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Matching Geographies and Job Skills in the Energy Transition

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Abstract

Driven by technological innovation, public policy, and other factors, the US energy system is facing rapid changes, raising concerns over potential job losses, particularly among fossil fuel workers. Because there will be considerable variation across the United States in the employment impacts of a changing energy landscape, policies must be tailored to local contexts. This analysis develops and implements a tool to help policymakers understand the localized opportunities and challenges that the US energy workforce may face in the years ahead. We first identify the exposure of local labor markets to job displacement in fossil fuel extraction, transportation, processing, and electricity industries. We then develop an empirical framework that assesses the extent to which the skill sets of existing fossil energy workers are a good match for growing job opportunities with similar pay in their local labor markets. We document substantial differences across local labor markets in terms of the demographics of local fossil fuel workforces, the skills they have attained from their current work, and how well these skills align with those in demand locally over the coming decade. We find that, with the exception of technical skills, the skills important to fossil fuel jobs typically are not the same as those necessary for fast-growing occupations with similar levels of pay, many of which require extensive service-oriented and management skills. Our methodology and associated analytical tools can be readily used to provide locally tailored information about skills gaps between the existing fossil energy workforce and in-demand sectors, suggesting areas where workforce development may bear the most fruit.

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1. Introduction

Recent technological-driven changes in the US energy system, coupled with the imperative of reducing greenhouse gas (GHG) emissions, have focused attention on who will bear the costs of the energy transition in the United States and how those costs can be minimized. A core concern is how measures to reduce US emissions will affect employment, particularly in regions where fossil fuel–related employment is highly concentrated geographically.

Governments in the United States and around the world have undertaken initiatives to support economic and workforce development in energy communities (e.g., JTAC 2020; Furnaro et al. 2021; IWG 2021), but extending these efforts across the United States will require a more detailed understanding of the local contexts in which workers may transition to new industries. Although numerous analyses offer high-level guidance on the types of policies and community organizing efforts necessary to support an equitable transition (e.g., Cha et al. 2020; Look et al. 2021; Ravikumar and Latimer 2022), existing research does not provide sufficiently detailed regional or industry-level analysis to enable the formulation of locally tailored policy responses.

Although several recent studies have estimated that a rapid reduction in greenhouse gas emissions would increase energy jobs on net (e.g., Brown and Ahmadi 2019; Pai et al. 2021), these analyses use modeling tools that do not account for local labor market dynamics. What's more, they do not examine whether new energy jobs are a good match for existing skill sets nor whether those new jobs emerge in regions that are negatively affected by a transition away from fossil fuels. This potential for a mismatch of job skills and regional differences in job growth and displacement could be compounded by the decline in geographic mobility over the past four decades, including by displaced workers unwilling or unable to relocate for new jobs elsewhere in the United States (e.g., Dao et al. 2017).

In this analysis, we first take a highly localized and industry-specific approach to examining potential fossil fuel–related job displacement in the United States. We then assess the degree to which the current skill sets of workers in energy communities match the skills needed in the economic sectors expected to grow most quickly in those areas. This analysis provides a novel assessment of the potential effects of the energy transition on the US workforce and seeks to inform place-based policies that can address local challenges and opportunities.

2. Related Research

While several studies have explored the historical and projected employment effects of decarbonization in the United States, few have taken a regional focus—especially across the entire nation. We are unaware of any published empirical work estimating the extent of the skills match (or mismatch) around the fossil fuel jobs that may be displaced due to decarbonization and the potential replacement employment opportunities. Still, a large body of evidence provides context and some intuition for our analysis.

2.1. Energy and Environmental Analysis

Researchers have examined the employment effects of a wide range of energy and environmental policies such as the Clean Air Act. For example, Greenstone (2002) finds that during the first 15 years of the Clean Air Act, nonattainment counties subject to greater regulatory oversight lost nearly 600,000 jobs, $77 billion in capital stock, and $156 billion of output (in 2021$) in pollution-intensive industries. Looking at the Clean Air Act Amendments of 1990, Walker (2011) uses plant-level data to estimate that changes in county-level regulatory status reduced the size of the regulated sector by as much as 15 percent in the 10 years following the changes. In later work, Walker (2013) finds that workers in newly regulated plants experienced, in aggregate, more than $6.4 billion (2021$) in forgone earnings due to displacement and lower earnings in future employment.

Prospective work that models the effects of climate policies on employment has mostly found more positive outcomes but tends to rely on optimistic assumptions about the ability of the workforce to take advantage of new jobs in the clean energy economy. For example, a worldwide simulation by Montt et al. (2018) based on a multiregional input–output database finds that most economies will experience net job creation and reallocation across industries under a scenario that limits global average temperature increase below 2°C, with job growth driven by the construction, manufacturing, and renewable energy sectors. Pai et al. (2021) estimate the employment effects of an energy transition across nearly 50 countries and five job categories (construction and installation, operations and maintenance, manufacturing, fuel production, and refining) under a scenario that limits global warming to below 2°C by 2100. Using energy data output from an integrated assessment model, they find that a rapid decline in fossil fuel jobs due to decreased production is compensated by gains in solar and wind jobs, particularly in manufacturing.

Mayfield and Jenkins (2021) model the costs of wind and solar deployment to achieve net-zero emissions by 2050 and estimate that increasing worker compensation along with domestic shares of clean energy manufacturing would have little to no effect on system-wide transition costs. Similarly, Vanatta et al.

(2022) use modeling tools to estimate that all coal-fired power plant jobs could be replaced by solar and wind jobs in the same regions at low system-wide costs (though this estimate does not account for retraining costs).

Brown and Ahmadi (2019) use the National Energy Modeling System to estimate the effects on the United States of a carbon price of $25 and $60 per metric ton of CO_2 (increasing annually by 5 percent plus inflation) matched by a reduction in personal income tax rates. They find that the $25 carbon tax would boost net employment nationally by 1.4 million jobs each year between 2020 and 2030, while the $60 tax would result in less (but still positive) net job growth because of more fossil fuel supply job losses. They also report that most US regions would experience net job gains, but they do not carry out state- or local-level analysis.

Shapiro and Metcalf (2021) use a model that includes endogenous labor force participation and allows businesses to adjust in multiple ways to a carbon price that reduces US emissions by 35 percent by 2035. They find positive effects on overall economic growth, along with small reductions in employment and labor force participation rates.

Although these modeling studies find positive (or only modestly negative) effects on employment, they make simplifying assumptions that do not account for important social and labor market dynamics that will surely affect outcomes for workers and communities (Hafstead et al. 2022). For example, there is variation in the "stickiness" of local employment markets. Consider oil extraction workers in the Bakken region of North Dakota, many of whom relocated there specifically for those jobs, versus workers in West Virginia who are third- or fourth-generation coal miners. Indeed, Weber (2020) finds that a large proportion of laid-off coal miners in Appalachia did not move after displacement, contributing to county-level incomes declining by roughly $100,000 per job displaced.

Although there is considerable opportunity for new jobs in clean energy and related technologies, job growth in these sectors may not occur in regions where fossil jobs are being lost. In research on the effects of the American Recovery and Reinvestment Act, Popp et al. (2020) find that although each $1 million of "green" stimulus created 15 new jobs between 2013 and 2017, there is little evidence of significant short-run employment gains or wage increases, and more jobs were created in commuting zones with more preexisting green skills.[1]

In a recent working paper, Curtis and Marinescu (2022) characterize "green jobs" across the United States using a near-comprehensive database of job listings. They find that green jobs are typically created in occupations that pay 21 percent more than other jobs, and that many of these jobs are located in regions with substantial fossil fuel extraction, particularly in Texas, Oklahoma, and parts of the Intermountain

[1] Popp and colleagues rely on a definition of "green" skills by Vona et al. (2018), who developed a method to identify a set of skills for green jobs that differ from those for other jobs.

West. However, fossil fuel workers may not have the necessary skill sets to take advantage of these employment opportunities. Indeed, Popp et al. (2022) argue in another recent working paper that innovation in technologies and workforce development are needed to facilitate a rapid transition to a clean energy economy.

Focusing on the oil and gas sector, Ravikumar and Latimer (2022) argue that regional variation in jobs and workforce skills necessitates a transition that "reflect[s] the diversity of the needs of oil and gas workers and their communities." They suggest locally tailored responses, such as the creation of regional planning authorities that enact federally supported policies in collaboration with state legislatures.

To our knowledge, our quantitative method provides the first region- and industry-specific analysis that can produce the type of labor market information needed to successfully implement the locally tailored workforce development efforts called for by experts across the literature (Cha et al. 2020; Look et al. 2021; Ravikumar and Latimer 2022).

2.2. Broader US Labor Market Dynamics

Even before the increase during the COVID-19 pandemic, the United States had relatively high levels of job turnover. Compared with other OECD countries, the United States has historically had a much higher job-finding rate and relatively high separation rate (Hobijn and Şahin 2009). At first blush, this may suggest that workers displaced by an energy transition could find work in growing sectors relatively easily. In Germany, Gathmann et al. (2020) report that workers younger than 50 suffer no long-term employment losses following mass layoffs, as geographic mobility fully shields them from the decline in local employment opportunities.

Of course, social policy, labor market dynamics, and many other factors distinguish the United States from Germany. As noted in Section 2.1, Weber (2020) find very limited geographic mobility following job losses in Appalachian coal country. In general, geographic mobility has declined in the United States since the 1990s. Molloy and Smith (2019) report that the share of individuals who moved within the United States during a year fell from 17 percent in the 1980s to 10 percent in 2017, and longer-distance moves, which are more likely to be between different labor markets, declined from 3 to 1.5 percent in this time. Dao et al. (2017) find that the cross-state migration response to local labor demand shocks declined after 1990. More recent analyses of increased trade with China (Autor et al. 2021), the Great Recession (Yagan 2019), and several recessions between 1973 and 2009 (Hershbein and Stuart, 2021) also observe that large adverse shocks to local labor markets led to lower employment or labor force participation but little outmigration.

These types of economic shocks have created large and long-lasting negative impacts on both workers and communities in the United States. Analyzing job losses between 2008 and 2010, Lachowska et al. (2020) find that workers' earnings were, on average, 15 percent lower five years after displacement. At a regional scale, Blanchard and Katz (1992) and Dao et al. (2017) both report that states that experience adverse employment shocks have permanently lower employment trajectories. In addition, the potential for workers to relocate does not address community-wide concerns (e.g., funding public services for those who remain), which may be particularly stark where many fossil energy jobs and public revenues are geographically concentrated (Raimi et al. 2022a).

In the energy sector and broadly across the US economy, a variety of factors are rapidly shaping the future of work. Widespread automation and digitization, the evolving local impacts of trade, a rise in remote work, and many other factors suggest the need for a broader exploration of future job growth for those who may be displaced in an energy transition. These factors, along with energy-specific issues, particularly the need to rapidly reduce greenhouse gas emissions, are crucial areas of inquiry to inform policymaking in the energy sector.

In this analysis, we contribute to the evidence base by assessing the skills that fossil fuel workers already have and how these compare with the skills needed to take advantage of nearby job opportunities. Understanding how the detailed geographic distribution of these existing workforce skills lines up with local job growth can help decisionmakers tailor place-based workforce and industrial policies for specific areas.

3. Data and Methods

This section provides information on the key data sources used in our analysis, followed by a description of how we use these data to develop our analytical tool.

3.1. Workforce Data

3.1.1. Jobs Impact by Industry

A transition to a net-zero energy system will have different implications for different fuels over multiple decades. However, scenarios that model deep emissions reductions by midcentury envision lower demand for the three fossil fuels—coal, oil, and natural gas—to varying degrees in the decades ahead (Raimi et al. 2022b).

We focus on industries that are directly involved in the extraction, transportation, and processing of fossil fuels, as well as fossil-fired electricity generation. Industries are defined using the North American Industry Classification System (NAICS), which groups all commercial establishments into a six-level hierarchy of industries based on the production activity in which they are primarily engaged and their usage of raw

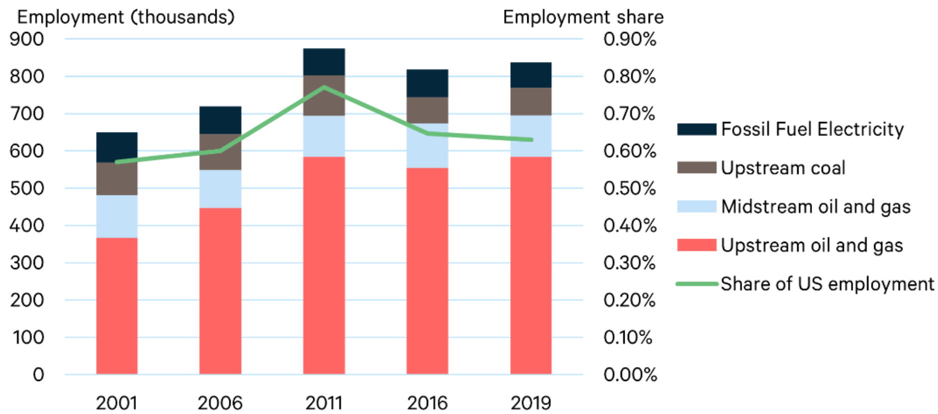
materials, capital equipment, and labor inputs. We then aggregate these industries into four groups based on similar final products and production processes: upstream oil and natural gas, upstream coal, midstream oil and natural gas, and fossil-fired electricity generation.

Table 1. Fossil Fuel Jobs Included in This Analysis

Industry Name	NAICS Code
Upstream Oil and Natural Gas	
Crude Petroleum and Natural Gas Extraction	211111
Natural Gas Liquid Extraction	211112
Drilling Oil and Gas Wells	213111
Support Activities for Oil and Gas Operations	213112
Oil and Gas Field Machinery Manufacturing	333132
Upstream Coal	
Bituminous Coal and Lignite Surface Mining	212111
Bituminous Coal Underground Mining	212112
Anthracite Mining	212113
Support Activities for Coal Mining	213113
Mining Machinery and Equipment Manufacturing	333131
Midstream Oil and Natural Gas	
Petroleum Refineries	324110
Pipeline Transportation of Crude Oil	486110
Pipeline Transportation of Natural Gas	486210
Pipeline Transportation of Refined Petroleum Products	486910
All Other Pipeline Transportation	486990
Electricity	
Fossil Fuel Electric Power Generation	221112

In 2019, these groups made up 0.63 percent of private sector employment nationally—roughly 840,000 jobs. As shown in Figure 1, these numbers have varied moderately in recent years, with the employment share ranging from a low of 0.57 percent to a high of 0.77 percent (note that these figures include only direct employment and do not account for indirect and induced jobs). Nationally, the majority of jobs are in the oil and gas sector, particularly upstream (Figure 1).

Figure 1. US Fossil Fuel Employment, 2001–2019



Source: Data from US Census Bureau (2022).

Decarbonization policies will have uneven impacts across these industries. For example, carbon-pricing policies or emissions intensity–based standards can be expected to reduce high-emissions fuels such as coal more than less emissions-intensive sectors such natural gas (assuming methane leaks are kept to low levels). We account for these differences across fuels by following a scenario produced by energy company BP (2022) that achieves net-zero emissions globally by 2050.[2] Because changes in employment are not provided in these scenarios, we make the simplifying assumption that employment changes proportionally with changes in energy use of the related product. Because labor productivity growth is expected to continue across all industries, we view these as lower-bound estimates of job loss under this particular net-zero scenario.

[2] See the appendix for details.

Table 2. Assumed Employment Reductions in 2050 under a Net-Zero Scenario

Industry	Estimated Job Loss
Upstream Oil and Natural Gas	-76.0%
Midstream Oil and Natural Gas	-88.3%
Upstream Coal	-98.3%
Fossil Fuel Electricity	-85.0%

Source: Energy data from BP (2022). We assume that employment changes in direct proportion with the relevant fossil fuel activity

Finally, note that while we focus on the direct employment impacts of decarbonization policies on fossil fuel jobs, there are also indirect impacts on employment in other sectors, and these serve as inputs to affected sectors or rely on consumption from fossil fuel workers. However, these indirect impacts are difficult to estimate precisely, especially at the regional level. We therefore focus on direct employment impacts, which can again be taken as a lower bound of the overall jobs impact of decarbonization policies.

3.1.2. Measuring Local Employment

To understand how an energy transition might play out in different labor markets, we must first define their geographic boundaries. Here we use commuting zones (CZs), which combine counties into 658 groupings. CZs were originally developed by the US Department of Agriculture to reflect where people live and work, based on hierarchical cluster analysis and the US Census Bureau's journey to work data (Fowler et al. 2016). Bartik (2021) argues that CZs define a local labor market better than counties because of employment spillovers across counties within a CZ.

We construct a CZ-level employment data set by aggregating county-level data for employment by NAICS code from the US Census Bureau's County Business Patterns (CBP) data set. The CBP data are extracted from the Business Register, a database of all known single- and multiestablishment employer companies maintained and updated by the US Census Bureau that contains the most complete, current, and consistent data for business establishments.[3] However, CBP data are often suppressed for confidentiality reasons in small counties and industries, which is

[3] The CBP data series excludes self-employed individuals, employees of private households, railroads, agricultural production, and most government positions, as well as businesses operating without an EIN or with an EIN but without employees. Note that since these data are collected by employers, an individual with multiple jobs at different employers will be double-counted.

particularly challenging for this analysis because many regions where fossil fuel production is concentrated are rural, and thus their data may be suppressed. We therefore use the WholeData series produced by the W. E. Upjohn Institute for Employment Research, a version of the CBP data that uses a linear programming algorithm to impute most of the suppressed county-industry employment data (Bartik et al. 2018).[4] These data are available only up until 2016, which is a limitation of our analysis.[5]

3.2. Job Skills

The goal of this analysis is to understand how the existing skill sets of workers in different jobs related to fossil fuel extraction, processing, transportation, and electric power generation compare with the skills required for future nearby job openings. This requires calculating separately the skills attained by current fossil fuel workers in each CZ and the skills required for future job openings in the CZ. This section describes our methodology used to estimate these values and the components of the estimation process.

3.2.1. Occupational Composition of Industries

To determine the skills possessed by fossil fuel workers at risk of displacement, we need to measure the specific occupations among the fossil fuel workforce in each CZ. We use occupational definitions from the Standard Occupational Classification (SOC) system from the US Bureau of Labor Statistics (BLS 2022) and measure future job displacement using estimates shown in Table 2. For each occupation j in each CZ c, we calculate $OccEmpShare_{j,c}$ by multiplying two different employment statistics:

- The share of workers in each fossil fuel industry *i* (see Table 1) that are in each occupation *j*. For example, 6.3 percent of Anthracite Mining (NAICS 212113) employees in the United States work as Roof Bolters, Mining (SOC 47-5043).
- The share of all at-risk fossil fuel jobs in a CZ that are in each industry. For example, 28.4 percent of at-risk fossil fuel jobs in the CZ consisting of Berks-Lehigh-Northampton Counties, Pennsylvania, are in anthracite mining. Note that the shares of at-risk fossil fuel jobs are based on the assumed employment reductions for each industry listed in Table 2.

[4] However, this algorithm is still unable to impute jobs into all industries: the county-level data at the NAICS6 level include 23,550 fewer total jobs than the county-level data totaled across all sectors.
[5] Beginning with the 2017 CBP data, the Census Bureau modified the data privacy methods in a way that made imputation impossible.

Multiplying these figures provides an estimate that Roof Bolters, Mining (SOC 47-5043), account for 1.8 percent (6.3% * 28.4%) of at-risk fossil fuel jobs in the Berks-Lehigh-Northampton Counties, Pennsylvania, CZ.

Our estimates are calculated using national-level data on the occupation shares in each industry from the BLS "May 2019 National Industry-Specific Occupational Employment and Wage Estimates" (BLS 2020). Although using data on occupation by industry at a more precise geographic level would be ideal, such estimates are potentially out-of-date (e.g., decennial census data from 2010) or unrepresentative due to sampling restrictions. Moreover, other data sources do not have sufficiently granular occupational or industrial classifications to provide information on all industries of interest, though even in the BLS data for some industries, the occupational composition must be estimated from higher-level aggregations.[6]

In general, the more granular occupational classifications available at the national level allow for more precise calculations of average skill attainment for a CZ, though potentially at the cost of losing information about location-specific occupational composition of industries. While it is possible that there is some variation in occupational composition by industry among different areas of the United States—for example, if more coal-mining company headquarters are located in West Virginia than in Montana, and the former therefore has a higher share of employees in executive management positions—it is unlikely that this variation is substantial enough to significantly bias calculations of average skill attainment. CZ-level data on the share of employment in each industry from the CBP are combined with these national-level industry occupational composition data to produce CZ-specific estimates of occupational composition in fossil fuel industries.

3.2.2. Skills Requirements of Each Job

In this analysis, we assume that the skill requirements for each occupation are good indicators of the skills that workers in the relevant industry have attained or will need to be hired in that job. Data on the skills required for each occupation are available from the Occupational Information Network (O*NET), developed under the sponsorship of the US Department of Labor's Employment and Training Administration (Handel 2016). [7]

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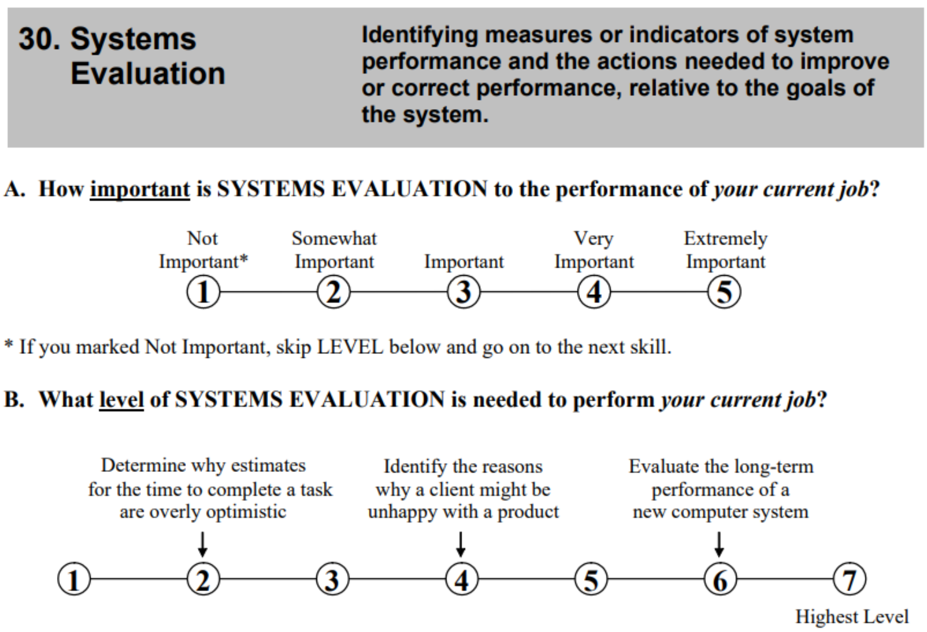
[6] Of the 16 fossil fuel industries of interest, most (13) have BLS occupational composition data at the four-digit NAICS level, 1 industry (NAICS 221112) has data at the six-digit NAICS level, and 2 have data at the three-digit NAICS level. This means that, for example, the same occupational composition data are used for bituminous coal underground mining as for anthracite mining.

[7] We focus on job skills, defined by O*NET as the ability to perform a task well and developed over time through training or experience, given the transferability of skills across occupations and for ease of analysis. However, an alternative dimension of job transitions that could be examined is the level of overlap among jobs in the tasks that are typically performed in each occupation, for example by using O*NET data on 'work activities'.

O*NET skills data are based on ratings (on a scale of 1 to 5) of the *importance* of 35 specific skills to the performance of a specific occupation, as well as ratings (on a scale of 1 to 7) of the *level* of these skills needed to perform the occupation (see the appendix for details). Ratings are made by trained occupational analysts, who consider job titles, descriptions, and other factors (Fleisher and Tsacoumis 2012).

Figure 2 provides an example of the skill questionnaire used in O*NET ratings, in this case for the systems evaluation skill, which entails the ability to assess the performance of a given system (e.g., a rotary drilling rig) and to diagnose and solve problems associated with that system. It asks the respondent to rate how important the skill of systems evaluation is to the job, as well as the level of this skill that is needed to perform the job.

Figure 2. Sample Questionnaire Used to Generate O*Net Data


30. Systems Evaluation — **Identifying measures or indicators of system performance and the actions needed to improve or correct performance, relative to the goals of the system.**

A. How <u>important</u> is SYSTEMS EVALUATION to the performance of *your current job*?

Not Important* ① — Somewhat Important ② — Important ③ — Very Important ④ — Extremely Important ⑤

* If you marked Not Important, skip LEVEL below and go on to the next skill.

B. What <u>level</u> of SYSTEMS EVALUATION is needed to perform *your current job*?

① — ② Determine why estimates for the time to complete a task are overly optimistic — ③ — ④ Identify the reasons why a client might be unhappy with a product — ⑤ — ⑥ Evaluate the long-term performance of a new computer system — ⑦ Highest Level

Source: Reproduced from O*NET Resource Center (2021).

For this analysis, we combine the *level* and *importance* indicators to create a single score for each skill. We first standardize the two indicators on a scale ranging from 0 to 1, using a modified version of the process suggested by O*NET.[8]

$$StandardizedScore_{s,imp\ |level} = \frac{OriginalRawScore - MinimumScore}{MaximumScore - MinimumScore}$$

where $StandardizedScore_{s,imp\ |level}$ is the standardized score for each skill *s* on either of the two indicators, $MinimumScore$ is the lowest possible score on the

[8] Standardization process described under "How do you calculate standard scores for the database variables?" at **https://www.onetcenter.org/faq.html.**

rating scale used, and $MaximumScore$ is the highest possible score on the rating scale used. For example, an original importance rating score of 3 is converted to a standardized score of 0.50 ($= (\frac{3-1}{5-1})$), while an original level rating score of 5 is converted to a standardized score of 0.67 ($= (\frac{5-1}{7-1})$). The single score for each skill *s*, with possible values ranging from 0 to 1, is then calculated as

$$SkillRating_s = StandardizedScore_{s,imp} * \ StandardizedScore_{s,level}$$

3.2.3. Attained Skills of Current Fossil Fuel Workers

One indication of the skills already attained by workers is those skills required for the jobs in which they already are employed. To assess the attained skills of the fossil fuel workforce, we calculate a weighted average skill attainment for each of the 35 skills s and for each commuting zone c:

$$\overline{AvgSkillAttainment_{s,c}} = \sum_{j=1}^{J} OccEmpShare_{j,c} * SkillRating_s$$

where $OccEmpShare_{j,c}$ is the share of each occupation in total fossil fuel employment in the commuting zone, and $SkillRating_s$ is calculated as the product of the (standardized) ratings of importance and required level for each skill (both as described in Section 3.2.2). This calculation provides an estimate of the skill composition of the fossil fuel workforce in each CZ.

If future researchers wish to examine specific industries in a given region (e.g., Wyoming), they could use a similar approach but limit their analysis to the occupations that make up the specific industry of interest (e.g., coal mining).

3.2.4. In-Demand Skills from Local Job Forecasts

To assess whether, and to what extent, the current skills of the fossil fuel workforce are a good match for future employment opportunities, we need information on which sectors and employment opportunities are expected to grow in each region. For this we turn to projected growth by occupation from the US Department of Labor State Employment Projections Managing Partnership (PMP 2022). These employment projections are developed by each state under sponsorship of the US Department of Labor and are currently available for 2018–28. Unfortunately, employment projections are not publicly available at the county or CZ level. We instead rely on state-level forecasts of jobs growth by occupation, which we match to CZs based on the state that contains the majority of counties within a CZ.

Because displaced workers will naturally seek opportunities with similar levels of compensation, we focus on the subset of jobs for which the salary is at least 90 percent as high as the displaced job. We therefore calculate in-demand skills in each CZ as those required for projected openings in occupations with average salaries at

least 90 percent as high as the average salary of fossil fuel workers in that CZ. Future analysis could adjust this constraint to either expand or narrow the range of employment opportunities based on the associated salaries.

The average in-demand rating for skill s of projected job openings in commuting zone c is calculated as

$$\overline{AvgInDemandSkill}_{s,c} = \sum_{j}^{J} SkillRating_{s,j,c} * OccEmpGrowthShare_{j,c}$$

Given $Salary_{j,c}$, the 2019 mean salary for an occupation j in the state in which CZ c is located, and $AvgSalary_c$, the average salary among fossil fuel workers in c, then

$$OccEmpShare_{j,c} = \begin{cases} \text{share of local openings in occupation j if } Salary_{j,c} \geq 0.9 * AvgSalary_c \\ \text{otherwise } 0 \end{cases}$$

In effect, we calculate the average level of each skill in demand for all jobs in a given CZ that pay average salaries near or above the average salary for fossil fuel workers in that CZ. The aggregate estimates of in-demand skills for each CZ are weighted by the share of projected growth in each job in a given CZ. For example, if job A were projected to provide twice the share of new employment opportunities as job B in a CZ, the skills associated with in-demand job A would be assigned twice the weight of the skills associated with in-demand job B.

Across the United States, the jobs with the largest aggregate projected growth are fast food and counter workers, home health and personal care aides, and cashiers. When we restrict the sample to only those jobs that pay 90 percent or more of the nationwide average of the fossil fuel jobs in our sample (roughly $75,000), the jobs with the largest aggregate projected growth are general and operations managers, registered nurses, and software developers and quality assurance analysts. Finally, when we restrict the sample to the 45 CZs where at-risk fossil fuel jobs accounted for 5 percent or more of total employment in 2016, the jobs with the largest aggregate projected growth that meet or exceed 90 percent of the average fossil fuel worker's salary are general and operations managers, management analysts, and financial managers.

As one example, in the CZ formed by Terrebonne, Lafourche, and St. Mary parishes on the Gulf Coast of Louisiana, the average annual salary for fossil fuel workers is $53,973. There are several occupations with average salaries that meet or exceed 90 percent of that level and are projected to grow strongly through 2028, such as carpenters (average salary $49,790), first-line supervisors of office and administrative support workers ($62,900), and lodging managers ($81,480).

3.2.5. Matching Existing and Future Skills

This section provides a description of the data sources and methods we use to assess the match between fossil fuel workers' attained skills and the projected in-demand skills in their CZ. Because it is difficult to interpret the potential match between the 35 skills included in O*NET, we aggregate them into the seven categories presented in Table 3. For each of these seven aggregate skills, we take a simple average of the ratings of the skills within each group (see the appendix for which skills are included in each group).

Table 3. Aggregate O*Net Skill Descriptions

Skill Name	Definition of Aggregate Skill
Content	Background structures needed to work with and acquire more specific skills in a variety of different domains
Process	Procedures that contribute to the more rapid acquisition of knowledge and skill across a variety of domains
Social	Developed capacities used to work with people to achieve goals
Complex problem-solving	Developed capacities used to solve novel, ill-defined problems in complex, real-world settings
Technical	Developed capacities used to design, set-up, operate, and correct malfunctions involving application of machines or technological systems
Systems	Developed capacities used to understand, monitor, and improve socio-technical systems
Resource management	Developed capacities used to allocate resources efficiently

In the following section, we apply the methodology described in Section 3 to measure the extent of the match (or mismatch) between the current skill sets of fossil fuel workers in each CZ with the skill sets projected to be in demand through 2028. For each of the seven aggregate skills listed in Table 3, we calculate a "skills mismatch" by subtracting the attained skill rating from the in-demand skill rating in each CZ with fossil fuel employment. We create an overall measure of skills mismatch in each CZ across all seven aggregate skills by summing these differences.

Under this approach, larger values indicate a larger gap between the attained skills of the fossil fuel workforce in a CZ and the skills required to take advantage of growing job opportunities that pay at least 90 percent as well. The approach also has the potential to result in a negative value for some CZs. A negative value would indicate that the

attained skills of the fossil fuel workforce exceed, on aggregate, the skills required for jobs that are projected to grow in that CZ and pay at least 90 percent as well.

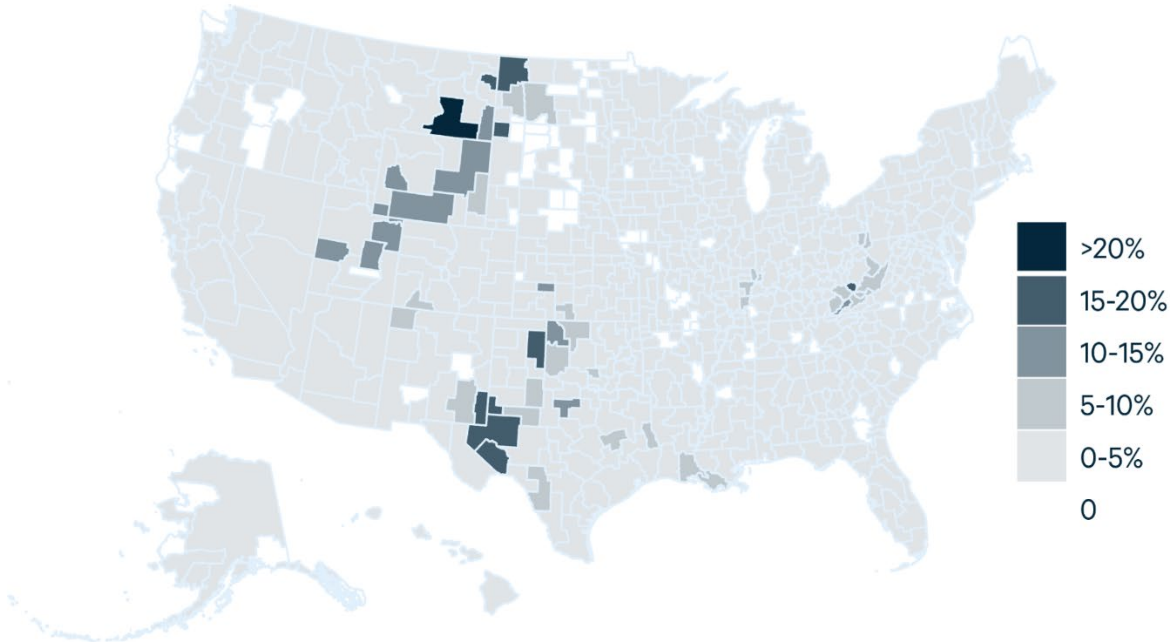
4. Results and Discussion

In this section, we present the key results of our analysis. First, we identify CZs with a large proportion of fossil fuel jobs at risk under a net-zero scenario. Second, we provide results on the extent of the match (or mismatch) between job skills for fossil fuel workers and in-demand job skills. Third, we focus on the skills gap in eight regions from across the United States where fossil fuel activities play a large role in the local economy. Fourth, we estimate relevant demographic information on the fossil fuel workforces in each CZ, which can help inform policymakers and others when considering geographically targeted approaches to economic and workforce development. Finally, we consider the broader applicability of our approach and current research needs.

4.1. Nationwide Fossil Fuel Employment

Nationally, fossil fuel jobs account for less than 1 percent of direct total employment in the United States. However, national-level data mask significant regional variation, with fossil fuel jobs accounting for more than 10 or 20 percent in some CZs. Figure 3 visualizes the proportion of total jobs that would be lost in each CZ under the net-zero scenario as a result of declining fossil fuel production, transportation, processing, and use for power generation. It does not account for job creation that would likely occur as a result of increased deployment of clean energy.

Figure 3. Fossil Fuel Employment at Risk by 2050 under a Net-Zero Scenario



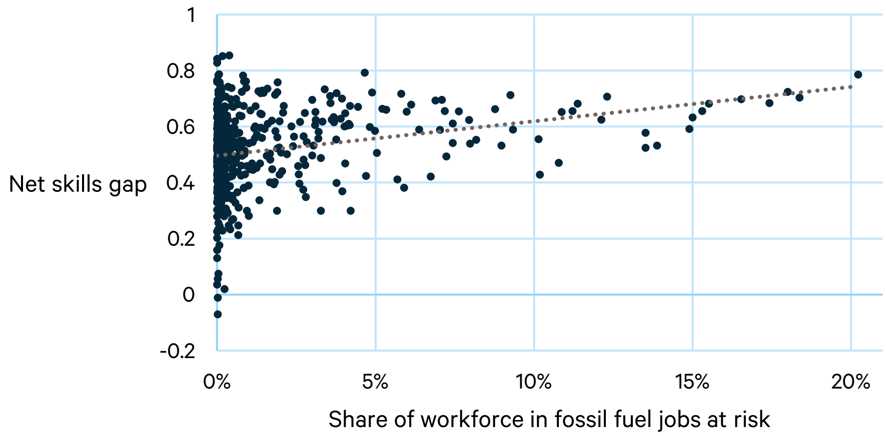
Notes: Employment data from Bartik et al. (2018) version of 2016 US Census Bureau County Business Patterns data.

The CZs with the largest share of jobs at risk are concentrated in four primary regions: the Intermountain West, Texas/Oklahoma, the Gulf Coast, and Appalachia. For much of Appalachia and the Intermountain West, this reflects a substantial dependence on coal extraction and, for some CZs, coal-fired power plants. For Texas/Oklahoma and the Gulf Coast, oil and gas extraction, transportation, and refining are leading contributors to employment.

4.2. Skills Matching

Next, we present nationwide results illustrating the extent of the match between fossil fuel workers' attained skills and the in-demand skills for job openings that pay at least 90 percent, as well as fossil fuel jobs in each CZ. To begin, we present a simplified measure of skills mismatch that sums the skills mismatch across all seven aggregate skills (described in Section 3.2.5) for every CZ with fossil fuel employment. Figure 4 illustrates our results, with the net skills gap (e.g., the size of the mismatch) on the *y*-axis and the share of jobs at risk under our net-zero scenario on the *x*-axis. In general, CZs with a higher share of jobs at risk also demonstrate a larger mismatch in skills. This indicates that CZs that are most dependent on fossil fuel jobs tend to have larger skills mismatches than those that are less dependent on fossil fuel jobs, although the correlation is weak (R^2 = 0.07).

Figure 4. Skills Mismatch and Jobs at Risk for All CZs

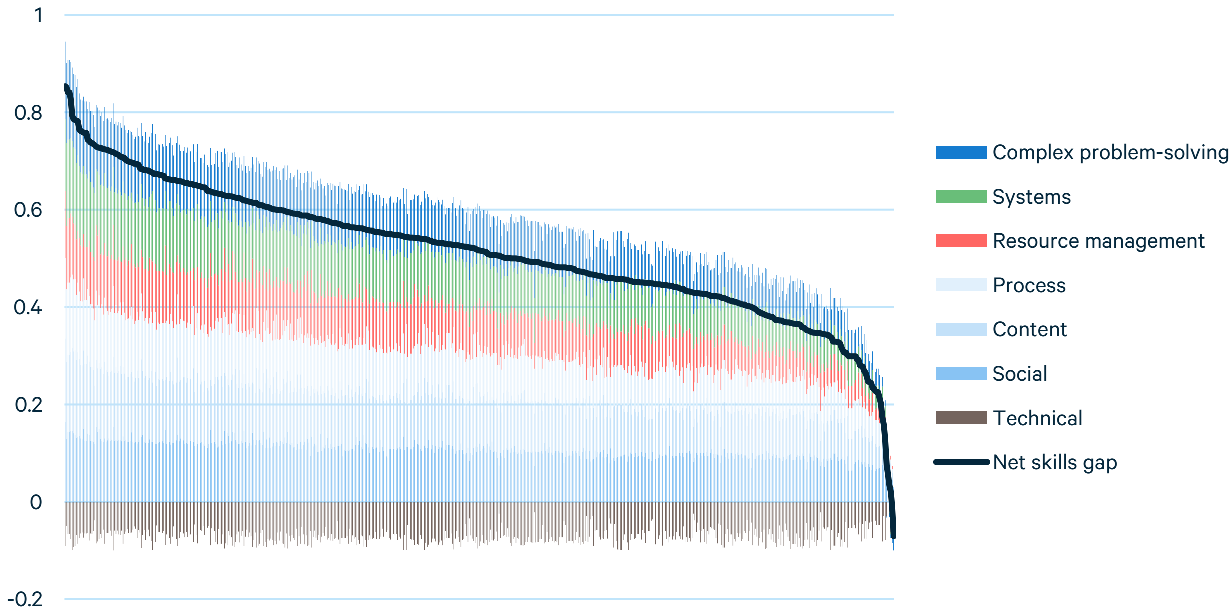


Notes: "Net skills gap" sums the differences between attained and in-demand skill levels across 7 aggregate skills among fossil fuel workers at risk in each commuting zone. Negative values indicate that fossil fuel workers' skills exceed, on aggregate, in-demand skills in that commuting zone.

Most of the CZs with the highest skills gaps and proportions of jobs at risk are found in the Intermountain West (particularly in Montana, New Mexico, Utah, and Wyoming), Appalachia (particularly in West Virginia), West Texas, and the Gulf Coast. Most CZs with the lowest skills gaps have a small proportion of the workforce that is vulnerable to a transition away from fossil fuels, and two show *negative* skills gaps, indicating that the skills attained in the fossil fuel workforce exceed, on net, those demanded in growing occupations that pay at least 90 percent as well as fossil fuel jobs.

Next, we examine which skills contribute most to the gap between the skills attained by fossil fuel workers and the in-demand skills. Figure 5 illustrates the size of the skills gap in each CZ attributable to the seven skill groups created using O*NET skills data: content, process, social, complex problem-solving, technical, systems, and resource management (see Table 3).

Figure 5. Skills Gap for Each Skill Type across All Commuting Zones with Fossil Fuel Employment



On average, the net skills gap across all CZs is 0.51, with the largest gaps in the social and content skill groups, which both show a net skills gap of 0.11. These are followed by complex problem-solving, process, and systems skills, each of which show a net gap of 0.10. Resource management skills show a smaller gap (0.08), while technical skills show a value of −0.07, indicating that fossil fuel workers have attained skills that exceed those required for in-demand jobs that pay at least 90 percent as well in their CZ.

When we restrict the analysis only to CZs where fossil fuel jobs at risk account for more than 5 percent of total jobs under the net-zero scenario, the results shift slightly, and the net skills gap is higher (0.61) than the national average. The largest gaps for these CZs are found in content (0.13) followed by systems (0.12) skills. Social, process, and complex problem-solving each show gaps of 0.11 for these CZs, followed by resource management (0.09). As with the national average, the attained technical skills among fossil fuel workers exceed in-demand skills (−0.07) in occupations that pay at least 90 percent as well in their CZ.

These results suggest that workforce development efforts in many regions with high levels of fossil fuel employment at risk may focus on developing foundational abilities that will allow displaced workers to more easily acquire specific skills in their future occupations (i.e., content skills). They also may suggest that government policy efforts or business decisions that seek to take advantage of a skilled fossil fuel workforce may be most successful when they leverage the existing stock of technical skills. Of course, any specific effort will need to account for a wide variety of local economic, social, and other factors that are beyond the scope of this analysis.

4.3. Illustrative Cases from Eight Energy Communities

Fossil energy communities vary widely across multiple dimensions. In this section, we examine eight CZs that are illustrative of different types of communities that are heavily reliant on fossil fuels for employment and economic development. We selected CZs that each include one or more counties identified by Raimi (2021) as being among the most vulnerable to a transition away from fossil fuels and that collectively represent a wide geographic range. Thus this subset of CZs broadly represents the parts of the United States that are most vulnerable to a transition away from fossil fuels. The counties and the CZs that contain them are identified in Table 4.

Table 4. Example Commuting Zones (CZs)

Commuting Zone	Example County	Region	Key Fossil Fuel Activity
30	Kern County, CA	Central California	Oil and gas extraction
79	Williams County, ND	Williston Basin	Oil and gas extraction
129	Campbell County, WY	Powder River Basin	Coal extraction
172	Terrebonne Parish, LA	Gulf Coast	Oil and gas extraction, oil refining
197	Midland County, TX	Permian Basin	Oil and gas extraction
203	Harris County, TX	Gulf Coast	Oil and gas industry hub
467	Mingo County, WV	Appalachia	Coal extraction
523	Green County, PA	Appalachia	Coal and gas extraction

Although these CZs vary in their geographies, economies, and other factors, they are fairly similar in terms of the skills gaps between fossil fuel jobs at risk and the occupations that are projected to grow quickly in the years ahead (and that pay at least 90 percent as well as fossil fuel jobs in that CZ). Figure 6 illustrates this dynamic through a series of radar plots that show this gap for each of the seven skill types identified in Table 2. For each skill type, the skills gap is represented by the difference between the red point (the attained skill level for fossil fuel workers) and the blue point (the skill level required for in-demand jobs that pay at least 90 percent as well as fossil fuel jobs in that CZ).

Figure 6. Skills Matching for High-Paying Jobs in Eight Fossil Fuel-Intensive Commuting Zones

Although there are differences across these eight CZs, two common themes emerge that are consistent with our results described in the previous section. First, fossil fuel workers meet or exceed the technical skills levels (e.g., operations monitoring, operation and control, equipment maintenance) associated with in-demand occupations in all CZs. Second, these workers fall short in most other skill categories

in all CZs for in-demand occupations where average salaries meet or exceed 90 percent of fossil fuel salaries.

Figure 6 also demonstrates modest variation in the skills gap across CZs. For example, the net skills gap is smallest in CZs 30 and 172 (Kern County, California, and Terrebonne Parish, Louisiana) and largest in CZ 467 (Mingo County, West Virginia). The largest individual gap (0.16) is found in content skills in CZ 467 (Mingo County, West Virginia), which also has particularly large gaps in systems (0.14) and complex problem-solving (0.13) skills.

This information should be seen as one useful input into a complex decision-making process when determining which workforce development interventions are likely to be most successful in fossil energy communities. It will need to be coupled with an understanding of other factors such as the types of jobs that fossil fuel workers *want* to seek out, more localized information about in-demand jobs, and additional region-specific information. Future research and engagement can help provide this information to further inform locally tailored workforce and economic development policy. The following section provides some relevant pieces of information that, when applied at local scale, can inform such decision-making.

4.4. Demographics of the Fossil Fuel Workforce

The demographic characteristics of displaced workers can help inform policy responses. For example, it may be impractical for government to spend on retraining individuals who plan to retire in the next decade. In other cases, workers who recently relocated to a new area may be more willing to relocate again, suggesting a potential role for targeted relocation assistance under certain circumstances. As Table 5 indicates, fossil fuel workers are more likely in comparison with the overall US workforce to be under age 55, earn a higher salary, have relocated within the past year, be male, and be the primary earner in their household.

Table 5. Demographics of Fossil Fuel Workers and US Average

	Median Salary	Share Age ≥55	Share Recently Moved	Share Male	Share with Some College	Share Primary Earner
All Fossil Fuel Workers	$74,576	23.2%	5.6%	81.4%	58%	65.6%
US average	$28,057	35.0%	6.6%	51.7%	58.1%	39.2%

Source: Author calculations based on US Census American Community Survey, 2015-2019.

Note: Values are calculated from all respondents to the ACS for which an industry is recorded. The US average is for all individuals age 16 and over who have worked at some point within the last five years, regardless of current employment status, and includes those who have since retired and now have low salaries and are over age 55. Restricting the calculations to the currently employed would exclude seasonal fossil fuel workers and increase sampling noise for the CZ-level estimates.

In CZs where fossil fuel jobs at risk under the net-zero scenario account for more than 5 percent of total employment, some of these differences are even more pronounced. Average salaries in these CZs are roughly $82,000, 87 percent of the workforce is male, and less than half of the fossil fuel workforce has any college education.

In addition, there is substantial variation across different fossil fuel regions. For example, fossil fuel workers in numerous CZs in the Permian Basin region of West Texas have median salaries that exceed $100,000 per year and have higher moving rates (7–8 percent) than the national average. For several CZs in Appalachian coal country, the share of the fossil fuel workforce is more than 90 percent male, while both college education rates (roughly 30 percent) and moving rates (2–3 percent) are well below the national average, consistent with recent findings from Weber (2020).

4.5. Broader Applicability and Research Needs

Our analysis highlights the extent of the match between the skills of fossil fuel workers and the jobs projected to grow most rapidly in the states where they live. This type of regional- and community-specific information will be crucial to consider when making decisions about the appropriate policy or other intervention to support energy communities. Future analysis could use this approach to answer many related questions to inform policymakers, workforce development professionals, educational institutions, labor unions, and others at multiple geographic scales and thus support policymaking and other decisions. For example, researchers might assess the extent of the skills match between fossil fuel workers and emerging energy technologies such as wind, geothermal, or carbon capture.

Much more research is needed to inform successful policymaking supporting energy workers in a transition to a net-zero economy. Research priorities include gaining an understanding of (1) which jobs are desirable for today's fossil fuel workers; (2) what skills are in demand at the CZ level, rather than at the state level; (3) which skills gaps are most important to fill to enhance workers' future prospects; (4) which skills gaps can be filled most quickly to minimize the cost and time associated with retraining; (5) how direct job losses and gains in the energy sector affect indirect and induced jobs; (6) to what extent this line of research can capture nonwage compensation (e.g., health and pension benefits); and (7) how economic development efforts can be integrated with workforce development efforts to ensure that workers are being trained for jobs in sectors with high labor demand.

5. Conclusion

Supporting fossil fuel workers in a transition to a net-zero emissions economy is a key priority for policymakers in the United States and around the world. In this analysis, we take a highly localized and industry-specific approach to understanding potential fossil fuel–related job displacement in the United States and measure the extent to which the skills of the fossil fuel workforce match the skills required to take advantage of high-paying, in-demand jobs.

We find a substantial gap between the skills needed to perform today's fossil fuel jobs and the skills that are likely to be in demand for jobs with similar pay in parts of the country with high concentrations of fossil fuel employment. We observe the largest skills gap in categories broadly defined as content (e.g., professional writing and speaking) and social (e.g., negotiation and persuasion) skills, reflecting high projected demand for management skills largely in service-oriented occupations. However, there is substantial variation across geographies, and fossil fuel workers exhibit considerable strengths in technical skills.

This analysis and our broader methodological approach can inform the development of place-based policies that can address local challenges and workforce development opportunities for today's fossil fuel workers. Our findings will be useful for policymakers looking to support fossil fuel communities in the United States, and our methodology can be applied to any geography with sufficient data. We also highlight a substantial number of important research questions that need to be answered to better inform such policies.

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7. Appendix

7.1. Concordance Between Industries from Different Data Sources

Several of the fossil fuel industries, which have employment data from the County Business Patterns (CBP), are at a more granular level of disaggregation than is available in the American Community Survey (ACS), from which the demographic data are drawn. For these industries, demographic data was drawn from the higher-level aggregation. Table A7.1 provides the list of industries in the ACS for which demographic data were used for the corresponding decarbonization-vulnerable industry. We also provide a concordance to higher-level industry and product group aggregations used in some figures, as well as to the 2012 version of the NAICS codes used in most data sources.

Table A7.1. Industries in the ACS for Which Demographic Data Were Used

Industry Name	CBP	ACS	Higher level	Product Group	NAICS2017
Crude Petroleum and Natural Gas Extraction	211111	211	211	Upstream oil and natural gas	211120
Crude Petroleum and Natural Gas Extraction	211111	211	211	Upstream oil and natural gas	211130
Natural Gas Liquid Extraction	211112	211	211	Upstream oil and natural gas	211130
Bituminous Coal and Lignite Surface Mining	212111	2121	2121	Upstream coal	212111
Bituminous Coal Underground Mining	212112	2121	2121	Upstream coal	212112
Anthracite Mining	212113	2121	2121	Upstream coal	212113
Drilling Oil and Gas Wells	213111	213	213	Upstream oil and natural gas	213111
Support Activities for Oil and Gas Operations	213112	213	213	Upstream oil and natural gas	213112
Support Activities for Coal Mining	213113	213	213	Upstream coal	213113
Fossil Fuel Electric Power Generation	221112	2211P	221112	Fossil Fuel Electricity	221112
Petroleum Refineries	324110	32411	324	Midstream oil and natural gas	324110
Mining Machinery and Equipment Manufacturing	333131	3331M	33313	Upstream coal	333131
Oil and Gas Field Machinery Manufacturing	333132	3331M	33313	Upstream oil and natural gas	333132
Pipeline Transportation of Crude Oil	486110	486	486	Midstream oil and natural gas	486110
Pipeline Transportation of Natural Gas	486210	486	486	Midstream oil and natural gas	486210
Pipeline Transportation of Refined Petroleum Products	486910	486	486	Midstream oil and natural gas	486910
All Other Pipeline Transportation	486990	486	486	Midstream oil and natural gas	486990

Source: Author calculations using concordances from Ruggles et al. (2022) and OMB (2017).

7.2. Assumptions of Potential Decarbonization Job Loss by Industry

We base our assumptions of potential decarbonization job loss by industry on the 2022 BP Energy Outlook for the Net Zero by 2050 scenario (BP 2022). These assumptions are produced as shown in Table A7.2.

Table A7.2. Assumptions of Potential Decarbonization Job Loss by Industry

Sector	Estimated Job Loss	Notes on Calculation
Upstream oil and natural gas	-76.0%	Mean of percent change in US production of oil (-83.3%) and Natural gas (-68.6%)
Midstream oil and natural gas	-88.3%	Percent change in US primary energy consumption of oil
Upstream coal	-98.3%	Percent change in US production of coal
Fossil fuel-based electricity	-85.0%	From combined global estimates of change between 2019 and 2050 net-zero scenarios in total electricity generation from oil (684 to 1 TWh), natural gas (6,519 to 2,165), and coal (10,276 to 464). National-level projections are not available.

7.3. Counties in Example Commuting Zones

This table provides a list of the eight CZs that were examined in Section 4.3 and shown in Figure 6.

Table A7.3. Counties in Example Commuting Zones (CZs)

CZ	Constituent Counties
30	Kern, Kings, Tulare Counties, CA
79	Williams, Mountrail, McKenzie, Divide, Burke Counties, ND and Richland County, MT
129	Campbell, Converse, Crook, Natrona, Weston Counties, WY
172	Assumption, Lafourche, St. Mary, Terrebonne Parishes, LA
197	Midland, Andrews, Crane, Ector, Glasscock, Howard, Loving, Martin, Reagan, Reeves, Upton, Ward, Winkler Counties, TX
203	Harris, Austin, Brazoria, Chambers, Colorado, Fayette, Fort Bend, Galveston, Liberty, Matagorda, Montgomery, San Jacinto, Waller, Washington, Wharton Counties, TX
467	Logan and Mingo Counties, WV
523	Greene, Allegheny, Armstrong, Beaver, Butler, Fayette, Washington, Westmoreland Counties, PA; Jefferson County, OH; and Brooke and Hancock Counties, WV

7.4. Workforce Demographics

For information on workforce demographics such as sex, age, salary, recent migration, and more, we use data from the American Community Survey (ACS).[9] Since the ACS is a survey (rather than based on administrative or census data), we use state-level data because they have a lower margin of error than data at the CZ level. Similar to the occupational composition data, these state-level data are nonetheless used to produce estimates of CZ demographic characteristics as weighted averages where the weights are CZ-specific shares of at-risk fossil fuel employment by industry. Specifically, the CZ-level demographic characteristics are calculated as

$$\overline{Demog}_c = \sum_i^I (\overline{StateLevel\ Stat}_{i,c} * EmpShare_{i,c})$$

where $\overline{StateLevel\ Stat}_{i,c}$ is the demographic statistic for workers in industry i across the entire state in which CZ c is located (e.g., median salary of workers in

[9] ACS data are also used for the occupational composition for NAICS 33313.

Wyoming petroleum refineries), and $EmpShare_{i,c}$ is the share of industry i in at-risk fossil fuel employment in CZ c (e.g., share of at-risk fossil fuel jobs in a Wyoming CZ in petroleum refineries). So, for example, the share of college-educated workers in a commuting zone, across all industries at risk of decarbonization, is calculated as the weighted average of the shares of college-educated workers in each of those industries across the whole state, where the weights are the share of the industry's at-risk fossil fuel employment in the CZ. Note that the shares of at-risk fossil fuel jobs are based on the assumed employment reductions for each industry listed in Table 2.

Whether individuals in a CZ recently relocated is measured as whether they moved within the past year from another Public Use Microdata Area (PUMA) of residence (or abroad) to the PUMA where their current housing unit was located. PUMAs are groupings of 100,000 or more residents that generally follow the boundaries of county groups, single counties, or census-defined "places." More information on this measurement is available from Ruggles et al. (2022).

7.5. O*NET Skills Descriptions

This table provides brief descriptions of the skills included in the O*NET Content Model, which we aggregate into seven skill types: content, process, social, complex problem-solving, technical, systems, and resource management.

Table A7.5. Description of Skills from O*NET

2.A. Basic Skills – Developed capacities that facilitate learning or the more rapid acquisition of knowledge		
2.A.1. Content – Background structures needed to work with and acquire more skills in a variety of different domains		
2.A.1.a	Reading Comprehension	Understanding written sentences and paragraphs in work related documents
2.A.1.b	Active Listening	Giving full attention to what other people are saying, taking time to understand the points being made, asking questions as appropriate, and not interrupting at inappropriate times
2.A.1.c	Writing	Communicating effectively in writing as appropriate for the needs of the audience
2.A.1.d	Speaking	Talking to others to convey information effectively
2.A.1.e	Mathematics	Using mathematics to solve problems
2.A.1.f	Science	Using scientific rules and methods to solve problems

2.A.2. Process – Procedures that contribute to the more rapid acquisition of knowledge and skill across a variety of domains		
2.A.2.a	Critical Thinking	Using logic and reasoning to identify the strengths and weaknesses of alternative solutions, conclusions or approaches to problems
2.A.2.b	Active Learning	Understanding the implications of new information for both current and future problem-solving and decision-making
2.A.2.c	Learning Strategies	Selecting and using training/instructional methods and procedures appropriate for the situation when learning or teaching new things
2.A.2.d	Monitoring	Monitoring/Assessing performance of yourself, other individuals, or organizations to make improvements or take corrective action
2.B. Cross-functional Skills – Developed capacities that facilitate performance of activities that occur across jobs		
2.B.1. - Social Skills - Developed capacities used to work with people to achieve goals		
2.B.1.a	Social Perceptiveness	Being aware of others' reactions and understanding why they react as they do
2.B.1.b	Coordination	Adjusting actions in relation to others' actions
2.B.1.c	Persuasion	Persuading others to change their minds or behavior
2.B.1.d	Negotiation	Bringing others together and trying to reconcile differences
2.B.1.e	Instructing	Teaching others how to do something
2.B.1.f	Service Orientation	Actively looking for ways to help people
2.B.2. - Complex Problem-Solving Skills - Developed capacities used to solve novel, ill-defined problems in complex, real-world settings		
2.B.2.i	Complex Problem Solving	Identifying complex problems and reviewing related information to develop and evaluate options and implement solutions
2.B.3. - Technical Skills - Developed capacities used to design, set-up, operate, and correct malfunctions involving application of machines or technological systems		
2.B.3.a	Operations Analysis	Analyzing needs and product requirements to create a design
2.B.3.b	Technology Design	Generating or adapting equipment and technology to serve user needs
2.B.3.c	Equipment Selection	Determining the kind of tools and equipment needed to do a job
2.B.3.d	Installation	Installing equipment, machines, wiring, or programs to meet specifications
2.B.3.e	Programming	Writing computer programs for various purposes

2.B.3.g	Operations Monitoring	Watching gauges, dials, or other indicators to make sure a machine is working properly
2.B.3.h	Operation and Control	Controlling operations of equipment or systems
2.B.3.j	Equipment Maintenance	Performing routine maintenance on equipment and determining when and what kind of maintenance is needed
2.B.3.k	Troubleshooting	Determining causes of operating errors and deciding what to do about it
2.B.3.l	Repairing	Repairing machines or systems using the needed tools
2.B.3.m	Quality Control Analysis	Conducting tests and inspections of products, services, or processes to evaluate quality or performance
2.B.4. - Systems Skills - Developed capacities used to understand, monitor, and improve socio-technical systems		
2.B.4.e	Judgment and Decision Making	Considering the relative costs and benefits of potential actions to choose the most appropriate one
2.B.4.g	Systems Analysis	Determining how a system should work and how changes in conditions, operations, and the environment will affect outcomes
2.B.4.h	Systems Evaluation	Identifying measures or indicators of system performance and the actions needed to improve or correct performance, relative to the goals of the system
2.B.5. - Resource Management Skills - Developed capacities used to allocate resources efficiently		
2.B.5.a	Time Management	Managing one's own time and the time of others
2.B.5.b	Management of Financial Resources	Determining how money will be spent to get the work done, and accounting for these expenditures
2.B.5.c	Management of Material Resources	Obtaining and seeing to the appropriate use of equipment, facilities, and materials needed to do certain work
2.B.5.d	Management of Personnel Resources	Motivating, developing, and directing people as they work, identifying the best people for the job

Source: O*NET Content Model Reference, https://www.onetcenter.org/dictionary/27.0/excel/content_model_reference.html.