments. Specifically, spending $1 million on clean energy investments generates about 17 jobs across all sectors of the U.S. economy, while spending the same $1 million on maintaining the existing fossil fuel infrastructure produces only about 5 jobs.[4] Clean energy investments will produce more jobs for electricians, roofers, steel workers, machinists, engineers, truck drivers, research scientists, lawyers, accountants, and administrative assistants. If the overall level of clean energy investments proceeds at around $200 billion per year—around 1.1 percent of current U.S. GDP, with $150 billion in private investments supported by $50 billion in public funds—this will generate about 2.7 million more jobs than if the same $200 billion were spent annually within the fossil fuel industry. This level of annual U.S. investments to raise energy efficiency standards and to raise the supply of clean renewable energy to substitute for fossil fuels should allow U.S. CO_2 emissions to fall by 40 percent within 20 years.[5]

While this paper advances a specific Just Transition program for the workers dependent on the U.S. fossil fuel industry, we should also underscore, at the outset, a broader point: that the single best form of protection for displaced workers in all industries is an economy that operates at full employment. A full employment economy is one in which there is an abundance of decent jobs available for all people seeking work. In a full employment economy, the challenges faced by displaced workers—regardless of the reasons for their having become displaced—are greatly diminished simply because they should be able to find another decent job without excessive difficulties. It also follows that, in a full employment economy, the costs to taxpayers of providing reasonable levels of financial support for displaced workers would be greatly diminished. Overall then, a commitment to full employment should be understood as fully consistent with and supportive of the project of building a clean energy economy.[6]

In considering the broader social context for a Just Transition program, we need to also recognize the major gender and ethnic disparities that will occur both as the fossil fuel industry contracts and the Just Transition program advances. The basic point is straightforward: U.S. fossil fuel industry employment is, at present, dominated by white males. Thus, as of 2015,

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[4] See Pollin et al. (2014), pp. 225-34.

[5] Pollin (2015) develops a comparable plan for the global economy, focused around investing between 1.5 – 2 percent of global GDP per year over 20 years in energy efficiency and clean renewables. This global plan is capable reduced global emissions by 40 percent within 20 years.

[6] See Pollin (2012) for further perspectives on full employment policies.

women account for only 5.2 percent of overall employment in the coal industry, 18.3 percent in oil and gas extraction, and 13.2 percent in all mining support activities. African-Americans accounted for only 1.5 percent of employment in coal, 3.5 percent in oil and gas, and 6.1 percent in support activities. This means that white men will be disproportionately hurt as the fossil fuel industry contracts but should also disproportionately benefit through a Just Transition program. It is also true that a disproportionate share of jobs in the clean energy industries will be created within the traditionally male-dominated manufacturing and construction industries. [7] The most effective way to reverse such gender and ethnic disparities is to support affirmative action within the growing clean energy sectors. Such measures will be facilitated by the fact that the growing clean energy economy will generate an abundance of overall job opportunities—more than enough to provide reemployment for displaced fossil fuel industry dependent workers, who will be mostly white males, as well as large numbers of new opportunities for both women and minority workers.

The paper proceeds as follows. In section 2, we briefly summarize the evidence on how much the U.S. fossil fuel industry will need to contract to achieve CO_2 emissions reduction targets consistent with the global targets established by the Intergovernmental Panel on Climate Change (IPCC). We then also consider the impact of fossil fuel cutbacks on five ancillary U.S. industries, including support activities for both coal and oil/gas as well as oil refining, electric power generation, and natural gas distribution. In considering the employment impacts in these five ancillary industries, we focus on the extent to which these industries are dependent on U.S. fossil fuel production relative to their other supply-chain linkages.

In section 3, we present estimates on job cuts that will occur in the fossil fuel and ancillary industries due to U.S. fossil fuel production cutbacks. We then estimate, on an industry-by-industry basis, the extent to which these job losses can be covered through attrition when currently employed workers reach retirement at age 65. Combining all fossil fuel and ancillary industries, we show that fully 83 percent of the job losses can be covered through attrition-by-retirement. To address the remaining 17 percent of job losses through fossil fuel industry cutbacks, we propose reemployment guarantees in the growing clean energy industries for displaced workers. As part of this job guarantee program, we estimate the costs of three provisions for the displaced workers: 100 percent compensation insurance for five years; retraining; and relocation support.

Given that our Just Transition program will rely heavily on workforce attrition through retirements at age 65, it follows that the pensions earned by these workers must be fully secured. Thus, in section 4, we review the status of pension programs in the fossil fuel and ancillary industries. We also propose measures to maintain these pension programs at full funding into the future.

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[7] Source for 2015 employment proportions is: http://www.bls.gov/cps/cpsaat18.htm. The broader set of employment opportunities through clean energy investments is presented in Pollin et al. (2014), p. 225 – 29.

In section 5, we examine measures to support communities that are presently heavily dependent on the U.S. fossil fuel industry, such as in Appalachia and Texas. These communities will face formidable challenges adapting to the fossil fuel industry's decline, even if all affected workers are themselves covered either through retirement with secure pensions or guaranteed reemployment. We therefore propose that new clean energy investment projects be located disproportionately into these distressed areas. We also discuss previous experiences with community redevelopment and transition programs in both the U.S and Germany.

In the concluding section 6, we bring together our cost estimates for the three components of our Just Transition program. This includes: 1) $300 million per year for reemployment and support for displaced workers; 2) $90 million per year to bring currently distressed pension fund programs to full funding; and 3) $200 million per year for community transition support. In total, this amounts to about $600 million per year, or $12 billion over the 20-year transition period.

In developing this Just Transition program and cost estimates, we of course draw upon and cite a range of previous research studies and policy proposals. In broad outline, our proposals have significant commonalities with those advanced by the Obama administration's "Power Plus" program, as well as by the 2016 presidential campaigns of both Bernie Sanders and Hillary Clinton. However, our cost estimates are less than half the $30 billion proposed by the Clinton campaign and less than one-third the $41 billion proposal by the Sanders campaign. To our knowledge, this is the first research study on Just Transition for the U.S. which delves into specifics on both policy proposals and costs in the three critical areas on which we have concentrated, i.e. jobs, pensions and community transition.

2. FOSSIL FUELS AND ANCILLARY INDUSTRY CONTRACTIONS

Cutbacks in Coal, Oil, and Natural Gas

The IPCC provides conservative benchmarks on the extent of CO_2 emissions reductions to stabilize the average global temperature at no more than 3.6^0 Fahrenheit (2^0 Celsius) above the pre-industrial average. A fair summary of their assessment is that global CO_2 emissions need to fall by 40 percent by 2035 and by 80 percent as of 2050.[8]

For the present discussion we assume that that U.S. emissions will need to decline at this average global rate. We focus on the on the 20-year goal of a 40 percent decline. To accomplish this goal will require across-the-board cuts in both production and consumption in all domestic fossil fuel sectors. But cuts will need to be greater for coal. Per unit of energy produced, emissions from burning coal are about 40 percent higher than those for oil and 50 percent higher than natural gas. In addition, certainly over the next 20 years, it will be more difficult to find substitutes for oil as a liquid fuel in transportation than for coal as a generator of

[8] See Robert Pollin memo, "Approximation of Emissions Reduction Requirements as Presented by Intergovermental Panel on Climate Change (IPCC) *Fourth and Fifth Assessment Reports*," (6/1/16).

electricity. Given these considerations, we proceed with the assumption that, by 2035, U.S. coal consumption will need to fall by 60 percent, while the cuts will need to be around 40 percent for oil and natural gas. This amounts to average annual rates of contraction of 4.5 percent for coal and 2.5 percent for oil and gas.[9]

Other major differences between coal versus oil and gas are also important for our purposes—in particular, the fact that the U.S. coal industry has already experienced a sharp decline in profitability over the past decade. The rise of environmental regulations has been only one factor here. Competition from low-cost natural gas, generated through fracking technology, has also caused major losses. The combined impact has been devastating. *Bloomberg News* reported in early 2016 that "Coal producers are suffering through a historic rout. Over the past five years, the industry has lost 94 percent of its market value, from $68.6 billion to $4.02 billion."[10] In addition, half the debt issued by US coal companies is presently in default,[11] and major coal producers Arch Coal, Alpha Natural Resources, and Peabody Energy have all filed for bankruptcy over the past year.[12] This is all *prior to* the 60 percent cut in coal production over the next 20 years that is needed to meet the 40 percent CO_2 emissions reduction requirement.

Conditions in oil and gas are different. The industry was booming from 2011 – 2014, as crude oil prices hovered around $100 a barrel. But profitability fell sharply as the price of oil declined below $60 a barrel in 2015 and below $40 a barrel in 2016. Plunging oil prices also rendered unprofitable most projects to produce natural gas through fracking. Over 2016, defaults on debt by oil and gas companies reached nearly 15 percent.[13] In Texas alone, the industry shed about 70,000 jobs.[14] It is not clear how much of an increase in the oil price would be needed to reverse these negative trends, or whether any such oil price increase is likely to emerge soon. In any case, a 40 percent production cut over the next 20 years will certainly worsen the already unstable situation.

Estimating Ancillary Industry Cutbacks

Working with the relevant U.S. government data, we performed extensive detailed calculations to generate estimates as to the effects of fossil fuel industry contraction on the employment levels of these five ancillary industries. The case of the natural gas distribution

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[9] Pollin et al. (2014) *Green Growth*, https://cdn.americanprogress.org/wp-content/uploads/2014/09/PERI.pdf, Chapter 5.
[10] http://www.bloomberg.com/news/articles/2016-01-21/the-coal-miner-on-everybody-s-list-as-next-bankruptcy-victim
[11] http://www.bloomberg.com/news/articles/2016-01-21/the-coal-miner-on-everybody-s-list-as-next-bankruptcy-victim
[12] Alpha: http://www.kccllc.net/alpharestructuring; Arch: http://www.archcoal.com/restructuring/; Peabody: http://www.peabodyenergy.com/content/2625/chapter-11-protection
[13] http://www.wsj.com/articles/new-lender-worry-oil-firms-max-out-credit-lines-1455236012
[14] http://www.wsj.com/articles/morecutsloomasoilnears251455238714

industry is most straightforward. We simply assume that employment levels for this industry will be impacted commensurately by the decline in U.S. natural gas production and consumption. That is, if natural gas consumption declines by 40 percent over a 20-year period, then employment in the natural gas distribution industry will also decline by 40 percent over the same time period.

We encounter a range of more complicated calculations with the other four ancillary industries, with separate issues at play with these four industries. We describe our general approach in each of the cases in what follows below. We cover these same issues in much greater technical detail in Appendix 1.

As we describe in Appendix 1, we made assumptions to estimate the extent of affected workers in the area of coal mining support activity. This is because the relevant government statistical sources do not break out coal mining support activities as separate from other forms of mining and extraction support activities.

In the area of petroleum refining, we needed to separate out the refining activities that are tied to energy production, and thus CO_2 emissions, from the production of petrochemicals and lubricants. These refining activities unrelated to energy production generate emissions to only a negligible extent. Of the total amount of refined petroleum products produced in the United States, about 76 percent are for energy products, including gasoline (49 percent), heating oil and diesel fuel (21 percent) and jet fuel (8 percent). We therefore set the employment level that will be affected by a contraction of U.S. fossil fuel consumption and production as being based on this 76 percent figure.

With respect to the fossil fuel based electric utility industry, government statistics include 20 occupational categories. Most of these occupational categories will be unaffected by whether electricity is generated from fossil fuel or renewable energy sources. Similar to the mining support activities, these occupations include management, finance, computer programming, marketing, and consumer service. The only occupations within this category that are likely to be heavily impacted by a transition from fossil-fuel to renewable-based electricity generation are those within the category of "installation, maintenance and repair." These jobs account for about 30 percent of all employment in the fossil-fuel based electric power industry. For our calculations, we therefore assume that 26 percent of all fossil fuel based utility employment will be affected by a transition to renewable energy electricity sources.

With coal industry support activities, we assume, over 20 years, a 60 percent decline—a 4.5 percent average annual rate of decline—which corresponds with our assumption for U.S. coal production itself over the 20-year cycle. Similarly, we assume a 40 percent decline for oil/gas extraction support activities, corresponding to our assumption for U.S. oil/gas production contraction. We also assume a 40 percent decline for petroleum refining and natural gas distribution. For the fossil-fuel based electric power generation industry, we assume a 50 percent production decline over 20 years—a 3.4 percent average annual rate of decline. This

reflects both the 60 percent decline in the coal industry and 40 percent in oil/gas. More details on these assumptions are also presented in Appendix 1.

3. MANAGING EMPLOYMENT LOSSES: RETIREMENTS AND JOB GUARANTEES

Advancing a Viable Program

The U.S. government has mounted multiple programs designed to assist workers facing job losses resulting from government policy choices. The most prominent of these is the federal Trade Adjustment Assistance (TAA) initiative which was first implemented in 1962 and still operates today. The TAA is designed to help workers displaced by shifts in U.S. global trade policies. The program supports wage insurance, health insurance, counseling, retraining, relocation, and job search. The program was most recently reauthorized in 2015, extending it through 2021. The estimated cost of the program through 2020 is $1.8 billion, or about $360 million per year.

Despite its recent reauthorization, TAA has long been criticized by a wide range of observers as not nearly adequate to provide significant support to workers who have experienced job losses or sharp wage cuts through reemployment.[15] For example, the wage insurance provision of the measure applies to workers 50 years and older only, with the federal government covering up to 50 percent of the difference of a worker's reduced wages, and with this support capped at $6,000 per year for two years. Consider the impact, for example, of moving from an auto industry job, where the average wage was $33.68 in 2015, or about $67,000 per year for full-time work to a position in a general merchandise store such as at Wal Mart, where the average wage was $15.15, or $30,000 as a full-time employee. The $6,000 annual wage insurance would certainly help, but even with that support, the former auto worker's income would still be down by roughly $31,000 per year—an income loss of 46 percent.[16] Even this underestimates the likely fall in wages, since the auto worker is losing a job where she enjoys seniority as well as firm-specific and union rents and moving into a new service-sector job at the entry level. The entry level wage at Walmart, for example, is $9 an hour as of January 2016, i.e. nearly $25 an hour lower than the average for the auto industry. Thus, if a laid-off auto worker moves into entry-level employment at Walmart, the income loss will be 66 percent, even with the $6,000 subsidy provided by the TAA.

Similar federal programs in recent decades have been no more effective than the TAA in relocating displaced workers into good new jobs. Rather, despite such initiatives,

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[15] As a sampling of recent perspectives on TAA: Gary Clyde Hufbauer at the Peterson Institute for International Economics describes it as "meager" (see Powell 2016); a 2012 study by Mathematica commissioned by the U.S. Department of Labor found that "TAA had a negative impact on total income, suggesting that these additional income payments did not fully compensate for participants' lower earnings," (D'Amico and Schochet, 2012, p. iii); a 2010 report by Vijaya for Demos concludes that TAA "has failed to respond adequately to the challenges facing dislocated workers (2010, p. 1).

[16] CES average hourly earnings of all employees; motor vehicle manufacturing (NAICS 3361) and general merchandise stores (NAICS 452) http://data.bls.gov/cgi-bin/dsrv?ce

displaced workers have been largely shunted into low-wage occupations. As the most significant case in point, a 1999 study by Powers and Markusen on the post-Cold War transition programs such as the Defense Reinvestment and Conversion Initiative found that "a majority of the workers displaced from defense-related industries between 1987 and 1997 now work at jobs that pay them less than their former wages and that fail to take advantage of their defense-bred skills, and a sizable minority has experienced a drop in earnings of 50 percent or more," (1999, p. 3).

Given this pattern, one cannot be optimistic that the results would be significantly better if similar policies were implemented as the primary component of a Just Transition jobs program. Fortunately, such support programs will only be needed to play a supplementary role in a comprehensive jobs program for fossil fuel workers. This is because we estimate that about 85 percent of the necessary job retrenchments can be managed through attritions by retirement when current employed fossil fuel workers reach age 65. For the other 15 percent of job losses throughout the fossil fuel and ancillary industries, a straightforward proposal will be to guarantee new employment opportunities within the rapidly expanding clean energy sectors. Providing such job guarantees will be readily manageable since, as we will see, the number of jobs that will need to be guaranteed for laid-off fossil fuel workers should be, on average, in the range of 2,700 per year, while the number of net new jobs generated by clean energy investments should be in the range of 3 million. In addition, moving displaced fossil fuel industry dependent workers into jobs that are at least broadly suitable to their experiences and skill levels should not present excessive obstacles in most cases. This is because of the wide range of jobs that will be created through clean energy investments.

Estimating Job Cuts and Reemployment Needs

To estimate how such a program would operate, we begin by assuming that that U.S. coal production will need to contract by about 60 percent within the next 20 years (an average of 4.5 percent per year)and oil and gas will need to decline by about 40 percent (an average of 2.5 percent per year). As discussed above, support activities for both the coal and oil/gas industries will also contract, as will the electric power generation, petroleum refining and natural gas distribution sectors. We factor each of these distinct industry contractions into our calculations.[17] In Tables 1 and 2, we review data on employment in the fossil fuel and ancillary industries that will provide the foundation for developing our policy framework. Table 3 then summarizes the main results of these previous two tables. Appendix 1 provides further details on our data sources and calculations on employment levels and reemployment needs.

We can follow our basic approach through the figures on the coal mining industry in column 1 of Table 1. We start in row 1 with the government figure on total employment in the

[17] Our estimate on reemployment needs is based on 2015 employment levels in the fossil fuel and ancillary industries. We do not include as among those eligible for reemployment support the workers who have already experienced job losses resulting from environmental regulations. However, one could make a legitimate case that such workers should also be included into the overall pool of workers to be guaranteed reemployment. We are not seeking to reach that level of specificity as yet with this proposal, but rather to provide a realistic framework for moving forward in the future with more detailed proposals.

industry for 2015 (we have rounded the figures to the nearest thousand). This is 66,000 employees total. We then calculate that the 60 percent employment contraction over 20 years will entail the loss of about 40,000 jobs in the industry over this 20-year period. At the end of the 20-year period, total coal industry employment will therefore be about 25,000. Considering the 40,000 job losses over the 20-year period, the annual contraction, as we see, will average about 2,000 jobs per year.

TABLE 1 BELONGS HERE

In rows 4 and 5, we then show figures on the number of workers in the industry who are between the ages of 45 and 64—which is 27,000 workers. This means that the number of workers who will reach 65 during the 20-year cycle of industry contraction will average about 1,400 per year. In other words, 70 percent of the 2,000 jobs (1,400 out of 2,000) that have to be shed per year in the coal industry will happen through natural attrition via retirements at age 65. But that does still leave 600 jobs per year that need to be shed by workers who would not have reached the standard retirement age of 65.

These 600 additional job cuts per year will need to come from workers who are 45 or under. If the additional job cuts came from older workers, we would then deplete the pool of workers reaching retirement age during the 20-year transition period. That would mean we could no longer cover 70 percent of the industry contraction through natural attrition by retirement at age 65.

In short, 600 younger coal industry workers will need to be laid off per year as the industry contracts by 60 percent over the 20-year transition period. These 600 workers will need to be guaranteed new jobs in the expanding clean energy economy. We discuss this in more specifics below, after considering the relevant figures for oil and gas and ancillary fossil fuel industries.

In column 2 of Table 1, we perform the same set of calculations for the oil and gas industry. With the oil and gas industry, we assume that production will decline by 40 percent over the next 20 years. With current employment at 192,000, that means that 77,000 jobs will be lost over the next 20 years, at an average rate of 3,800 job losses per year. As we see in row 4 of Table 1, there are presently approximately 58,000 oil and gas industry workers between the ages of 45 and 65. This means that, on average, 2,900 per year will reach age 65 over the 20-year transition period—a figure equal to 76 percent of the total annual job losses that will result while the industry contracts by 40 percent within 20 years. This also means that the industry will then have to shed 900 additional jobs per year to reach the overall job contraction level of 3,800 jobs per year. These 900 jobs will need to come through laying off younger workers, and those 900 workers, just as with the 600 per year in the coal industry, will need to be guaranteed jobs within the expanding clean energy industry.

In Table 2, we conduct the same set of calculations for our five ancillary industries—i.e. support activities for oil and gas as well as coal, plus petroleum refining, fossil-fuel based electric power generation and natural gas distribution. We have discussed above how we

estimate the extent to which demand in each of these industries is tied to production in the coal, oil and gas industries specifically. Our current employment estimates presented in row 1 are derived from these estimates (with further details presented in Appendix 1).

TABLE 2 BELONGS HERE

Working from these estimates of current employment levels tied to oil and gas production specifically, in row 2, we present our assumptions as to the level of contraction that will be experienced by each of these five ancillary industries, following from a 60 percent decline in coal production and a 40 percent decline in oil and gas over the next 20 years. Based on these figures, we then are able to estimate the extent to which jobs will be lost in each of these industries on an annual basis, and what proportion of those job losses can be covered through attrition by retirement at age 65.

As we show in row 6 of Table 2, the number of workers in the ancillary industries who will require reemployment ranges between 1,200 in support activities for oil and gas to zero with greenhouse gas-creating petroleum refining, fossil fuel-based electric power generation, and natural gas distribution industries. The reason for the zero figures for these three ancillary industries is that we estimate the steady-state annual job losses in these industries as (row 3) as less than or equal to the workers per year reaching retirement at 65 (row 5).

In Table 3, we add up the totals for: 1) industry job losses through a 20-year steady state contraction; 2) the number of workers reaching 65 over the 20-year contraction; 3) the percentage of workers reaching 65 as a share of industry job losses; and 4) the number of workers requiring reemployment. As we see, considering all of these industries, a steady-state 20-year contraction for the fossil fuel and ancillary industries will entail about 16,475 job losses. Of that total, about 13,735 or roughly 83 percent of these job losses can be handled through attrition by retirement at age 65. That leaves about 2,700 workers who will be displaced through the industry contractions. These workers will need to be guaranteed reemployment in the newly expanding clean energy industries.

TABLE 3 BELONGS HERE

Measures to Support Job Guarantees

There will be three types of major costs associated with providing job guarantees for displaced fossil fuel workers in the clean energy sector, such that this guarantee will entail minimum hardships for the displaced workers as they move into their clean energy industry jobs. These costs include: 1) compensation insurance; 2) job retraining; and 3) moving expenses. We consider these in turn.

Compensation Insurance

As one feature of the job guarantee program for these displaced workers, we propose that the workers receive 100 percent compensation insurance over a five-year period. This means

that any gap between what these workers were earning in their fossil fuel industry jobs—including wages and benefits—and what they are paid in their new clean energy jobs would be covered in full through the insurance guarantee.

To estimate the costs of such compensation insurance, we show data in Table 4 on average compensation at present in the coal and oil/gas industries as well as our five ancillary industries. Along with these figures, we provide an estimate of average compensation for a composite of clean energy industries, including building retrofits and electrical grid upgrades as energy efficiency investment activities as well as bioenergy, wind, solar, geothermal and hydro as renewable energy industries.[18] Our estimate for average total compensation from these clean energy activities is about $82,000, as reported in the header for Table 4. In column 3 of Table 4, we show the difference in compensation that would need to be covered for the 2,740 displaced workers per year. In column 4, we can then calculate totals by industry for one year of full compensation insurance. For example, for coal, we see in row 1 that the average compensation for the 600 displaced workers is $96,000. This is $14,000 more than the $82,000 average compensation for the average clean energy sector worker. As we therefore show in column 4, the cost of providing one year of 100 percent compensation insurance for the 600 displaced coal workers will be $8.4 million.

TABLE 4 BELONGS HERE

Rows 2 – 7 of Table 4 shows the same calculations for the oil and gas industry as well as the five ancillary industries. As we show, there will be no compensation insurance necessary for oil/gas support activities, since the average compensation level in this industry is the same as for clean energy. There will also be no need for compensation insurance for workers displaced in oil refining, fossil fuel-based electricity production and natural gas distribution, since the job losses in these industries will be less than or equal to the number of workers who will retire each year at age 65.

Overall then, the total annual cost of compensation insurance will be $38.0 million, which we can round up to about $40 million. If each of these workers were then to receive five years of compensation insurance, that would bring the total cost of this program to about $200 million per year.

Job Retraining

As we have noted above, the range of new jobs that are being generated through clean energy investments is wide. These jobs vary widely in terms of the formal educational credentials as well as special skill requirements. Some of the jobs will require skills closely aligned with those that the displaced workers used in their former fossil fuel industry jobs. These include a high percentage of construction-related jobs for efficiency investments as well as most management, administrative and transportation-related positions throughout the clean

[18] Our method of estimating a weighted average for compensation in the clean energy industry is described in Pollin et al. (2014), pp. 353-359.

energy industries. In other cases, new skills will have to be acquired to be effective at the clean energy industry jobs. For example, installing solar panels is quite distinct from laying oil and gas pipelines. This is why a Just Transition program must include a provision for retraining for the displaced fossil fuel industry workers. The government program will also need to serve as a job placement clearinghouse for all displaced workers.

The U.S. government has already been operating a clean energy job training program. This is 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. This figure can serve as one benchmark for estimating the costs of the program we are describing. But it is likely to be a high-end figure, since this existing government program is meant to be available to anyone interested, while the program we are describing is intended for only the roughly 2,740 displaced fossil fuel industry workers. At the same time, concerns were raised that the funding level for this broader program was inadequate, so perhaps the $75 million funding figure is not too far from what is realistically required. For example, a 2012 report from the U.S. Department of Labor found that the program had been only partially successful in placing workers in jobs in clean energy sectors. A 2013 study by an outside consulting group, IMPAC International, reported that, according to the majority of program administrators, funding to support the programs was not available for a sufficiently long time. These critiques need to be fully recognized in moving forward with any additional job training program (see Pollin et al. 2014, pp. 310 – 11 for further details). However, we must also recognize that, under the job guarantee feature of the just transition program, there will not be any pressure to place workers into jobs. Rather, the sole aim will be to get workers adequately trained into the new jobs that they will have been guaranteed.

Another way to roughly gauge the costs of the targeted program specifically for the displaced fossil fuel workers is with reference to the overall costs of providing community college education. The average annual non-housing costs for community college is presently around $10,000.[19] We assume that workers would require the equivalent of two full years of training, which they would most likely spread out on a part-time basis, as they move into their guaranteed jobs. By this measure, the full costs of the training program for 2,700 workers would be about $55 million.

The midpoint between the $75 million for the broadly available federal clean energy job training program and the costs of two years for community college training, at $55 million, is $65 million. For our purposes, we assume that the annual costs for training program specifically for displaced fossil fuel workers would be around this $65 million midpoint figure. [20]

[19] https://trends.collegeboard.org/college-pricing/figures-tables/average-estimated-undergraduate-budgets-2015-16
[20] Louie and Pearce (2016) developed a detailed analysis of the retraining costs of coal industry workers into employment in the solar photovoltaic industry. They estimated total retraining costs under both "best" and "worst" case scenarios, with large ranges for both cases. The best case scenario is between about $180 - $650 million, while

Moving Allowances

Not all of the 2,700 displaced workers will need to relocated to begin their new jobs in clean energy. This will be especially the case to the extent that regional redevelopment programs operate successfully in the distressed fossil fuel dependent areas. We discuss this further in Section 4. But some displaced workers will need to relocate and therefore need to receive relocation support. As a generous rough estimate, we allow for an average of $10,000 per displaced worker for relocation expenses. That would put the full cost of relocation allowances at $27 million per year.

Total Cost Estimate

Our rough estimate of the overall annual costs of providing an effective job guarantee program for displaced fossil fuel industry dependent workers will include the following: 1) $200 million per year for compensation insurance; 2) $65 million per year for retraining support; and 3) $27 million for relocation allowances. This totals to $292 million. For the sake of simplicity and to err on the side of overstating our estimate, we round this up to $300 million.

Managing Sharp Employment Downturns

To this point, we have generated our estimates based on the assumption of a steady rate of contraction for coal, oil and gas, and the five ancillary industries over a 20-year period—i.e. a 4.5 rate of decline for coal, 3.4 percent for fossil-fuel based electric power generation, and 2.5 percent for oil/gas and the other four ancillary industries. It is within this framework of a steady rate of decline per year that we estimate that about 85 percent of job losses through industry contraction can be handled through attrition by retirement.

As a first approximation, it is reasonable to assume that both the fossil fuel industry and the ancillary industries will in fact contract at fairly steady rates. Still, it is also reasonable to expect that the rate of decline will either accelerate or decelerate significantly at various points within the 20-year investment cycle. For the purposes of designing effective Just Transition policies, we have to especially account for the prospect that, at various points, large production sites, like one big coal mine, could shut down all at once. This could produce layoffs in the hundreds or more as one-time events. In such situations, it will not be possible to cover something like 85 percent of the job losses through attrition by retirement when workers turn 65.

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under their worst case, the range is between about $540 million and $1.9 billion. These figures are not directly comparable to ours. This is because they assume: 1) a 100 percent shutdown in coal, as opposed to our assumption of a 60 percent decline in coal and 40 percent in fossil fuels; and 2) all coal industry workers will need retraining, not just the younger workers who will not reach retirement age of 65 within 20 years. They also report a one-time figure applying to all coal-industry workers, while our figure is $60 million per year over 20 years. Our figure for retraining is therefore $1.2 billion over 20 years, which is within the range of their low- and high-end estimates for their "worst case scenario." Considering all of these differences, our estimate for retraining is broadly in line with those by Louie and Pearce.

Rather, the job losses in such situations are likely to hit workers of all ages to a roughly equivalent extent. That in turn means that more workers will need to be placed into new jobs and provided with wage and benefit insurance as well as retraining and relocation support. The resources needed to manage such larger transition programs will therefore need to be in place.

By definition, we cannot predict how large or frequently any such substantial spikes off of the trend line are likely to occur. As one comparable experience, the U.S. textile industry declined at an average rate of 6 percent per year between 1990 – 2007[21] (i.e. two full NBER business cycles). But the standard deviation around this average rate of decline was large, at 4.6 percentage points. Moreover, in one year, 2003, job losses reached 14.6 percent relative to the total losses over the 18-year trend. This was a rate of job loss nearly 2.5 times greater than the 6.0 percent trend rate of decline.[22]

Treating this experience with the U.S. textile industry as a rough reference point, let us consider the prospect that, over one or two years over the 20-year pattern of decline, employment losses in either the coal or oil/gas industries will spike at 3 times the average rate. It is not likely that both the coal and oil/gas industries will experience such shocks at the same point in time. It is also not likely the impact of such a one-time spike will impact the ancillary industries to an equivalent extent at the same time. But for our purposes, let us assume that this does occur. In other words, we are assuming a maximum one-time negative employment shock within the entire fossil fuel industry at one point in time within the overall 20-year pattern of decline.

As we have seen in Table 3, total employment losses through the steady rate of decline is about 16,500 per year. A one-year employment spike at three times the trend rate of decline would therefore mean about 50,000 job losses in the fossil fuel and ancillary industries. It would still be the case during this one-year spike in employment losses that 13,700 workers would reach age 65 throughout the fossil fuel and ancillary industries. That would then mean that during this very high end spike year in employment losses, replacement jobs would need to be found for about 36,000 workers as opposed to the trend average of 2,700 .

Finding new jobs for 36,000 workers is obviously far more challenging than doing so for the 2,700 workers that are needed under the steady-state pattern of employment loss. Full re-employment for these workers may therefore entail significant delays. Wage and benefit insurance will therefore need to be provided for them as long as necessary. At the same time, assuming that clean energy investments in the U.S. are maintained at $200 billion per year, that still means that roughly 2.7 million jobs have been created that would not have existed if those same funds had been spent on maintaining the existing fossil fuel economy. The new clean energy investments should therefore create ample new job opportunities even for 36,000 laid-off workers, assuming reasonably effective management of these Just Transition policies. This is especially the case given that this magnitude of job losses is likely to occur only as a one-time event over the 20-year transition cycle.

[21] This time period represents two full business cycles, as measured by the NBER, http://www.nber.org/cycles.html
[22] CES, all employees, textile mills (NAICS 313) http://data.bls.gov/cgi-bin/dsrv?ce

4. GUARANTEEING FULLY-FUNDED PENSIONS

If our Just Transition program is going to rely heavily on workforce attrition through retirements at 65, then it is imperative that all affected workers have secure and decent pensions waiting for them upon retirement. Accomplishing this will be a major challenge. This is because most U.S. workers, both those working within the fossil fuel industry and more generally, have inadequate pension coverage.

U.S. workers finance their retirements through a combination of three sources—Social Security, their own private savings, and employer-based pensions. Individual savings are not nearly high enough to finance retirement. This is especially true in the aftermath of the 2007-09 financial collapse. Most households have yet to recover from the nearly 30 percent decline in overall household wealth resulting from the crisis. With Social Security, the current average benefit is about $16,000,[23] which is only slightly higher than the $15,300 threshold for food stamp eligibility.[24] Meanwhile, about one-third of all private industry workers had no retirement benefits from their employers.[25]

Within this context, the most effective approach to guaranteeing adequate retirement support for fossil fuel industry workers would be to provide such support to *all workers*, regardless of the industries that employ them.[26] However, short of such an ambitious overhaul of the entire U.S. pension system, there are measures that the federal government will need to take to ensure pension security for the fossil fuel industry workers specifically.

At present, there are dramatic differences in the conditions of the pension funds in the coal industry as opposed to oil and gas and the ancillary industries. These differences reflect the broader conditions in these respective industries over the past several years. In Tables 5 - 8, we provide some basic evidence on the status of the pension funds and other key financial indicators for the largest firms in each industry. We present further details in Appendix 2.

Coal

The coal industry's pension funds are already severely underfunded. Most of the industry's pension funds are managed through the United Mine Workers of America Retirement Fund, which covers multiple employers. But this fund has suffered from the rapid decline of the coal industry and is currently underfunded by roughly $2 billion.[27] As we write, a significant

[23] https://www.ssa.gov/news/press/basicfact.html
[24] http://www.fns.usda.gov/snap/eligibility
[25] http://www.bls.gov/ncs/ebs/benefits/2015/ownership/private/table02a.htm
[26] One important proposal for achieving this is developed by Ghilarducci (2008).
[27] This is from the most recent (2013) ERISA Form 5500. The relevant section is Schedule MB. An online source putting the liability at "about $2 billion" is http://www.wsj.com/articles/coal-companies-get-reprieve-on-pension-costs-1429733342

portion of the fund—chiefly associated wth coal firms in bankrupcy—is in ongoing danger of running out of cash.[28]

We can obtain a fuller sense of the financial situation in the industry through the summary data shown in Table 5. The table shows unfunded pension liabilities as well as net income, dividend payouts, and stock buybacks for the five largest U.S. coal producers, Peabody, Arch, Cloud Peak, Alpha, and Alliance.

TABLE 5 BELONGS HERE

As row 1 of Table 5 shows, in combination, these five firms were carrying unfunded pension liabilities of $1.9 billion as of 2015.[29] But there are also big differences between the individual firms. Peabody has $800 million and Alpha has $1.1 billion respectively in unfunded pension liabilities. By contrast, Arch and Alliance have only modest unfunded liabilities, at $30 and $40 million respectively. Cloud Peak has no unfunded pension liabilities.

In terms of net income, these five firms have lost a combined $11.5 billion between 2012 – 2015. Arch sustained the largest losses at $4.8 billion, while Peabody lost $3.9 billion. Alliance was the only company earning significant profits of $1.5 billion over this period.

Given these highly negative overall income figures for all but Alliance, we should not expect these firms to have have significant funds available to be distributed to shareholders as dividends or to engage in share buybacks. In fact, as we see in Table 5, Peabody is the only major coal firm that both paid significant dividends ($277 million) or engaged in buybacks ($100 million). But even with Peabody, as we see in row 6 of Table 5, the combined $377 million total flowing to dividend payouts and buybacks amounts to less than half of the firm's $800 million in unfunded pension liabilities, leaving a difference of $423 million between dividend payouts and buybacks relative to the unfunded pension liability.

With four of the five largest coal firms experiencing serious distress and three of them carrying massive unfunded pension liabilies, we should expect the firms to pursue various tactics to avoid meeting their pension fund obligations. The experience in recent years with Peabody is instructive. In 2007 Peabody spun off some of its underperforming coal assets together with a large portion of its pension and retiree health care liabilities into a new company called Patriot Coal. Patriot then filed for Chapter 11 bankruptcy protection in 2012. As part of that proceeding, the company sought to be unburdened of its pension and retiree health care obligations. In May 2013, a judge approved Patriot's request to offload $1.5 billion in retiree health obligations. The

[28] In July 2016, Phil Smith, government affairs director of the United Mine Workers observed that "If we don't get new money into this pension plan through this legislation within the next 12 to 18 months, that fund will be past the point of no return," (in Shesgreen, 2016).

[29] This $1.9 billion figure is virtually identical to the $2 billion figure of unfunded liabilities with the multiemployer plan, as estimated by ERISA. This is the case even though the figures on individual pension plans come from the SEC as opposed to ERISA, with the two sources using different accounting methodologies. See Appendix 2 for details.

workers' union fought a campaign to compel Peabody to pay for the liabilities, and reached a settlement in 2013 in which Peabody paid $310 million into the fund (MacGillis 2013).

Through the PBGC, the federal government does have substantial authority to require companies to fulfill their pension fund obligations, as opposed to avoiding them through Peabody-type strategies. We discuss this further below. But when companies are truly in crisis—i.e. that they have no funds available to support their pension funds, even when such support is set as a first priority—then the federal government will need to intervene to protect the workers' pensions. This may not have been the situation with Peabody/Patriot in 2012. But there is a high likelihood that it will be so in the near future with Peabody itself and other U.S. coal firms.

These pension commitments must be fully honored. The Obama administration did propose to do so, under its "Power Plus" plan to support coal communities and workers. The Obama administration's own description of the program for its Fiscal Year 2017 budget proposal states as follows:

The Budget revises the formula for transfers of funds to the UMWA 1993 Health Benefit Plan by taking into account all beneficiaries enrolled in that health care plan as of this proposal's enactment. The Budget further accounts for those retirees whose health benefits were denied or reduced as the result of a bituminous coal industry bankruptcy proceeding commenced in 2012. Additionally, the Budget would transfer funds to the Pension Benefit Guaranty Corporation (PBGC) for the purpose of protecting the long-term solvency of the 1974 UNWA Pension Plan and Trust (1974 Pension Plan). The 1974 Pension Plan is significantly underfunded and approaching insolvency. Transfer would continue until that plan is fully funded.[30]

To date, the Obama proposal has been blocked in Congress by the Republican majority and its future is uncertain. But the broader point is that such a measure must be understood as a centerpiece for any kind of U.S. Just Transition program. To prevent an even greater underfunding gap, the fund could be "frozen" at its existing level of commitments to workers. The fund would be closed to newly-hired employees, but there are likely to be very few such new hires in any case, as the transition from fossil fuels to clean energy proceeds.

Oil and Gas

Table 6 shows the status of the pension fund liabilities and other financial figures for the five largest U.S. oil and gas corporations, Exxon/Mobil, Chevron, Conoco/Phillips, Anadarko, and Devon. As we see, all five of the companies are carrying unfunded pension liabilities as of 2015, totaling $14.2 billion—i.e. seven times the roughly $2 billion of unfunded liabilities for the five largest coal producers. Individually, the unfunded pension liabilities range between $8.6 billion for Exxon/Mobil to $250 million for Devon.

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https://www.whitehouse.gov/sites/default/files/omb/budget/fy2017/assets/fact_sheets/Investing%20in%20Coal%20Communities.pdf

TABLE 6 BELONGS HERE

Despite carrying these unfunded pension liabilities, the oil and gas corporations are currently at nowhere near the level of distress faced by coal companies. This is true even though, as Table 6 shows, three of the five—Conoco/Phillips, Andarko, and Devon—did experience major net income losses in 2015, due to the sharp fall in oil prices that year. Nevertheless, Exxon/Mobil and Chevron were both highly profitable in 2015. Moreover, considering the years 2012 – 14, all five of the firms were profitable, Exxon/Mobil, Chevron, and Conoco/Phillips earned between $24 - $115 billion over these three years, while the net income of Anadarko and Devon were much more modest, but still substantial, at between $1.5 - $1.8 billion.

As Table 6 also shows, all of the firms were actively paying out dividends between 2012 – 15. Total dividend payouts over these years for all five firms amounted to $91.7 billion. All of the firms other than Devon also engaged in stock buybacks. As we see in row 6 of Table 6, the total of dividend payouts plus stock buybacks substantially exceeded the level of unfunded pension liabilities for all the firms. With Exxon/Mobil for example, dividend payouts plus stock buybacks for 2015 exceeded their 2015 unfunded pension liability by $90.2 billion.

Even with Anadarko, the poorest performer among these five large firms, dividend payouts and stock buybacks exceeded their unfunded liabilities by $876 million. This is even after Anadarko lost $1.8 billion from 2012 – 2014 and $6.8 billion in 2015. In other words, even Anadarko was able to deliver dividends to their shareholders and to engage in financial engineering through stock buybacks at more than twice the level of funding that would have been necessary to bring their pension fund to full funding. More generally, it is clear that, certainly in recent years, the oil and gas companies have overwhelmingly channeled funds into dividends and stock buybacks as opposed to supporting their pension funds—both when the firms have had highly profitable years and when they have experienced losses.

Given that, over the next 20 years, the oil and gas industry will need to contract by between 30 – 40 percent as part of the clean energy transition, the evidence to date makes clear that the companies are hardly likely to replenish their pension funds as a matter of course. The federal government will therefore have to mandate full funding. One way to enforce this would be for the PBGC to utilize its powers under the 2006 Pension Protection Act to prohibit the oil 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 can also exercise its authority under the 2006 Act to place liens on company assets when pension funds are underfunded.

Utilities and Fossil Fuel Support Industry Firms

The financial situation for the large utilities and fossil fuel support industry firms are shown in Tables 7 and 8 respectively. The patterns are broadly similar to those for the large oil and gas firms, which also means that they bear no resemblance to those for the large coal firms.

TABLES 7 AND 8 BELONG HERE

With the utilities, four of the five large firms—Southern, Exelon, Berkshire Hathaway, and Pacific Gas & Electric—are operating with unfunded pension liabilities as of 2015. These range between $417 million (Berkshire Hathaway) to $5.1 billion (Exelon). The one exception as of 2-15 is Duke Energy, which had actually *overfunded* its pension fund by $409 million.

However, as with the oil and gas companies, these unfunded liabilities are modest relative to the profitability of these firms as well as the level of funding they have channeled to dividend payouts and financial engineering. All five of the firms were highly profitable over 2012- 15, including, specifically 2015 itself, when most of the oil companies experienced large losses. Berkshire Hathaway is the only major utility in which the 2015 level of pension underfunding exceeded its funding of dividends plus stock buybacks. But Berkshire Hathaway also earned $2.4 billion in net income in 2015 and $5.3 billion between 2012-14. There is clearly no reason to question the capacity of Berkshire to fully cover its pension fund obligations.

With the five largest large fossil fuel industry support firms—Schlumberger, Haliburton, Baker Hughes, National Oilwell Varco and Weatherford—all but Haliburton were carrying unfunded pension liabilities as of 2015. But the amounts are relatively small. Specifically, with four of the firms, their use of funds for dividend payouts and stock buybacks exceeded their unfunded pension liabilities by between $1.8 billion (Baker Hughes) and Schlumberger ($17.1 billion). The exception is Weatherford, which did not channel any funds to either dividend payouts or stock buybacks. Unlike the other four firms, Weatherford also experienced net income losses for all the years 2012 – 15. Nevertheless, with its unfunded pension liability at only $124 million as of 2015, its level of financial stress is not nearly as severe as the coal companies we discussed above.

Given these financial conditions for the utilities and support industry firms, protecting the pensions of workers in the industry should follow the same approach that we have already sketched for the oil and gas industry. That is, these firms should be required to fully fund their pensions and to maintain full funding before they are permitted to pay dividends or engage in stock buybacks. Such regulations should be sufficient to guarantee pensions in most circumstances over the transition in which fossil fuel production and consumption decline steadily. If firms do face genuine crisis conditions comparable to those currently faced in the coal industry, policy interventions comparable to the Obama Power Plus program for coal will need to be implemented more broadly. But none of the large utilities or support industry firms are presently even approaching the level of distress that would require a federal bailout to guarantee the workers' pensions. Precisely because conditions in the industry are favorable, this is an opportune period to set down strong and workable pension fund protection standards.

5. COMBINING COMMUNITY SUPPORT WITH CLEAN ENERGY INVESTMENTS

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. As we see in Table 9, West Virginia has the highest share of coal employment, with the 20,281 coal industry workers representing 2.9 percent of the overall statewide workforce. In Wyoming, the 6,673 coal industry workers represented 2.4 percent of the state's overall workforce. As the table shows, these are the only two states in which coal industry jobs exceeds one percent of overall statewide employment.

TABLE 9 BELONGS HERE

In fact, coal production is further concentrated by county within these heavily-producing states. Three counties produce 45 percent of Kentucky's coal output, a single county produces 60 percent of Montana's output, two counties produce two-thirds of Pennsylvania's output, six counties produce half of West Virginia's output, and Campbell County alone in Wyoming itself produces 88 percent of that state's output.[31]

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 California, along with offshore federal waters—account for 71 percent of all U.S. production, with Texas by itself accounting for 35 percent. With natural gas, the top four producing states—Texas, Pennsylvania, Louisiana and Oklahoma—account for 60 percent of total production, with Texas along producing 28 percent. In terms of employment, as we see in Table 10, Texas has the largest number of employees, at 313,121, while Oklahoma has the highest proportion, at 4.1 percent of total employment. In addition to these two states, only three states, Louisiana, Colorado and Kansas, have employment levels in oil and gas exceeding 1 percent of total statewide employment.

TABLE 10 BELONGS HERE

The impact of a long-term, permanent decline 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

[31] US Energy Information Administration. 2015. *Annual Coal Report 2013*. Table 2: Coal production and number of mines by state, county and mine type. http://www.eia.gov/coal/annual/pdf/acr.pdf

and Pittsburgh over the past three decades. But smaller communities that are less diversified will experience still greater losses. Midland Texas, a city of 140,000 residents, relies both on traditional oil and gas extraction as well as more recent shale oil projects to generate 65 percent of the city's overall economic activity.[32] Midland and its sister city Odessa were booming in recent years, with average real earnings in the fossil fuel sectors rising by an average of 22 percent between 2006 – 2014, due especially to the growth in shale oil extraction.[33] But the area also experienced a loss of about 13,000 jobs in 2015—7.5 percent of the area's overall workforce—as oil prices fell.[34] Without an effective transition program, this pattern of decline will persist.

The situation is, again, still worse for coal-dependent communities. For example, in Boone County, West Virginia, 47 percent of all jobs in recent years were with the region's coal industry.[35] However, just between 2011 and 2014, coal mining employment in the area fell from 4,600 to 1,400, a 70 percent decline.[36] The County's budget also fell 45 percent between 2012 and 2015.[37] In 2016, three elementary schools were consolidated and at least 70 teachers were laid off.[38] Again, in the absence of a well-functioning transition program, this pattern will persist 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 we have already discussed in terms of providing job opportunities for younger displaced fossil fuel industry workers. In section 1, we briefly describe a U.S. clean energy program centered around investments in energy efficiency and clean renewable energy at $200 billion per year, or roughly 1.1 percent of current U.S. GDP.

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[32] http://www.wsj.com/articles/oil-bust-forces-west-texas-to-adjust-1456950453
[33] http://www.dallasfed.org/research/heart/midland.cfm#n7
[34] 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. http://beta.bls.gov/dataQuery/find?st=240&r=20&fq=areaT:%5BCombined+areas%5D&more=0
[35] http://www.downstreamstrategies.com/documents/reports_publication/DownstreamStrategies-coalWV.pdf
[36] https://www.snl.com/web/client?auth=inherit#news/article?id=35618381&KeyProductLinkType=0&cdid=A-35618381-9782
[37] http://wvpublic.org/post/boone-county-less-coal-less-money-fewer-miners
[38] http://wvpublic.org/post/boone-county-teachers-search-opportunities-after-layoffs

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 generous support to advance regionally appropriate clean energy projects. For example, Texas and Wyoming could receive additional support to build wind energy production projects. The Appalachian region could receive extra support for upgrading the energy efficiency of their building stock and electrical grid transmission system. One major project for these 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 2015, the program had reclaimed over $5.7 billion worth of damaged sites spanning nearly 800,000 acres. But a 2015 study by Dixon and Bilbrey estimates that at least an additional $9.6 billion will be needed to remediate the remaining 6.2 million acres of land and waters damaged though mining and abandonment. Under the Obama administration's Power Plus Plan, $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 represent significant support. Nevertheless, the $1 billion budgeted under Power Plus is only about 10 percent of the nearly $10 billion Dixon and Bilbrey estimate will be needed to adequately remediate the damaged 6.2 million acres. New sources of revenues are clearly required. We take up this and other funding issues below.

There are no comparable federal reclamation projects for abandoned oil and gas extraction production sites. Major producing states, including Texas and Pennsylvania, do have reclamation regulations in place. But there is no systematic evidence documenting how these regulations have generated company-financed reclamation work, and what the economic impact may have been from any such reclamation projects.

The reclamation of the abandoned projects will need to be accomplished in any case. Otherwise, the damaged 6.2 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. Dixon and Bilbery further argue that "these problems continue to markedly impede local economic development and threaten the livelihoods of citizens," (2015, p. 13).

While reclamation projects are an imperative, 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, since that infrastructure was built to meet the specific needs of each of the industries.[39]

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

[39] With respect to repurposing the infrastructure around the nuclear sites, Lowrie et al. 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," (1999, pp. 120 – 121).

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. 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 (2000).

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. The clean-up operation began in 2002, and is schedule to take 40 years to complete.[40] 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 (Hendren 2015).

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. (1999) reaches the same conclusion. 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 (1999, p. 121).

[40] In May 2016 Congress legislated to maintain funding for the site: http://www.portman.senate.gov/public/index.cfm/press-releases?ID=84DB38D2-5B4C-434F-BC68-B14E60DFA440

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.[41]

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.[42] For example, RAG AG, a German coal mining firm, has been developing plans to convert coal mines that are scheduled to close in 2018 into hydroelectric power storage facilities to stabilize energy production when solar or wind power fluctuates. In periods of slack solar and wind energy production, water that was earlier pumped into a surface pool during excess supply periods is dropped through 1,000 meters of pipes to drive the underground turbines. 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.[43] San Diego and Philadelphia both lost around 50,000 jobs over this period,[44] representing declines in both cases of about 6 percent of their respective workforces.[45]

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 – 97, i.e. about $4 billion per year. A 1999 study by Powers and Markusen found that these programs were adequate in terms

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[41] U.S. Department of Energy, "U.S. Departments of Energy and Interior Announce Site for Solar Energy Demonstration Projects in the Nevada Desert," Press release, 7/8/10, http://energy.gov/ articles/us-departments-energy-and-interior-announce-site-solar-energy-demonstration-projects-nevada.

[42] The description in this paragraph is based on Galgoczi (2015) and Dohmen and Schmid (2011).

[43] http://www.epi.org/publication/technicalpapers_justtransition/, p. 6

[44] https://wdr.doleta.gov/opr/FULLTEXT/1994_12_NEW.pdf, pp. 4-3, 4-5

[45] Employment in Philadlelphia 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
Source: 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

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.

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 we have 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.

6. OVERALL COSTS FOR JUST TRANSITION

The Just Transition program that we have developed here will require significant levels of government spending in three areas. These include:

Guaranteed Jobs and Support for Laid-off Workers. Our high-end estimate for this, including workers who face job losses either due to steady industry decline or large-scale production site shut downs, is $300 million per year.

Fully guaranteed pensions. As a high-end figure, the U.S. government will have to spend $1.8 billion to bring the United Mine Workers Health and Retirement Fund to full funding. This amounts to $90 million per year over 20 years. The figure can be lower to the extent that the coal companies can be made to contribute toward closing their underfunding gap. By contrast, the oil and gas companies, as well as the five ancillary industries, are still fully capable of closing their underfunding gaps. These gaps should therefore be handled through regulatory interventions.

Community transition. Working from the largely successful Worker and Community Transition program, the high-end level of support would be around $200 million per year. This would be in addition to the direct clean energy investment projects flowing into all regions of the country. Alternatively, if we use the less successful Defense Reinvestment and Conversion Initiative as a financial model, that would imply spending about $12,000 per displaced worker, amounting to annual spending of around $150 million per year. Thus, a reasonable range for these programs is between $150 - $200 million per year.

Combining these three policy areas, we approximate the total costs as being about $600 million per year over a 20-year transition period. This level of federal spending can be readily absorbed within the broader $200 billion annual U.S. clean energy investment program that we have sketched above, with direct public spending in this program at around $50 billion per year. The Just Transition program we are proposing, costing around $600 million per year, would amount to one percent of the $50 billion in overall public spending needed to build a clean energy U.S. economy.

As one option, these funds could be generated through the savings the federal government would obtain through investments to raise efficiency standards by 30 percent in most of the buildings they own or lease, as stipulated by the 2007 Energy Independence and Security Act. These building efficiency investments should save the federal government about $1.3 billion per year, i.e. more than twice as much as would be needed for the Just Transition program. Beyond this, establishing a carbon cap or tax to discourage fossil fuel consumption could realistically generate about $200 billion per year. The total costs of the Just Transition program would therefore amount to about 0.3 percent of the revenues that could come from a carbon tax or cap.[46]

In short, a Just Transition for U.S. fossil fuel industry workers is eminently affordable. It is also an imperative—both a moral and strategic imperative. It is not a substitute for effective full employment policies, a universal system of decent pensions, and gender equality, in the energy industry and elsewhere. But at the very least, we must recognize that it will be virtually impossible to move forward at the pace that is necessary with a clean energy transformation without making firm commitments to generously supporting the workers and communities that will be hurt by this transition.

[46] These savings and revenue figures are derived in Pollin et al. (2014), Appendix 5, esp. Table A5.3.

Appendix 1. Estimating Employment Impacts of U.S. Fossil Fuel Production Contraction for Fossil Fuel and Ancillary Industries

There are three major surveys of employment and wages by industry in the US: the Current Population Survey labor force statistics (CPS), the Current Employment Statistics (CES) and the Occupational Employment Statistics (OES). See Table A1.1 for a detailed comparison of the three data sources. In estimating employment and earnings by industry, we rely to the extent possible on the largest, most frequent, and hence most reliable survey, the CES. However, while the CES provides the most reliable aggregate employment and average wage estimates, we will have to adjust CES figures to account for shortcomings in the data as well as other factors.[47]

TABLE A1.1 BELONGS HERE

First, taking advantage of the fact that CPS contains demographic information about the ages of employees, we use the CPS data to generate age distributions, which we then apply to CES aggregate employment figures to generate estimates of employment by industry and age group. Using these numbers, we estimate how many workers will leave employment naturally via retirement each year. Since the CPS accounts for industry of employment with verbal phrases rather than precise NAICS codes, we match each NAICS industry with its closest match in the CPS. The CES-CPS matches are presented in Table A1.2.

TABLE A1.2 BELONGS HERE

Table A1.3 contains the age distributions by industry. We note here that while the CES data contains better industry-level detail than the CPS or OES, we must make some adjustments to the CES NAICS industries as well. For example, the CES does not have estimates for the support activities for *coal* mining industry, which is narrower than the support activities for *mining* industry for which the CES does have estimates. More on this below.

TABLE A1.3 BELONGS HERE

Next, we have to adjust the CES employment-by-industry figures by a set of industry-specific factors. We address these on a case-by-case basis for the following industries: coal mining, oil and natural gas extraction, petroleum refining, support activities for oil and natural gas extraction, support activities for coal mining,, fossil fuel electric power generation, and natural gas extraction.

1. Coal mining (NAICS 2121) and oil and gas extraction (NAICS 211)

The CES provides employment estimates for both of these industries. We assume that *all* 257,200 workers in these industries—65,500 coal (NAICS 2121) and191,700 oil and gas (211)—are affected by the necessary 60 percent decline in coal production and forty percent reduction in oil and natural gas production, resulting in 39,300 lost jobs in coal and 76,680 lost jobs in oil and gas over the next twenty years.

2. Petroleum refining

[47] The CES is summarized here: http://www.bls.gov/bls/bureau-of-labor-statistics-information-guide.pdf, p. 14; the OES here: http://www.bls.gov/news.release/ocwage.tn.htm; the CPS here: http://www.bls.gov/bls/bureau-of-labor-statistics-information-guide.pdf, p. 16

According to the CES, employment in petroleum refining (NAICS 32411) is 72,100. However, not all petroleum is refined into fossil fuels that are burned to produce energy. The petroleum that is refined into, for example, plastics and asphalt, will not contribute to greenhouse gas emissions and can be omitted from our production decline calculations. According to the Energy Information Agency, only 76 percent of petroleum is refined into fossil fuel products.[48] Accordingly, we scale down the total employment figure from 72,100 to 54,796 (i.e. 72,100 x 0.76 = 54,796). Assuming a forty percent production decline, job losses in petroleum refining will therefore amount to 21,918 over the next twenty years.

3. Support activities for oil and gas extraction

According to the CES, there are 289,400 workers in the support activities for oil and gas extraction industry (NAICS 213112). We assume all of these workers will be affected by the decline in fossil fuel production. Assuming a 40 percent decline, 116,000 jobs will be lost in this industry over the next 20 years.

4. Support activities for coal mining

The CES does not have employment estimates for a support activities for coal mining industry. It contains only the three-digit industry support activities for mining (NAICS 213) and the six-digit NAICS industry support activities for oil and gas extraction (213112). We estimate employment in the support activities for coal mining industry as follows. First, we derive employment in the support activities for mining *except oil and gas extraction* industry by subtracting employment in the support activities for oil and gas extraction (NAICS 213112) industry from employment in the support activities for mining (NAICS 213) industry. Then, we multiply this by the proportion of coal employment (NAICS 2121) in the mining except oil and gas extraction industry (NAICS 212), which is 0.33.[49] This gives us an estimate of 29,000 workers in the support activities for coal mining industry.. Assuming a 60 percent production decline, that makes 17,000 lost jobs over the next twenty years.

5. Fossil fuel electric power generation

The CES employment estimate for this industry (NAICS 22112) is 96,300. But not all of these workers are employed in occupations that will be affected by green transition. Of the total, the only occupations likely to be exposed to retrenchments are the installation, maintenance and repair occupations, which account for 26 percent of total employment.[50] Using the CAP/PERI scenario, a high end estimate of the necessary contraction in this sector would be 50 percent.[51] Thus, total job loss over the 20-year transition would be 12,500 jobs.

6. Natural gas distribution

There are 114,100 workers employed in the natural gas distribution industry (NAICS 2212). Assuming all of these workers will be affected by a green transition, and assuming a 40 percent necessary contraction, 45,640 jobs will be lost in this industry over the 20 years of transition.

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[48] https://www.eia.gov/tools/faqs/faq.cfm?id=41&t=6
[49] 65,500 in NAICS 2121/198,600 in NAICS 212 = 0.33
[50] According to OES estimates, there are 95,480 total workers in NAICS 22112 and 24,500 in installation, maintenance and repair occupations. 24,500 / 95,480 = 0.26.
[51] Table 5.5, p. 188

Table A1.6 shows the full set of steps we have taken to generated the figures reported in Tables 1 – 3 of the main text.

TABLE A1.6 BELONGS HERE

Appendix 2. Accounting Methodology and Data Sources for Fossil Fuel Firms' Unfunded Pension Fund Liabilities and Related Financial Data

In its basics, an unfunded pension fund liability is the difference between a pension plan's assets and its obligations to beneficiaries. Calculating this number involves a number of assumptions about both future values of a pension plan's assets as well as the actuarial trajectory of the plan's beneficiaries. For the U.S. economy, there are two federal government sources of information on unfunded pension liabilities. These work with different methods of reporting. Both methods are valid, but they serve somewhat different purposes. The first source is the U.S. Department of Labor, which collects information from pension plans for the purpose of administering the Employee Retirement Income Security Act (ERISA). The U.S. Securities and Exchange Commission (SEC) is the other source. The SEC requires publicly-traded companies to provide information on benefit plan obligations as part of their required financial disclosures to investors.

The single most important difference between the two is that the SEC requires firms to provide projections of future benefits, while the ERISA data focus on current obligations only. SEC unfunded liability estimates are consequently substantially higher than ERISA estimates. Beyond this, the extent of reporting differs between the two sources. ERISA provides comprehensive information on pensions across the various U.S. industries. The SEC data are more detailed in presenting individual firm data on pensions alongside other standard financial data for individual firms, including their profits, dividend payments and spending on share buybacks. Table A2.1 summarizes the main differences between the two sources.

TABLE A2.1 BELONGS HERE

Because our purpose here is to compare individual firm unfunded liability levels alongside other financial indicators, we therefore are presenting figures as presented in the SEC filings on the five largest firms operating in each of the sectors. In Tables A2.2 – 2.5, we provide the full citations for the information reported in Tables 5 – 8 of the main text.

TABLES A2.2 – 2.5 BELONG HERE

We obtained the size rankings of the firms in each sector as follows:

- ***Oil and Gas Extraction:*** http://www.forbes.com/sites/rrapier/2016/03/30/the-worlds-largest-public-oil-and-gas-companies/#1706a2d16cf1
- ***Coal:*** https://www.eia.gov/coal/annual/pdf/table10.pdf. The fifth largest US coal firm, Murray Energy, is privately held, so no public financial data are available. We therefore included information on the sixth largest firm, Alliance Energy Partners.
- ***Utilities and Natural Gas Distribution:*** Compustat database. Within Compustat, we ranked firms in electricity production (NAICS 2211) and natural gas distribution (NAICS 2212) industries by 2014 revenue levels.
- ***Fossil Fuel Support Activities:*** Compustat database. We first created a ranking of the largest oilfield services companies by combining the support for oil and gas operations (NAICS 213112), oil and gas well drilling (NAICS 213111) and oil and gas equipment

(NAICS 333132) industries, then ranking firms by their 2014 revenues. Most oilfield services companies operate across these segments, so the primary NAICS code is arbitrary.

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Table 1. Coal, Oil, and Natural Gas Industries:
Attrition by Retirement and Job Losses for Younger Workers

	Coal Mining	Oil and Gas Extraction
1. Current Employment, total	66,000	192,000
2. Job Losses over 20-year transition	40,000 (assuming 60% production decline	77,000 (assuming 40% production decline
3. Average annual job losses over 20-year production decline (= row 2/20)	2,000	3,800
4. Number of workers between 45 - 65	27,000	58,000
5. Number of workers per year reaching 65 during 20-year transition period (= row 4/20)	1,400	2,900
6. Number of under 45 workers per year requiring reemployment (= row 3 – row 6)	600	900

Source: See Appendix 1

Table 2. Five Ancillary Industries:
Attrition by Retirement and Job Losses for Younger Workers

	Support activities for oil and gas extraction	Support activities for coal mining	Greenhouse gas-creating petroleum refining	Fossil fuel-based electric power generation	Natural gas distribution
1. Current Employment, total	289,000	29,000	55,000	30,000	114,000
2. Job Losses over 20-year transition	116,000 (40% contraction)	17,000 (60% contraction)	22,000 (40% contraction)	15,000 (50% contraction)	46,000 (40% contraction)
3. Average annual job losses over 20-year production decline (= row 2/20)	5,800	850	1,100	625	2,300
4. Number of workers between 45 - 65	92,600	9,300	25,000	12,500	51,000
5. Number of workers per year reaching 65 during 20-year transition period (= row 4/20)	4,600	460	1,250	625	2,500
6. Number of under 45 workers per year requiring reemployment (= row 3 – row 6)	1,200	390	0	0	0

Source: See Appendix 1

Table 3. All Industries: Summary Figures on Attrition by Retirement and Job Losses

	Industry job losses through steady 20-year contraction	Number of workers reaching 65 over 20-year contraction	Workers reaching 65 as share of industry job losses over 20-year contraction *(percentages)*	Number of younger workers requiring reemployment
Coal Mining	2,000	1,400	70.0%	600
Oil and Gas Extraction	3,800	2,900	76.3%	900
Oil and Gas Extraction Support Activities	5,800	4,600	79.3%	1,200
Coal Mining Support Activities	850	460	54.0%	390
Greenhouse gas-creating petroleum refining	1,100	1,250	113.6%	0
Fossil-fuel based electric power generation	625	625	100%	0
Natural Gas Distribution	2,300	2,500	108.6%	0
TOTAL	**16,475**	**13,735**	**83.3%**	**2,740**

Source: See Appendix 1

Table 4.
Estimating Annual Costs of 100% Compensation Insurance for Displaced Fossil Fuel Industry Dependent Workers

Average compensation for clean energy sector employees = $82,000

	1. Number of displaced workers per year	2. Average compensation in industry	3. Difference between fossil fuel and clean energy industry jobs *(= column 2 - $82,000)*	4. Annual costs for compensation insurance *(= columns 1 x 3)*
1. Coal	600	$96,000	$14,000	$8.4 million
2. Oil/Gas	900	$114,000	$32,000	$28.8 million
3. Coal Support	390	$84,000	$2,000	$780,000
4. Oil/Gas Support	1,200	$81,000	0	0
5. Petroleum Refining	0	$108,000	$26,000	0
6. Electric Power Generation	0	$113,000`	$31,000	$775,000
7. Natural Gas Distribution	0	$99,000	$17,000	0
TOTALS	**2,740**	**---**	**---**	**$38.0 million**

Sources: Current Employment Statistics; Pollin et al. (2014), 353-59.

Table 5. Major US Coal Companies:
Status of Pension Funds and Overall Financial Conditions
2012 – 2015

	Peabody Energy	Arch Coal	Cloud Peak Energy	Alpha Natural Resources	Alliance Resource Partner	TOTALS
1. Unfunded pension liabilities, 2014, 2015	$800 million	$30 million	0	$1.1 billion	$40 million	$1.9 billion
2. Net income, 2015	-$2.0 billion	-$2.9 billion	-$205 million	Not available	+ $306 million	-$4.8 billion
3.Net Income, 2012 – 14	-$1.9 billion	-$1.9 billion	+$305 million	-$4.3 billion	+ 1.2 billion	-$6.6 billion
4. Dividend Payouts, 2012-15	$277 million	$70 million	0	0	0	$347 million
5. Stock Buybacks, 2012 – 15	$100 million	0	0	$10 million	0	$110 million
6. (Dividend payouts + stock buybacks)/unfunded pension liabilities *= (rows 4+5)/row 1*	$423 million	$40 million	0	$1.1 billion	$40 million	$1.4 billion

Sources: See Appendix 2.

Table 6. Major U.S. Oil and Gas Companies:
Status of Pension Funds and Overall Financial Conditions
2012 – 2015

	Exxon/Mobil	Chevron	Conoco-Phillips	Anadarko	Devon	TOTALS
1. Unfunded pension liabilities, 2015	$8.6 billion	$3.3 billion	$1.2 billion	$800 million	$250 million	$14.2 billion
2. Net income, 2015	+ $16.5 billion	+ $4.7 billion	-$4.4 billion	-$6.8 billion	-$15.2 billion	-$5.2 billion
3.Net Income, 2012 – 14	+114.7 billion	+ $67.2 billion	+24.2 billion	$1.8 billion	$1.5 billion	+209.4 billion
4. Dividend Payouts, 2012-15	$44.6 billion	$30.2 billion	$13.8 billion	$1.5 billion	$1.5 billion	$91.7 billion
5. Stock Buybacks, 2012 – 15	$54.2 billion	$13.0 billion	$5.2 billion	$196 million	0	$72.7 billion
6. (Dividend payouts + stock buybacks)/unfunded pension liabilities *= (rows 4+5)/row 1*	$90.2 billion	$39.9 billion	$17.8 billion	$876 million	$1.3 billion	$150.2 billion

Sources: See Appendix 2.

Table 7. Major U.S. Utilities:
Status of Pension Funds and Overall Financial Conditions
2012 – 2015

	Duke	Southern	Exelon	Berkshire Hathaway	Pacific Gas & Electric	TOTALS
1. Unfunded pension liabilities, 2015	*Overfunded:* $409 million	$1.3 billion	$5.1 billion	$417 million	$2.6 billion	$9.0
2. Net income, 2015	$2.8 billion	$2.4 billion	$2.3 billion	$2.4 billion	$888 million	$10.8 billion
3.Net Income, 2012 – 14	$6.4 billion	$6.1 billion	$1.6 billion	$5.3 billion	$3.2 billion	$22.6 billion
4. Dividend Payouts, 2012-15	$8.4 billion	$7.5 billion	$5.1 billion	0	$3.2 billion	$24.3 billion
5. Stock Buybacks, 2012 – 15	0	$570 million	0	$36 million	0	$606 million
6. (Dividend payouts + stock buybacks)/unfunded pension liabilities *= (rows 4+5)/row 1*	$8.0 billion	$6.8 billion	0	-$381 million	$600 million	$16.0 billion

Sources: See Appendix 2.

Table 8. Major Fossil Fuel Support Industry Firms: *Status of Pension Funds and Overall Financial Conditions 2012 – 2015*

	Schlumberger	Haliburton	Baker Hughes	National Oilwell Varco	Weatherford International	TOTALS
1. Unfunded pension liabilities, 2015	$558 million	0	$247 million	$192 million	$124 million	$1.1 billion
2. Net income, 2015	$2.1 billion	-$667 million	-$2.0 billion	-$767 million	-$2.0 billion	-$3.2 billion
3.Net Income, 2012 – 14	$17.8 billion	$8.2 billion	$4.1 billion	$7.3 billion	-1.6 billion	$35.8 billion
4. Dividend Payouts, 2012-15	$7.4 billion	$1.9 billion	$1.1 billion	$2.0 billion	0	$12.5 billion
5. Stock Buybacks, 2012 – 15	$10.4 billion	$5.1 billion	$950 million	$3.0 billion	0	$19.5 billion
6. (Dividend payouts + stock buybacks)/unfunded pension liabilities *= (rows 4+5)/row 1*	$17.2 billion	$7.0 billion	$1.8 billion	$4.8 billion	$124 million	$30.6 billion

Sources: See Appendix 2.

Table 9. U.S. Coal Employment in States with 4,000 or more Employees, 2013

	Coal Employment	Total State Employment	Coal as Share of Total Employment
West Virginia	20,281	703,916	2.9%
Wyoming	6,673	279,748	2.4%
Kentucky	12,905	1,779,777	0.7%
Alabama	4,212	1,845,086	0.2%
Pennsylvania	8,382	5,596,841	0.2%
Virginia	4,521	3,640,209	0.1%
Illinois	4,164	5,687,541	0.07%

Source: EIA 2013 Annual Coal Report, Table 18; BLS Quarterly Census of Employment and Wages, 2013 Annual Average Employment by State http://www.bls.gov/cew/cewind.htm#year=2013&qtr=A&own=0&ind=10&size=0

Table 10. U.S. Oil and Gas Extraction Employment in States with 15,000 or more Employees, 2013

	Oil and Gas Extraction Employment	Total State Employment	Oil and Gas as Share of Total Employment
Oklahoma	91,473	2,254,523	4.1%
Texas	313,121	15,505,307	2.0%
Kansas	33,742	1,864,258	1.8%
Louisiana	34,842	2,632,302	1.3%
Colorado	35,065	3,351,702	1.1%
Ohio	22,629	6,663,005	0.3%
Pennsylvania	20,525	7,321,660	0.3%
California	44,653	21,449,488	0.2%

Source: BEA regional data, Total Full-TIme and Part-Time Employment by Industry. http://www.bea.gov/iTable/iTable.cfm?reqid=70&step=1&isuri=1&acrdn=6#reqid=70&step=1&isuri=1,

Table A1.1. Comparison of U.S Government Employment Statistics Sources

	Entity surveyed	Survey scope	Survey frequency	Worker age demographic information	Industry detail	Occupational detail
Current Employment Statistics (CES)	Establishments	577,000 establishments	Monthly	No	Two-, three-, four-, and selected five- and six-digit NAICS industries	None
Occupational Employment Statistics (OES)	Establishments	200,000 establishments	Semiannual, estimates pooled over three years	No	Two-, three-, four-, and selected five- and six-digit NAICS industries	SOC
Current Population Survey (CPS)	Households	60,000 households	Monthly	Yes	Industry verbal descriptions, which do not map 1-to-1 onto NAICS industries	Occupation verbal descriptions, which do not map 1-to-1 onto SOC occupations

Table A1.2 Matching the CPS (used to generate age distributions) and the CES (used to provide employment estimates) industries

Industry	CES	CPS
Coal mining	Coal mining (NAICS 2121)	Coal mining
Oil and gas extraction	Oil and gas extraction (NAICS 211)	Oil and gas extraction
Petroleum refining	Petroleum refining (NAICS 32411)	Petroleum refining
Support activities for oil and gas extraction	Support activities for oil and gas operations (213112)	Support activities for mining
Support activities for coal mining	Support activities for mining (213112)	Support activities for mining
Fossil fuel electric power generation	Fossil fuel electric power generation (NAICS 22112)	Electric power generation, transmission and distribution
Natural gas distribution	Natural gas distribution, NAICS 2212)	Natural gas distribution

Table A1.3. Age Distribution by Industry

	Coal Mining	Oil and Gas Extraction	Petroleum refining	Support activities for oil and gas extraction	Support activities for coal mining	Fossil fuel electric power generation	Natural gas distribution
4. Current employment, total, CPS, http://www.bls.gov/cps/cpsaat18b.htm	68,000 (coal mining)	103,000 (oil and gas extraction)	183,000 (petroleum refining)	609,000 (support activities for mining)	609,000 (support activities for mining)	661,000 (electric power generation, transmission and distribution)	128,000 (natural gas distribution)
5. Number of workers 65+, CPS	3,000	3,000	4,000	21,000	21,000	16,000	4,000
6. Number of workers, 45 to 64, CPS	28,000	30,000	82,000	196,000	196,000	327,000	58,000
7. Proportion of workers, 45 to 64 (=row6/row4)	41%	30%	45%	32%	32%	49%	45%

Table A1.4. Job loss calculations

	Coal Mining	Oil and Gas Extraction	Petroleum refining	Support activities for oil and gas extraction	Support activities for coal mining	Fossil fuel electric power generation	Natural gas distribution
1. Current Employment, total, CES, http://data.bls.gov/cgi-bin/dsrv?ce	65,500 (coal mining, NAICS 2121)	191,700 (oil and gas extraction, NAICS 211)	72,100 (petroleum refining, NAICS 32411)	289,400 (support activities for oil and gas operations NAICS 213112)	88,100 (support activities for mining except oil and gas=support activities for mining, NAICS 213 - support activities for oil and gas NAICS 213112)	96,300 (fossil fuel electric power generation, NAICS 22112)	114,100 (natural gas distribution, NAICS 2212)
1a. Scaled employment, total	65,500 (=row1)	191,700 (=row1)	54,796 (= row1*0.76, source: https://www.eia.gov/tools/faqs/faq.cfm?id=41&t=6)	289,400 (=row1)	29,073 (=row1 * 0.33 proportion of coal miners in total mining except oil and gas employment)	25,038 (=row1 * 0.26 proportion of industry workers in relevant installation, maintenance and repair occupations 49-000 http://www.bls.gov/oes/current/naics5_221112.htm	114,100 (=row1)
2. Job Losses over 20-year transition	39,300 (assuming 60% production decline)	76,680 (assuming 40% production decline)	21,918 (assuming 40% production decline	115,760 (assuming 40% production decline)	17,444 (assuming 60% production decline)	12,500 (assuming 50% contraction)	45,640 (assuming 40% contraction)
3. Average annual job losses over 20-year decline (=row2/20)	1,965	3,834	1,096	5,788	872	625	2,282

Table A2.1. The Two Sources of Pension Fund Data for U.S. Public Corporations

	ERISA	**SEC**
Primary Audience	Regulators	Investors
Includes projections of future benefits	No	Yes
Unit of observation	Pension plans, by firm or industry	Individual Firms
Universe covered	All US pension plans	Consolidated pension obligations of US publicly-traded companies
Most recent year available	2013	2015

Table A2.2. Oil and Gas Industry:
Sources on Pension Funds and Related Financial Data

	Unfunded pension liability (Notes to the financial statements)	**Net income** (Income statement)	**Dividends and share repurchases 2015** (Statement of cash flows)
ExxonMobil https://www.sec.gov/Archives/edgar/data/34088/000003408816000065/xom10k2015.htm	Note 17, p. 86	p. 63	p. 66
Chevron https://www.sec.gov/Archives/edgar/data/93410/000009341016000049/cvx-123115x10kdoc.htm	Note 23, p. FS-52	p. FS-23	p. FS-26
ConocoPhillips https://www.sec.gov/Archives/edgar/data/1163165/000119312516472901/d145414d10k.htm	Note 18, p. 116	p. 81	p. 84
Anadarko Petroleum https://www.sec.gov/Archives/edgar/data/1163165/000119312516472901/d145414d10k.htm	Note 16, p. 128	p. 86	p. 90
Devon Energy https://www.sec.gov/Archives/edgar/data/1090012/000119312516466687/0001193125-16-466687-index.htm	Note 15, p. 95	p. 58	p. 59

Table A2.3. Coal Industry:
Sources on Pension Funds and Related Financial Data

	Unfunded pension liability (Notes to the financial statements)	**Net income** (Income statement)	**Dividends and share repurchases 2015** (Statement of cash flows)
Peabody Energy https://www.sec.gov/Archives/edgar/data/1064728/000106472816000157/btu-20151231x10k.htm	Note 15, p. f-49	p. f-2	p. f-6
Arch Coal https://www.sec.gov/Archives/edgar/data/1037676/000110465916105176/a15-23239_210k.htm	Note 21, p. f-40	p. f-5	0 p. f-8
Cloud Peak Energy https://www.sec.gov/Archives/edgar/data/1441849/000110465916097811/a15-23313_110k.htm	Not applicable	p. 77	p. 80
Alpha Natural Resources https://www.sec.gov/Archives/edgar/data/1301063/000130106315000015/anr-12312014x10k.htm	p. 130	p. 93	p. 96
Alliance Resource Partners https://www.sec.gov/Archives/edgar/data/1086600/000110465916100435/a15-23386_110k.htm	p. 102	p. 74	p. 76

Table A2.4. Utilities Industry:
Sources on Pension Funds and Related Financial Data

	Unfunded pension liability (Notes to the financial statements)	**Net income** (Income statement)	**Dividends and share repurchases 2015**[1] (Statement of cash flows)
Duke Energy https://www.sec.gov/Archives/edgar/data/17797/000132616016000221/duk-20151231x10k.htm	Note 21, p. 205	p. 87	p. 89
Southern Co https://www.sec.gov/Archives/edgar/data/3153/000009212216000126/so_10-kx12312015.htm	Note 2, p. ii-72	p. ii-52	p. ii-54
Exelon https://www.sec.gov/Archives/edgar/data/9466/000119312516457652/d129102d10k.htm	Note 14, p. 367	p. 201	p. 202
Berkshire Hathaway Energy https://www.sec.gov/Archives/edgar/data/71180/000108131616000023/bhe123115form10-kcombined.htm	Note 12, p. 149	p. 115	Not applicable
PG&E https://www.sec.gov/Archives/edgar/data/75488/000100498016000065/form10k.htm	Note 11, p. 110	p. 69	p. 73

Table A2.5. Fossil Fuels Support Industry:
Sources on Pension Funds and Related Financial Data

	Unfunded pension liability (Notes to the financial statements)	**Net income** (Income statement)	**Dividends and share repurchases 2015** (Statement of cash flows)
Schlumberger https://www.sec.gov/Archives/edgar/data/87347/000156459016012009/slb-10k_20151231.htm	Note 18, p. 57	p. 32	p. 35
Halliburton https://www.sec.gov/Archives/edgar/data/45012/000004501216000272/hal_12312015-10k.htm	Note 15, p. 71	p. 45	p. 48
Baker Hughes https://www.sec.gov/Archives/edgar/data/808362/000080836216000053/0000808362-16-000053-index.htm	Note 13, p. 70	p. 45	p. 49
National Oilwell Varco https://www.sec.gov/Archives/edgar/data/1021860/000119312516469696/d118658d10k.htm	Note 10, p. 90	p. 71	p. 73
Weatherford International https://www.sec.gov/Archives/edgar/data/1603923/000160392316000144/wft201510-k.htm	Note 19, p. 76	p. 45	p. 53