The Challenges and Opportunities to the Local Workforce Associated with Community Scale Energy Transitions

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Introduction

Energy transitions, defined by the shift from fossil fuels to renewable energy sources,[i] are no longer just environmental imperatives but are also reshaping the economic and employment landscapes of communities nationwide.[1] This transition, while beneficial in the long run for sustainability and environmental health, poses both unique challenges and opportunities for the workforce in communities across the United States. This article explores these dynamics, providing insights into the current workforce landscape in traditional energy sectors and anticipated shifts in employment as communities embrace renewable energy solutions.[2]

The transition to a community-scale energy paradigm—where energy production and consumption are localized within the community, empowering residents and local entities to control their energy future—is complex and multi-dimensional. This paradigm shift involves decentralizing energy systems, moving away from large-scale, centralized power plants, and focusing instead on smaller, community-driven energy projects like microgrids, rooftop solar, and wind cooperatives. This approach not only addresses environmental concerns but also reshapes the socio-economic fabric of communities by fostering local economic growth, enhancing energy resilience, and promoting energy equity. While the challenges are significant, particularly in terms of potential workforce displacement and the need for substantial retraining, the opportunities for creating a more sustainable and economically diverse local economy are profound. Successful transitions will depend on proactive community planning, supportive policy frameworks, and a clear vision for a renewable energy future that benefits everyone.[3]

The transition from fossil fuels to renewable energy is not just a technological shift but a comprehensive transformation that touches every aspect of community life. The complexities range from workforce skill gaps and economic impacts to social and regulatory issues; they can be especially challenging for communities and individuals that have experienced histories of low access to capital and social mobility. However, these challenges are not insurmountable. With strategic planning, inclusive policies, and community engagement, these transitions can lead to a more sustainable, resilient, prosperous, and equitable future.[4]

The opportunities presented by community-scale energy transitions can also transform local workforces and economies. By embracing renewable energy, communities not only address the urgent need for environmental stewardship but also create durable and diverse employment opportunities, boost local economic health, and enhance their resilience and sustainability.[5] These transitions, when strategically managed and inclusively implemented, offer a prosperous and sustainable future for all community members.

[i] The U.S. Department of Energy (DOE) defines fossil fuels as non-renewable energy sources that originated from prehistoric plants and animals. These organic materials were gradually buried under layers of rock and transformed under pressure and temperature over millions of years into coal, oil, and natural gas. These fossil fuels are extracted through mining or drilling processes and are commonly burned to produce electricity or refined for use as fuel for heating and transportation. DOE defines renewable energy sources as those that come from unlimited, naturally replenished resources such as the sun, tides, and wind.

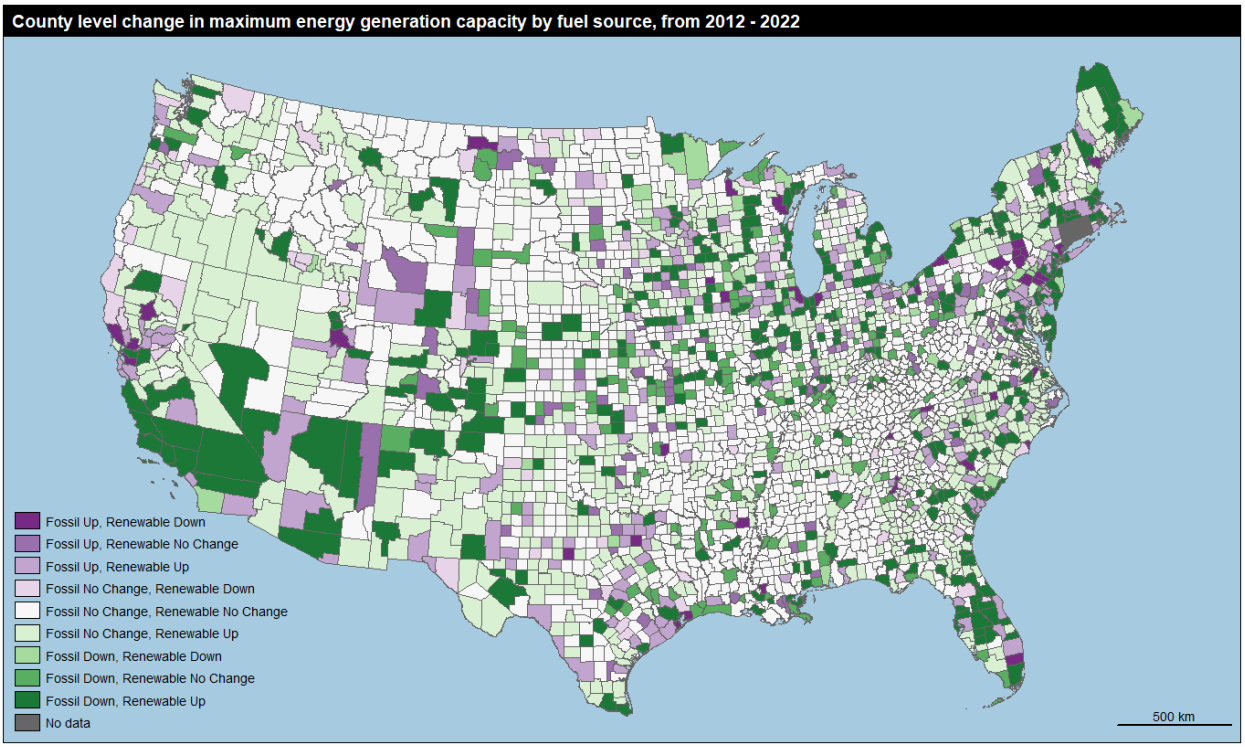

Figure 1. Changes in maximum or nameplate generation[ii] capacity by fuel source and county for the continental United States. Over 40% of counties in the continental United States saw no change in nameplate generation capacity between 2012 and 2022. Data from Energy Information Agency EIA-860 data files.

Data from the Energy Information Agency highlights the range of community-scale energy transitions when considering communities as producers of energy as opposed to simply consumers. As Figure 1 shows, between 2012 and 2022, 39 counties saw increased fossil-fuel generation capacity *and* decreased renewable energy capacity, while 327 counties saw a decrease in fossil-fuel generation capacity *and* an increase in renewable energy-generation capacity. Approximately one-third of all U.S. counties had no energy generation capacity of any type, in either 2012 or 2022. When considering the implications of workforce dynamics in community-scale energy transitions, capturing the local environmental, cultural, and economic conditions of the community of interest is important.

Workforce Dynamics in Energy Transitions

Current Landscape: Workforce in Traditional Fossil-Based Energy Sectors

The existing workforce in traditional energy sectors, comprising coal, oil, and natural gas, is a significant aspect of many local economies, particularly in regions where these industries have historically been economic pillars[iii]. The workforce in these sectors often possesses specialized skills tailored to the

[iii] In the context of energy generation facilities like wind farms, solar panels, or power plants, the nameplate capacity represents the peak theoretical output under ideal conditions. However, the actual energy produced can

extraction, processing, and distribution of fossil fuels. Moreover, these jobs tend to have longer union histories and offer higher wages and benefits compared to other local employment opportunities, creating a dependency that can complicate transitions away from fossil fuels. In some cases, local institutions and social identity can be intricately linked to these industries, creating cultural bonds beyond those associated with economic activity.

The interdependence between these communities and traditional energy jobs is profound. In many cases, entire towns or regions have developed around the energy industry, with local economies and subsidiary services ranging from healthcare to infrastructure heavily reliant on the prosperity and stability of fossil fuel jobs. This symbiotic relationship underscores the potential economic disruptions that could occur as these areas move towards renewable energy sources.

The energy sector itself is a diverse part of the economy, covering power generation, transmission, distribution, mining, and drilling, as well as research and development of new technologies. Figure 2 shows national changes in employment levels for four major energy sub-sectors: Coal Mining, Electric Power Generation/Transmission/Distribution, Natural Gas Extraction, and Oil and Gas Extraction.[1]

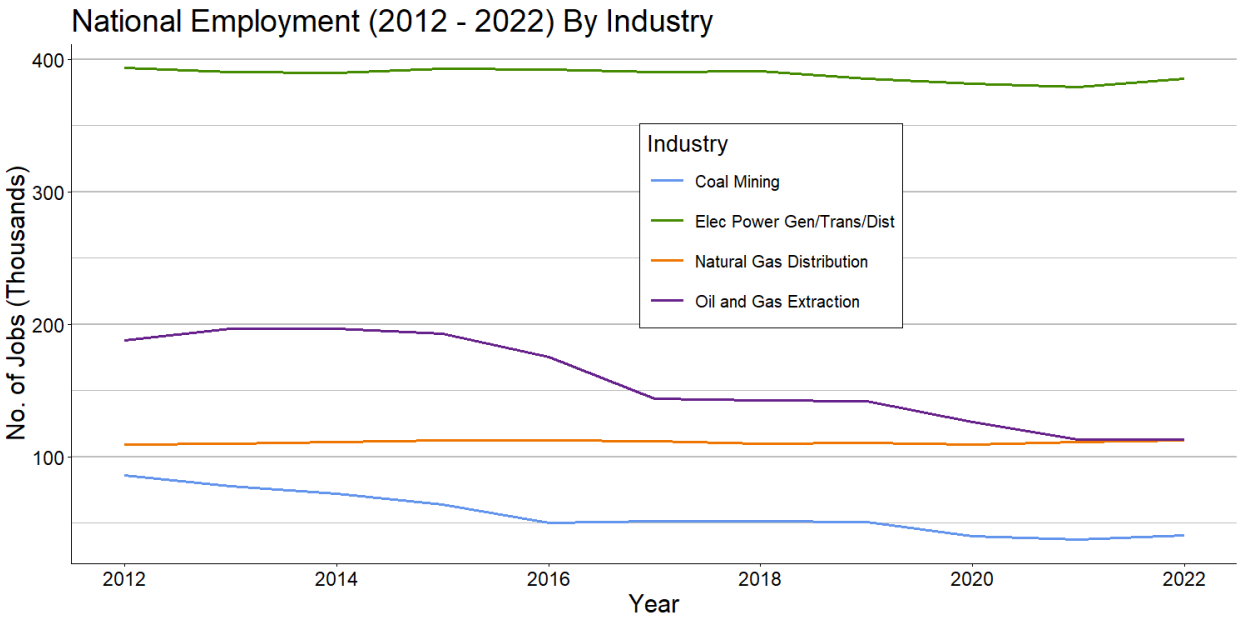

Figure 2. Changes in employment (in thousands) between 2012 and 2022 for four major sub-sectors of the energy industry.

In contrast to the steady decline in employment for Coal Mining and Oil and Gas Extraction, both Natural Gas Extraction employment and Electric Power Generation/Transmission/Distribution employment have held relatively steady. These trends could be due to technological changes that affect the demand for labor in certain sub-sectors or could reflect labor shifts on a national scale.

be less than the nameplate capacity due to various factors like maintenance, operational inefficiencies, and environmental conditions.

While the national view is useful context, understanding community-level energy transitions requires community-level data. Figures 3 and 4 show a more nuanced view of the county-level change in employment levels grouped by the county-level type of change in energy generation capacity.[2] The research team used Bureau of Labor Statistics (BLS) Quarterly Census of Employment and Wages (QCEW) data from 2012 and 2022 to assess sub-sector employment trends for the Electric Power Generation, Transmission, and Distribution sub-sector (Figure 3), and the Oil and Gas Extraction sub-sector (Figure 4). The height of each bar is proportional to the share of counties whose change in employment falls in the given range. The vertical dashed line represents a 0% percent change in employment between 2012 and 2022, so that all observations to the left of the line are counties that experienced declining employment levels over that time. Complete data was only available for a subset of counties nationwide.

For the Electric Power Generation, Transmission, and Distribution sub-sector in Figure 3, the data highlight disparities in county-level employment trends. Whereas many counties saw decreases or complete disappearance of jobs in this sector, a small handful of counties saw large employment growth as high as 600%. Because Figure 3 shows that national employment in the Electric Power Generation, Transmission, and Distribution sub-sector has remained largely constant, Figure 3 suggests that jobs in this sector are becoming more concentrated in a small number of geographic locations. Unsurprisingly, counties that experienced greater decline in total energy generation capacity were less likely to have experienced any employment growth.

In contrast, for the Oil and Gas Extraction sub-sector shown in Figure 4, the majority of counties experienced employment stagnation or decline from 2012 to 2022. Counties that did experience Oil and Gas Extraction sub-sector employment growth typically had more modest growth than in the Electric Power Generation, Transmission, and Distribution sub-sector. These county-level data are consistent with Figure 2, which shows national employment in Oil and Gas Extraction declined by approximately a third from 2012 to 2022. While some geographic concentration may be occurring for Oil and Gas Extraction, the magnitude of the concentration appears to be smaller than in the Electric Power Generation, Transmission, and Distribution sub-sector, Figure 3. Across the four energy sub-sectors shown in Figure 2, 256 counties lost *all* energy sector employment between 2012 and 2022.

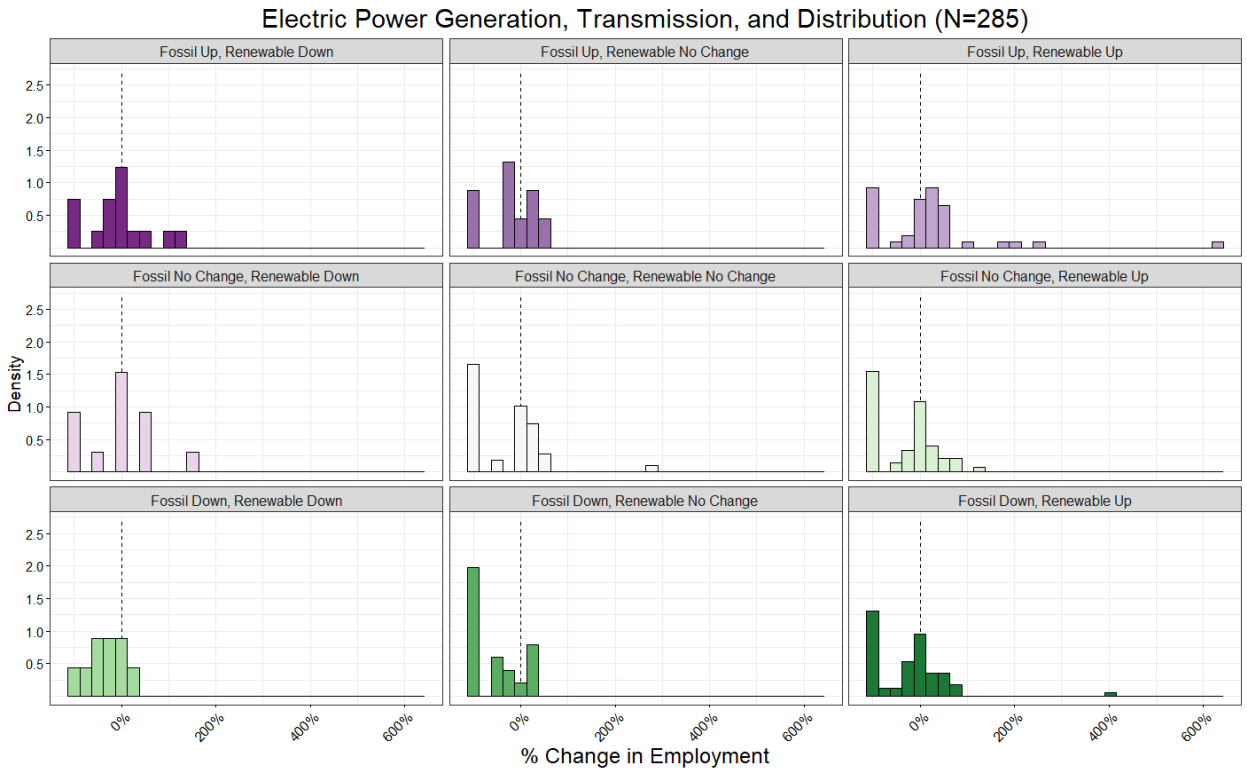

Figure 3. Percent change in employment between 2012 and 2022 for the Electric Power Generation, Transmission, and Distribution sub-sector. The colors signify the changes in energy generation capacity by fuel type as in Figure 1, and the height of each bar is proportional to the share of counties whose change in employment falls in the given bar for each group of energy generation capacity. The percentage changes are calculated for each county, with 2012 serving as the baseline.

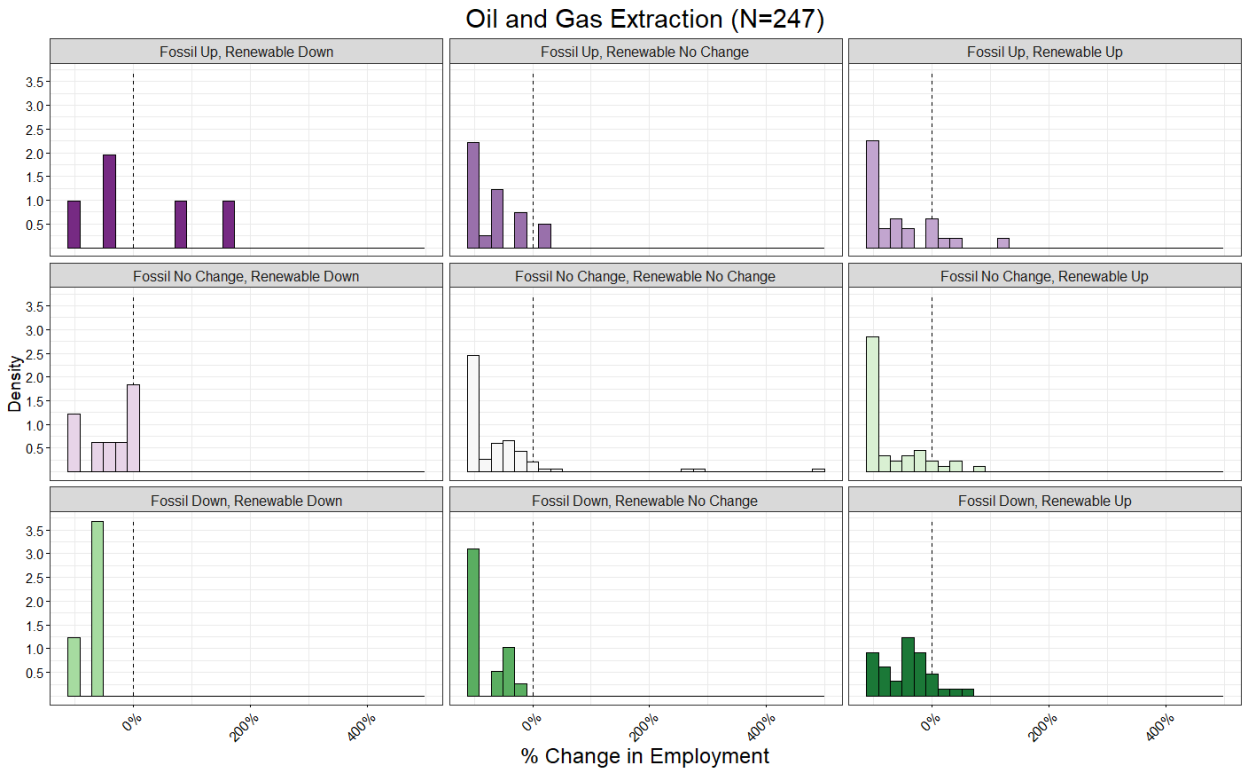

Figure 4. Percent change in employment between 2012 and 2022 for Oil and Gas Extraction sub-sector.

In addition to the number of jobs, community-scale energy transitions can also impact wages. Figure 5 shows national changes in real (inflation-adjusted) wages for the same four major energy sub-sectors.

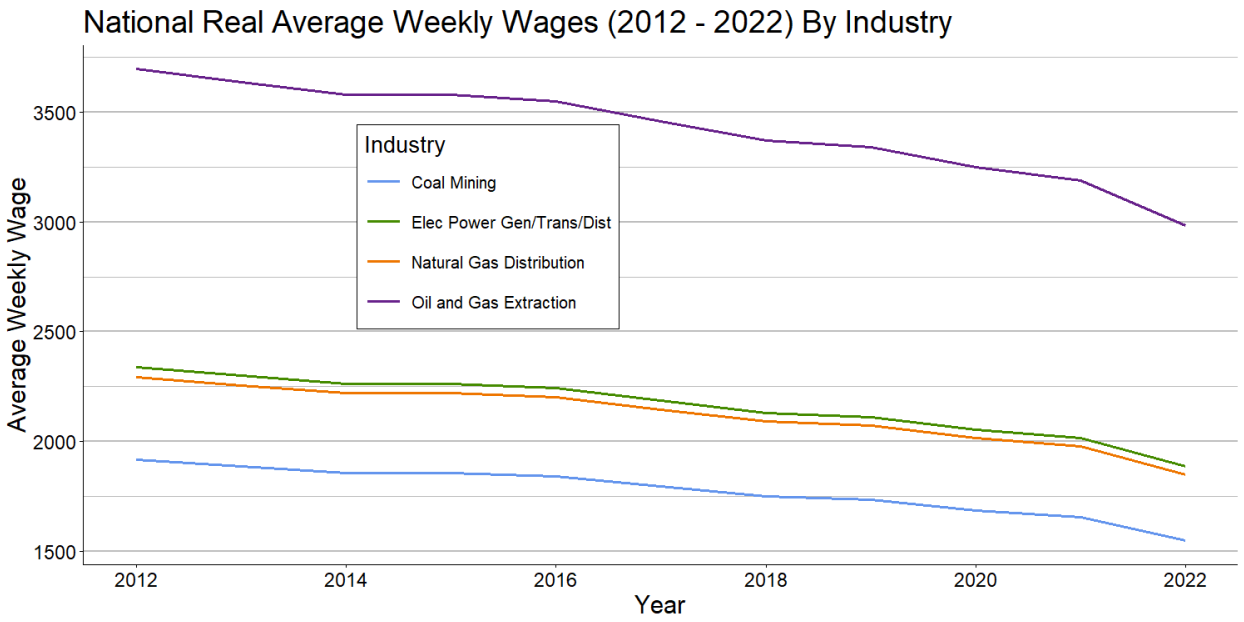

Figure 5. National average weekly real wage for each of the four energy sub-sectors from 2012 to 2022. All dollar values are in 2022 dollars. Data come from BLS QCEW and were adjusted to 2022 dollars with BLS inflation data.

In real terms, weekly wages for each of these four sub-sectors are declining. Of note, jobs in the Oil and Gas Extraction sector pay significantly higher weekly rates than the other energy sub-sectors, although the gap between Oil and Gas Extraction and other sub-sectors has closed somewhat in recent years. However, county-level data in Figure 6 and Figure 7 again shows disparate outcomes in real wage

growth.

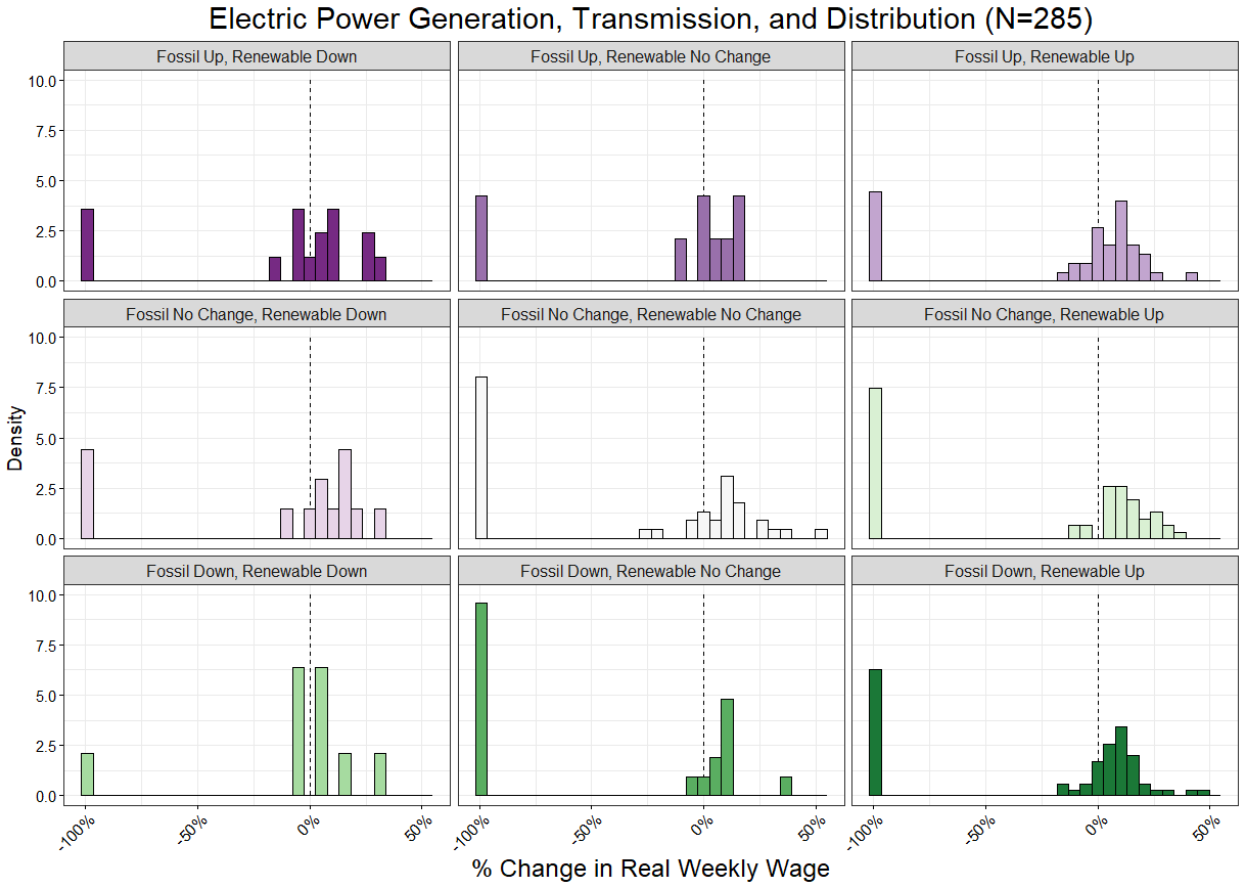

Figure 6. Percent change in average real weekly wage between 2012 and 2022 for the Electric Power Generation, Transmission, and Distribution sub-sector. The colors signify the changes in energy generation capacity by fuel type as in Figure 1, and the height of each bar is proportional to the share of counties whose change in employment falls in the given bar for each group of energy generation capacity. The percentage changes are calculated for each county, with 2012 serving as the baseline.

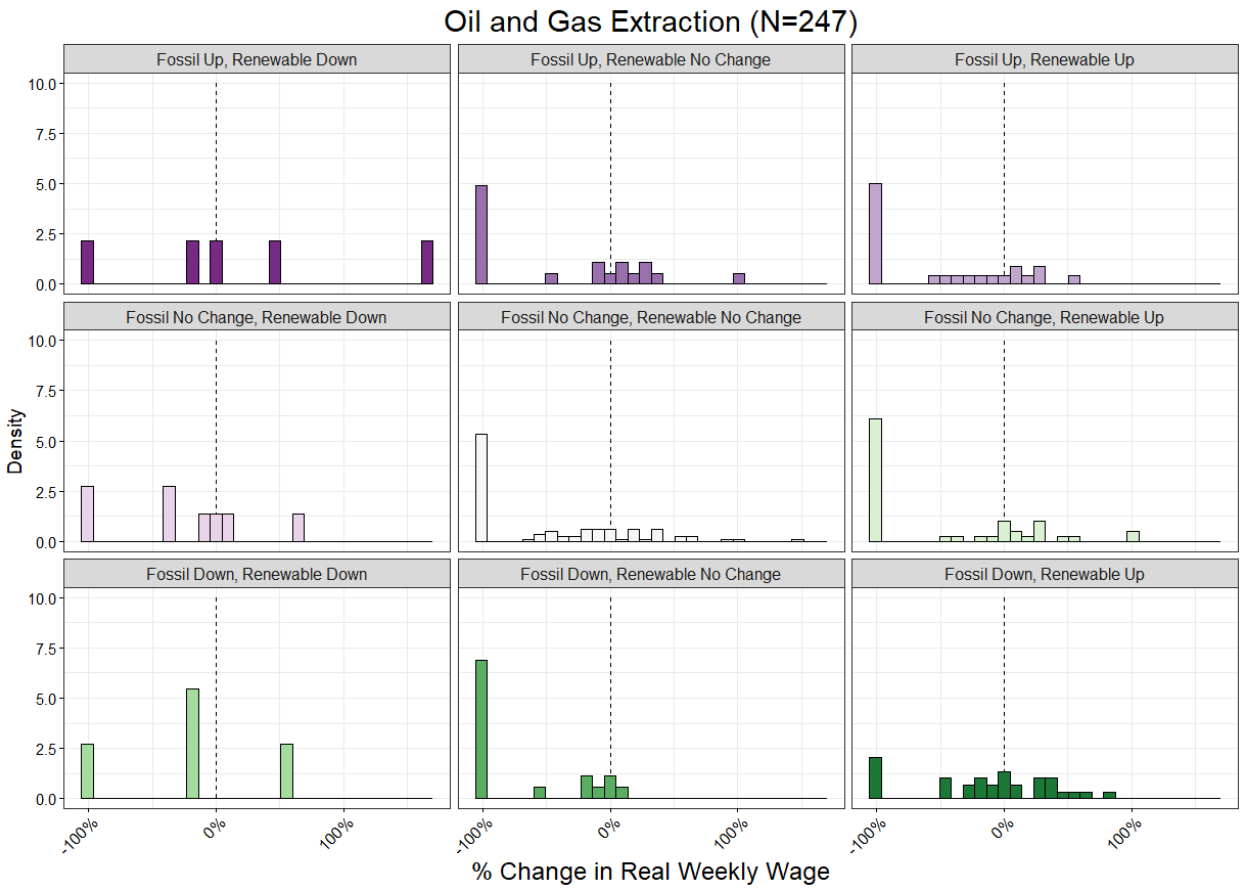

Figure 7. Percent change in real weekly wage between 2012 and 2022 for Oil and Gas Extraction sub-sector.

Much like the county-level employment data shown in Figures 3 and 4, real wage growth has been diverse among counties in ways not captured by the national level data. For the Electric Power Generation, Transmission, and Distribution sub-sector in Figure 6, the disparity in real weekly wage growth is apparent, particularly for counties that saw an increase in renewable energy generation capacity. Counties that saw decreases in their fossil fuel generation capacity alongside increases in renewable energy generation capacity experienced strongly divergent trajectories, with some counties experiencing total decline of employment and wages, with others experiencing strong real weekly wage growth of 20% or more between 2012 and 2022. These data suggest divergence in county-level wage outcomes and concentration of high-wage employment in only some geographic locations. For the Oil and Gas Extraction industry in Figure 7, the data show some divergence between counties and likely concentration of high-wage jobs, but those trends are weaker than in the Electric Power Generation, Transmission, and Distribution industry.

These data illustrate the highly localized nature of the energy transition and its impact on the workforce. Even counties that have experienced similar changes in power generation capacity from fossil and renewable energy can have diverging outcomes in terms of employment and wages, suggesting the importance of local environmental, legal, cultural, and policy factors in shaping workforce tends. Policymakers, researchers, and planners must work with each local community to understand the

community-specific context at play. In addition, further research can help to identify driving factors behind the divergent outcomes from community to community.

Challenges During Community Scale Energy Transitions

Community-scale energy transitions present complex challenges for the local workforce. As regions pivot from traditional to renewable energy sources, various hurdles emerge, ranging from skill mismatches and economic impacts to social and regulatory challenges.

Skill Gaps and Training Needs

One of the most immediate challenges is the mismatch between the existing skills of the workforce in traditional energy sectors and the demands of new, renewable energy technologies.[6,7] Workers adept in the operations of coal plants or oil extraction may find their expertise less relevant in industries that prioritize solar, wind, or bioenergy technologies. This skills gap highlights the urgent need for comprehensive re-skilling and upskilling initiatives.

To bridge this gap, communities and policymakers must implement targeted training programs.[8] These programs should focus not only on technical skills related to renewable energy but also on digital literacy and other soft skills that will be increasingly important in a more automated, technology-driven industry. Effective strategies may include partnerships between local governments, educational institutions, and industry leaders to ensure that training programs are accessible and aligned with future job market demands.

Skill gaps and training needs are not unique to energy transitions. Education and training centers are already providing certification and degree programs to train new workers and develop new skills in existing workers throughout the energy space. The American Association of Community Colleges released a strategic plan in 2011 to review and put in place goals and create cohesion for training centers across the country.[9]

Job Displacements and Unemployment Fears

The shift to renewable energy is often accompanied by concerns about job losses in traditional sectors, potentially leading to significant unemployment and economic instability in communities that rely heavily on fossil fuels. While the overall number of jobs in renewable energy may be growing, these are not always located in the same regions where job losses are occurring, nor do they always require the same skill sets.

Quantifying these job losses and understanding their impact on local economies is crucial.[10] While transitions may lead to short-term displacement, they can also spur economic diversification and long-term growth. However, the real-world impact can vary greatly, with some communities experiencing prolonged periods of unemployment and economic decline if transitions are not managed carefully and with foresight.

Social Implications of Workforce Transitions

Beyond economic factors, energy transitions can severely affect the social fabric of communities. For many regions, the identity and culture are closely tied to traditional industries; shifts away from these can lead to a sense of loss among residents. Furthermore, a need exists to ensure that the new energy

sectors are inclusive and diverse, providing opportunities for all community members, including historically marginalized groups.

Addressing these social implications requires thoughtful community engagement and proactive measures to ensure inclusivity.[11] Initiatives might include community dialogues to address cultural shifts, and policies aimed at ensuring workforce diversity in new energy projects.

Policy and Regulatory Hurdles

Navigating the legislative landscape can also present significant challenges. Regulatory and policy hurdles can slow down the adoption of new technologies and the transition of the workforce. In some cases, existing laws may favor traditional energy sectors through subsidies or restrictive zoning laws that hinder the development of renewable energy projects.

The role of government is pivotal in either facilitating or hindering progress. Effective policy measures, such as incentives for renewable energy investments and support for displaced workers, can accelerate transitions.[12] Conversely, outdated regulations can result in bottlenecks that slow down change and increase the cost of transition for communities and workers alike.

Opportunities Emerging from Energy Transitions

While the shift from traditional fossil fuels to renewable energy sources presents numerous challenges for the workforce, it also creates substantial opportunities. These opportunities not only mitigate the potential downsides of the transition but can also serve to invigorate local economies, enhance community resilience, and align with broader sustainable development goals.

Job Creation Potential in Renewable Energy Sectors

Renewable energy projects are significant creators of new jobs, ranging from manufacturing and installation to maintenance and administration of renewable energy systems.[13] For instance, the solar-power industry requires a diverse workforce including engineers, installers, maintenance personnel, and sales and marketing teams. Wind energy projects demand turbine manufacturers, wind farm developers, and logistical support roles. These jobs not only vary in function but also come with the promise of long-term career prospects due to the growing commitment of governments and businesses to green energy goals. Further, because of their place-based nature, many of these jobs, such as those involved in installation or maintenance, cannot be outsourced overseas.

Moreover, these new jobs often require different skills than those demanded in traditional energy sectors, providing an impetus for local workforce training programs. The continuous evolution of technology in the sector also promises ongoing learning and development opportunities, making a career in renewable energy more dynamic.

Economic Benefits of a Localized Energy Workforce

The economic benefits of a localized energy workforce are significant.[14] By investing in renewable energy projects, local economies can retain more wealth within the community. For example, community-owned renewable projects often circulate money within the local economy rather than transferring it to external stakeholders or multinational corporations.[15] This reinvestment can lead to a multiplier effect, boosting local businesses and services.

Several examples illustrate successful economic development through renewable energy initiatives. For instance, regions that have embraced wind and solar energy projects have seen not only job creation but also an increase in local tax revenues, which can be used to improve infrastructure, schools, and community services. [16] These economic benefits can be particularly impactful in rural or economically depressed areas, where new energy projects provide a vital source of employment and community development.

Enhancing Community Resilience and Sustainability

Community-scale energy transitions significantly enhance local resilience and sustainability.[17] Energy independence, achieved through localized renewable energy projects, reduces reliance on external energy sources, which can be subject to market volatility and geopolitical tensions. This independence ensures a more stable and predictable energy supply, crucial for both households and businesses.

Moreover, aligning local energy projects with sustainable development goals can yield extensive environmental and social benefits. These projects not only reduce carbon footprints and environmental impact but also foster a sense of community ownership.

Maximizing Workforce Opportunities

As communities across the country increasingly commit to transitioning from fossil fuels to renewable energy sources, adopting strategies that not only mitigate challenges but also maximize opportunities for the local workforce becomes essential. These strategies involve fostering education and continuous learning, implementing innovative employment models, and ensuring robust governmental and policy support. Together, these approaches can help in developing a skilled, versatile, and resilient workforce well-prepared for the demands of new energy sectors.

Education and Continuous Learning

Education is foundational in preparing for and maximizing the benefits of energy transitions. Developing specialized educational programs tailored to the evolving needs of the renewable energy sector is crucial.[18] These programs should focus on new technologies and sustainable practices, equipping students with the skills needed for jobs in solar, wind, bioenergy, and other renewable technologies. Moreover, continuous learning and professional development opportunities need to be integrated into career paths, ensuring that the workforce can adapt to ongoing technological advancements.

Partnerships between educational institutions and energy companies are also vital.[19] These collaborations can ensure that educational curricula are aligned with industry needs, providing hands-on learning experiences through internships and apprenticeships. Such partnerships can effectively bridge the gap between the supply of skilled labor and the demand for expertise in renewable energy fields, facilitating smoother transitions and better employment outcomes.

The renewable energy sector also presents an opportunity to rethink traditional employment models. Cooperative models, where workers have ownership stakes in the businesses and share in the profits, are particularly promising in the renewable sector.[20] These models can increase job satisfaction, improve worker retention, and foster a deeper commitment to the company's success and sustainability goals.

They also help in distributing the economic benefits of energy projects more equitably across communities.

Furthermore, the rise of freelance and gig opportunities in green technology is creating more flexible employment options for many, particularly in areas like solar panel installation, energy efficiency auditing, and remote monitoring of energy systems.[21] These roles cater to individuals seeking less traditional employment structures but still offer the potential for career growth and skill development in high-demand areas.

Governmental and Policy Support

Effective governmental and policy support is crucial in maximizing workforce opportunities in energy transitions.[22] Governments can play a transformative role by offering incentives for companies that invest in local workforces and adopt sustainable practices. These incentives can take various forms, including tax breaks, grants for training programs, or subsidies for renewable energy projects that prioritize local employment.

In addition, comprehensive policy frameworks are needed to support workforce transitions. These policies should address the needs of displaced workers from traditional energy sectors while also fostering an environment that encourages investment in renewable energy innovations. Legislation that facilitates educational advancements, supports innovative employment models, and provides economic incentives can create fertile ground for robust and sustainable growth in the renewable sector.

Strategically approaching community-scale energy transitions by focusing on education, innovative employment models, and strong governmental support can significantly enhance the prospects for local workforces. By implementing these strategies, communities can ensure that transitions not only contribute to global sustainability goals but also bring about tangible benefits for local economies and their inhabitants, paving the way for a resilient and prosperous future.

The Future of Work in Energy Transitions

The transition from traditional fossil fuels to renewable energy sources is not only a pivotal environmental shift but also a transformative movement for the workforce across various communities. This shift redefines future job markets and necessitates new strategies in economic forecasting and workforce planning. Understanding the long-term impact of these changes on local workforces is essential for preparing communities to thrive in a future where renewable energy plays a dominant role.

Predicting the Long-Term Impact on Local Workforces

As the nationwide commitment to renewable energy strengthens, the job market in energy sectors is expected to evolve significantly. Renewable energy projects—such as solar farms, wind turbines, and bioenergy facilities—are increasingly becoming significant employers in various regions. These sectors require a diverse array of roles, from scientific and engineering positions to construction, maintenance, and administrative jobs. The expansion of these industries is likely to drive substantial employment growth in areas that actively invest in and promote renewable energy projects.

Moreover, the characteristics of these jobs are predicted to differ markedly from those in traditional energy sectors. Renewable energy jobs tend to be more distributed geographically, given the need to

harness wind, solar, and other resources that are not tied to specific locations like oil or coal reserves.[23] This decentralization has the potential to benefit a broader range of communities, including rural areas that might not have traditionally benefited from localized economic booms associated with fossil fuels.

In terms of economic forecasts, the shift towards renewable energy is expected to contribute positively to local economies. Increased investment in renewable energy technologies is likely to spur innovation and lead to decreases in costs over time, similar to what has been observed with technologies like solar photovoltaic systems.[24] Economic models suggest that with appropriate policy frameworks in place, the growth in renewable energy sectors could offset the job losses in fossil fuel industries, leading to a net gain in employment opportunities.

Effective workforce planning will be crucial to managing this transition. Communities and policymakers need to anticipate the changes in the job market and create educational and training programs that can prepare the workforce for new opportunities in green energy.[25] A need also exists to focus on supporting transitions for workers from declining sectors, ensuring that they are not left behind as the economy shifts towards more sustainable practices.

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