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Creating And Accelerating The Shift From Fossil Fuel Jobs To Green Energy Jobs

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Abstract
The green energy job market in the United States is growing consistently, whereas fossil fuel employment is declining. Green energy jobs have overtaken fossil fuel jobs in electric power generation (EPG), and they are beginning to command a presence in the fuels sector. Demand for green energy workers is very high, and green energy employers are having trouble finding qualified workers to fill their open positions. Real wages in green energy are increasing, the jobs are stable, and workers have more choice as to which parts of the US they want to live in. Meanwhile, workers are being pushed out of fossil fuel jobs, and this has caused fossil fuel dependent communities to languish. However, workers pushed out of fossil fuel industries are not shifting to green energy jobs, despite their attractive qualities. This is caused by numerous, major barriers. However, solutions are starting to form amongst major institutions such as the Brookings Institute and the New York Times, showcasing that there is a real problem and potential for opportunity in this area. A possible solution is to take this job transition online, consolidating the workers, employers, and necessary re-training in one place.

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I. Introduction

Fossil fuel job market growth has stagnated in the United States. From 2019 to 2021, some industries have shrunk dramatically, such as coal. On the other hand, in that same time frame, the green energy job market has grown consistently (excluding pandemic losses) as green energy develops a commanding presence. Throughout the two primary sub-sectors of energy, green energy jobs are showing significant growth while fossil fuel jobs are showing stagnation and decline (United States Energy and Employment Report, 2022).

The job market for electric power generation (EPG) is dominated by green energy workers, and this gap continues to grow. Approximately 77.4% of total EPG jobs in the United States are now in a green energy technology, such as solar or wind (United States Energy and Employment Report, 2022). Based on recent trends, this split is likely to grow even more lopsided. EPG green energy jobs have grown consistently since 2015 (pre-pandemic) and have outpaced fossil fuel EPG job growth. As an example, solar and wind EPG employment together (68% of the renewable energy market) recorded 22% growth from 2015 to 2019, whereas coal recorded job losses of 18%, and oil recorded job losses of 9% (United States Energy and Employment Report, 2017).

It is important to note that the natural gas EPG job market did record significant growth from 2015-2019 (38%), but since it is about 1/4 the size of the wind and solar EPG job market, it does not carry the same influence in the green energy/fossil fuel split.

From 2020 to 2021, the green energy EPG workforce grew by 3.56% - although not very significant on its own, it outpaced fossil fuel EPG workforce growth, which was 0.62%. The projected growth for green energy is ~7% across most technologies; for fossil fuels, it is ~4-5%. Thus, it is likely that an even greater majority of EPG jobs will be green energy in the future (United States Energy and Employment Report, 2022).

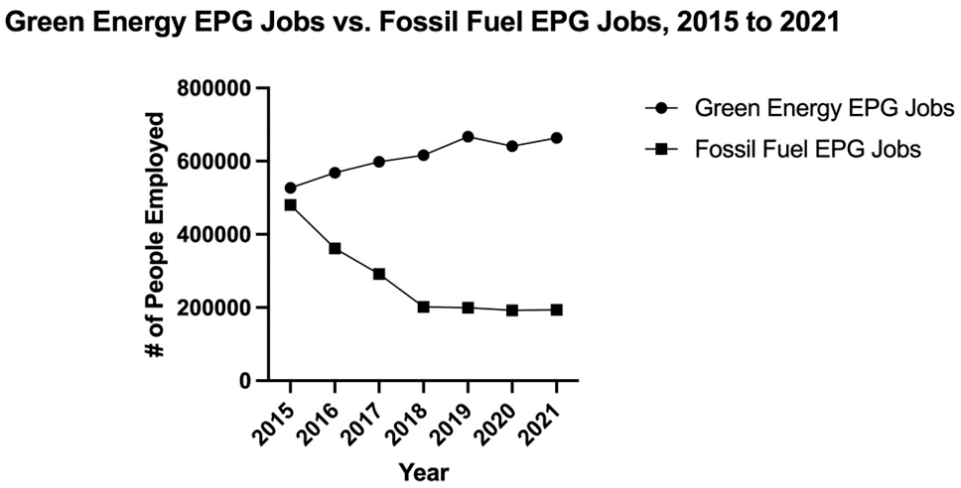

Figure 1: Graph Of EPG Job Estimates In Fossil Fuels And Green Energy From 2015 To 2021

While the fuels job market is currently dominated by the fossil fuel industry, the green energy market is quickly becoming more prevalent. As of 2021, 86% of the current fuels workforce is working in fossil fuels. However, this number has shrunk since 2015, and projections say that it will likely continue to decrease (Department of Energy, 2017).

From 2020-2021, fuels jobs for fossil fuels contracted by about 5%. On the other hand, the green energy fuel job market grew by 4.49%. The coal fuel job market has taken the biggest hit. From 2020 to 2021, the coal fuel job market shrank a dramatic 12%, and overall it has decreased by 28% from 2017 to 2021.

Within the coal industry, mining jobs fell by 39% from 2009 to 2016, and then by another 39% from 2019 to 2021. Other fuels in the fossil fuel sector include petroleum, whose job market has shrunk by 6.38% from 2020 to 2021, and natural gas, whose job market has grown by just 0.86% from 2020 to 2021.

The years 2020-2021 was a timeframe when most job markets bounced back from the COVID-19 pandemic; however, all fossil fuel jobs in the fuels sector failed to restore their original employment rates. On the other hand, all green fuels jobs (ex. nuclear fuel, ethanol, and biofuels) grew 4-5%, and have continued to grow consistently in past years. Green energy fuel jobs now command 13% of the fuels market and are likely to command higher percentages in the future (United States Energy and Employment Report, 2022).

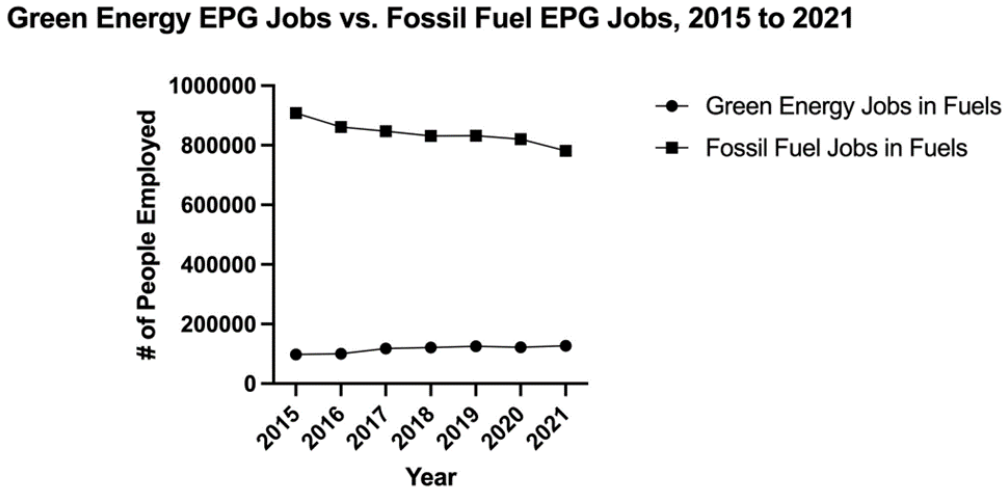

Figure 2: Graph Of Fuel Job Estimates In Fossil Fuels And Green Energy From 2015 To 2021

II. Literature Review

High Demand for Green Energy Workers

There is a high demand for green energy workers among energy employers, and there are not enough qualified applicants to fill the roles demanded. The high demand is likely due to technological advances and government incentives.

True wages have increased across all green energy jobs. In 2016, the median wage for green energy jobs was $30.85 per hour (inflation-adjusted to 2022 dollars) (Muro et. al, 2019). The largest green energy industries (wind and solar, which account for 68% of the EPG renewable energy market) had median wages of $38.96 and $34.31 respectively in 2022. In fact, all green energy industries in which data is available (91% of the total green energy market) have greater median wages than $30.85, suggesting that a true increase in the median wage paid to green energy workers has occurred. This wage growth suggests increasing demand for green energy workers among employers (Bureau of Labor Statistics, 2022).

Green energy employers across all technologies have also reported difficulty finding qualified and interested workers to fill their roles. The two most commonly cited reasons are that the applicant pool is very small, and the applicants have insufficient qualifications. For example, in solar EPG, all sectors (construction, manufacturing, wholesale, business, utility, and others) had 75% or more of employers reporting difficulty hiring workers (United States Energy and Employment Report, 2022). Construction especially had this problem, with 93% of employers reporting at least some difficulty, and 40% reporting it was "very difficult" to hire workers.

Wind EPG had similar statistics, in which four of the six sectors within wind energy production had 90% or more of employers report difficulty hiring workers. Green energy employers want workers, and there are not enough applicants qualified to fill the positions demanded.

Demand for green energy workers is high enough that many green energy employers are training workers on the job. The training they receive is evidenced by the fact that although green energy workers have less educational attainment compared to the national average, they hold significantly higher O*Net scores across STEM skills. O*Net is a system that measures the general knowledge base of people in a certain topic. It is measured on a 1-5 scale, with 5 being perfect knowledge in every regard.

For example, less than 20% of clean energy production workers have bachelor's degrees (compared to 38% of people ages 25 or older in the US), and over 40% of clean energy production workers have a high school diploma or less (compared to 32% nationwide). Yet, clean energy production workers have O*Net scores of 4.0 in mechanical engineering, 3.1 in design, and 2.7 in physics, compared to the national averages of 2.4, 1.9, and 1.6 respectively. In fact, clean energy production workers outstrip the national average knowledge scores in almost every STEM category. According to the Brookings Report source, since the O*Net data comes from worker questionnaires, small quantitative jumps can represent significantly better knowledge of a topic (Muro et. al, 2019).

Thus, it is likely the case that clean energy production workers (and clean energy workers in general) have significantly better knowledge across STEM topics, despite a lower average education level. This indicates that clean energy workers are acquiring STEM (and particularly engineering) skills on the job. On-the-job training incurs extra costs because the employer is paying and educating workers before they can produce meaningful value. The fact that many employers are willing to do this signifies few qualified applicants on the market (Muro et. al, 2019).

III. Why Demand Is High For Green Energy Workers

But why is demand for clean energy workers so high? Demand for clean energy workers is soaring for a few reasons, including technological advancements, government support, and profitability.

One key reason is technological advancements in green energy technology. Renewable energy has seen major technological advancements over the past 10 years. Technological advancements usually make it cheaper to produce renewable energy (an example is the falling average price of production for solar photovoltaic cells), or they make it easier to build large-scale renewable energy installations (such as large wind farms). Both serve as an impetus to hire clean energy workers for building and maintaining clean energy facilities, design home installations, and more. As the price decreases, consumers are more likely to buy the products that these workers produce. Some very recent technological advancements are outlined below, which suggest that demand for clean energy workers will continue to increase over the next 5-10 years.

An example of a technological advancement is offshore wind farms, which are important since wind speeds over the sea are usually higher and more consistent than over land, and offshore wind avoids the usual noise pollution and habitat loss problems that come with building a conventional wind farm. Although offshore wind farms have been around since 2000, they are becoming significantly more efficient and cost-effective. Orsted, a company specializing in renewable energy projects such as offshore wind farms, has already produced over 5,000 megawatts of electricity. (International Energy Agency, 2022) This electricity is currently providing power for tens of thousands of homes in Connecticut, Maryland, and Rhode Island.

In addition to standard offshore wind, the rise of floating offshore wind farms in waters deeper than 60 meters has opened up new possibilities. About 80% of offshore wind potential lies in this domain. The United States and US-based wind companies have started to invest heavily in this technology, with a goal of 15,000 megawatts of electricity generated by 2035, which is approximately 1% of total energy produced in the United States in 2022 (International Energy Agency, 2022).

Another significant technological advancement is in creating sodium-ion electric vehicle (EV) batteries. These batteries eliminate the need for rare-earth materials like lithium, making them more sustainable and environmentally friendly. In addition, these batteries will be cheaper due to the fact that they will not require materials that are difficult and expensive to mine. The combination of these two factors will lead electric vehicles to be significantly cheaper and more environmentally friendly if they adopt this technology. The market for sodium-ion batteries is expected to mature by 2030 (International Energy Agency, 2022). This will lead to cost reductions and improved performance of EVs.

Finally, low-emission hydrogen production, particularly through efficient technology such as solid oxide electrolysers (SOEC), has witnessed significant milestones. Companies like Sunfire and Bloom Energy have successfully deployed SOEC technology, and it proved to be efficient and compatible with other industrial processes. Furthermore, the construction of a 500 MW/year manufacturing facility by Topsoe in Denmark indicates the approaching commercialization of SOEC electrolysers. This will make the large-scale production of hydrogen fuel cell vehicles far more feasible (International Energy Agency, 2022).

Another reason for soaring demand for clean energy workers is government support and incentives. In the US, there is significant government support for clean energy. The Department of Energy (DOE) and President Biden have provided substantial block grants, which are sums of money given to smaller governments from a large governing body, to promote the transition to cleaner and more energy-efficient technologies.

This money can be used to hire personnel; thus, these grants amount to extra labor at no cost to renewable energy companies. Therefore, green energy companies are incentivized to hire more green energy workers, so they can turn a greater profit.

One example of a block grant is the Energy Efficiency and Conservation Block Grant (EECBG), which is a $430 million block grant accessible to states, local governments, and tribes. This grant aims to support the production and services associated with clean energy and energy efficiency. The funds can be used for technology, infrastructure, or regulations associated with these two goals (Department of Energy, 2023).

Another example of government support for clean energy is the Inflation Reduction Act. Signed by President Biden on August 16, 2022, it offers 27 possible tax credits to both producers and investors in the clean energy sector, which has stimulated hiring in the clean energy sector (White House, 2022).

One more key reason why demand for green energy workers is increasing is because of profitability. Renewable energy has started to become more profitable to produce than fossil fuel energy. According to a study by the International Renewable Energy Agency (IRENA), two-thirds of renewable energy produced in 2021 (approximately 163 gigawatts) was cheaper to produce than the cheapest sources of fossil fuel energy (Masterson, 2021). There are a few reasons for this. Firstly, renewables by their nature cut spending. In order to produce energy from fossil fuels, both the energy production mechanism (ex. coal plants) and the extraction of the fuel (ex. mining) must be paid for. Most renewable energy (such as solar or wind) is not based on a fuel - the only major cost is the energy production mechanism.

The second reason for this cost gap is an economic concept known as marginal costs. Marginal costs relate the change in the cost of a product to the change in the quantity of a product. As the quantity of a product decreases, the cost of the product increases, because there is less of the product. Unlike renewable energy, fossil fuels take millions of years to form, and there is a finite quantity to be mined. It is good to note that this is where the names of "renewable" and "non-renewable" come from. There are limited amounts of non-renewable energy sources, unlike renewable energy sources Some reserves of fossil fuels are easier to extract from than others. As we exhaust the easily extractable fossil fuels, we have to use more dangerous, time-consuming, and expensive methods of extraction in order to obtain fossil fuels. This inevitably drives up the cost of fossil fuels over time (raising the marginal cost), whereas renewables do not face this problem. Overall, renewables have become more profitable than fossil fuels, leading to a high demand for workers to help green energy companies build more facilities and expand (Gapminder, 2022).

IV. Attractiveness Of Green Energy Jobs To Fossil Fuel Workers

Green energy jobs are attractive to workers in the fossil fuel industry. People working in the fossil fuel industry have a clear incentive to switch to green energy jobs, which are in very high demand.

In 2022, the median wage for the two main sectors of renewable energy was $38.96 per hour for solar and $34.31 for wind power (Bureau of Labor Statistics, 2022). In 2016, the inflation-adjusted median wage for green energy jobs was $30.85 (the actual wage was $25.30 at this time) (Muro et. al, 2019). Real wages are increasing for green energy jobs, making them more attractive. In addition, this is significantly higher than the national average for a full-time employee, which sits at $28.20 (Bureau of Labor Statistics, 2022).

Job stability is another key reason why green energy jobs might be attractive to fossil fuel workers. Green energy jobs are likely to provide more job stability than fossil fuel jobs in the future. Green energy jobs are growing faster, and some sectors of fossil fuel jobs are shrinking. Although the solar job market took a significant hit in 2020 due to the pandemic, 2021 saw it rebound to almost where it was in 2019. The wind workforce was

the only energy job market that actually grew during the pandemic and then continued that growth into 2021. However, this is not the case with fossil fuels. The coal job market took a large hit during the pandemic and then took another hit in 2021. Although the natural gas job market had grown from 2000-2019, it took a hit during the pandemic, and it failed to bounce back in 2021. Overall, future green energy job stability may be higher than fossil fuel job stability, making green energy jobs more attractive for current fossil fuel workers (United States Energy and Employment Report 2017, 2022).

An additional key factor as to why green energy jobs might be attractive to fossil fuel workers is the location flexibility of green energy jobs, especially compared to fossil fuel jobs. This location flexibility has many advantages, such as being able to live near family or being able to raise children in an area with better schooling. In order to produce solar energy, only open space and direct sunlight is needed. Solar farms are present in vastly different regions with vastly different climates. For example, the Oklahoma countryside has the same concentration of solar farms as the California coastline (National Renewable Energy Agency, 2018).

On the other hand, fossil fuels are relatively geographically concentrated. Fossil fuel mining can only happen on land rich in resources necessary for fossil fuel energy (coal, natural gas, oil, etc.). Jobs involved with mining, processing, and shipping these resources are concentrated in just a few geographical areas in the US. These areas are generally sparsely populated with few other industries, with most of the fossil fuel industry located in areas such as northern Alaska, the rural midwest, and the Appalachian region (White House, 2022).

Finally, green energy jobs might be attractive for current fossil fuel workers because some forms of fossil fuel extraction can be toxic to the places around the extraction site, which can affect the workers and their families. For example, fracking, which is how natural gas is extracted from the earth, can be very toxic for the water systems around the extraction site. People living in these areas have reported being able to light their tap water on fire, showing that there is an extreme amount of gas and other flammables in the water. It is important to note that this could be solved with completely state-of-the-art natural gas mining facilities, but most companies fail to currently have these facilities. In coal mining communities, there are measurable amounts of silica and coal dust in the air -- this causes pneumoconiosis (black lung disease) and other lung problems even among people in the area who do not mine coal (Boyle et. al, 2017). The mining also causes elevated levels of toxic metals such as arsenic, selenium, and mercury in surrounding water streams, which can significantly affect even non-mining communities nearby. The same problems do not happen to areas near green energy jobs in the US, as most mining for toxic materials (like cadmium for solar panels) happens overseas (Boyle et. al, 2017).

V. Communities Dependent On Fossil Fuel Industry And Green Energy As A Possible Solution

The decrease in fossil fuel jobs hurts communities highly dependent on the fossil fuel industry. As fossil fuel jobs begin to diminish, the economy of these places takes a significant hit. Green energy jobs could be a possible way to revitalize these communities.

Fossil-fuel-dependent communities are greatly impacted by the decline of fossil fuel jobs in the US (particularly coal). Certain regions of the country tend to have significant amounts of their population working in fossil fuels; some counties have up to 50% of their working-age population in the fossil fuel industry (Appalachian Regional Commission, 2020). The disappearance of fossil fuel jobs can cause widespread unemployment, which then leads to a significant decline in the economy of these communities. The domino effect does go further, if these towns provide services for other areas, non-mining communities also feel the economic impact.

One example of this happening to a community is coal mining in Appalachia. Appalachia lost 55% of its coal mining jobs between 2000 and 2019. This caused many local economies to decline, particularly in southern West Virginia and eastern Kentucky, where the mining jobs were most concentrated. Total private sector employment stagnated from 2000 to 2019 in Appalachian counties with over 1/5 of their workforce in coal, whereas national employment grew 18% in the same time period. Even in non-mining Appalachian counties, total private sector employment only grew 8%, suggesting that the economic downfall of highly fossil fuel dependent areas led to economic stagnation elsewhere.

The loss of coal mining jobs has caused widespread migration away from coal-producing regions in Appalachia, with the prime working-age population decreasing nearly 15% in Appalachian mining communities from 2000 to 2019. Appalachian mining communities report significantly higher poverty rates, lower education levels, and higher mortality rates compared to the nation as a whole (Appalachian Regional Commission, 2020). Even non-mining communities in Appalachia report elevated levels of poverty and lower levels of education compared to the US, again demonstrating that the loss of coal-mining jobs has a domino effect in nearby non-mining communities. It is important to note that although Appalachia's standard of living has always been lower than the national average, the problem has persisted in recent years.

Green energy jobs and industries could be a way of revitalizing these local communities. Since green energy jobs generally train on the job and do not require college degrees, they are accessible to former fossil fuel workers. Workers previously employed in fossil fuels would now be in a sector with a growing job market and demand for workers. The companies looking for workers would have significantly more labor, leading them

toward growth and expansion. It could be mutually beneficial for green energy employers and former fossil fuel workers if people start shifting to green energy jobs on a large scale (Appalachian Regional Commission, 2020).

VI. The Shift From Fossil Fuel Jobs To Green Energy Jobs Is Not Happening, And The Barriers Preventing The Shift

Although it is clear that fossil fuel workers switching to green energy jobs would be beneficial for everyone involved, this shift is not yet occurring. There are many barriers in the way of this shift, including the weakness of job retraining in America, workers having to take a pay cut, and the lack of union structure.

The density of unions in the fossil fuel workforce has not carried over to green energy jobs, meaning that likely most workers in fossil fuel jobs are not shifting to green energy jobs. Workers generally try to unionize, as it often raises pay and worker conditions. So if fossil fuel workers were switching to green energy jobs, they would likely try to unionize. Fossil fuel unionization rates currently sit at around 20% (Skinner, 2022). This is a large percentage of workers, especially when taking into account that the total workforce includes management and high-level advisors. On average, higher-level officials with higher levels of skill benefit less from unions and therefore do not tend to join unions.

Therefore, in the fossil sector, a culture of unions is established that workers wish to be a part of for their professional careers. However, this culture does not yet exist in green energy jobs, as the fossil fuel unionization rates remain much higher than the unionization rates in green energy jobs. The unionization rate for solar energy sits around 4%, and the unionization rate for wind energy is about 6% (United States Energy and Employment Report, 2022). These numbers are similar to the national average of 6% unionization amongst workers, whereas fossil fuel industry unionization rates are more than triple the national average (Skinner, 2022). Therefore, the union-based workforce of fossil fuels has clearly not transitioned to green energy, suggesting that many workers are not transitioning from fossil fuels jobs to green energy jobs.

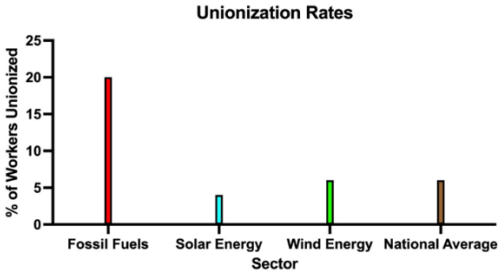

Figure 3: Graph of Unionization Rates Estimates Currently in the United States across multiple sectors

But why is the shift from fossil fuel jobs to green energy jobs not happening? The transition from fossil fuel jobs to green energy jobs is not happening for a few key reasons. Workers would have to take a pay cut in order to join these green jobs, the union structure is lacking, and American job retraining remains weakly established. These barriers are standing in the way of the economically beneficial shift from fossil fuel jobs to green energy jobs.

Although demand for green energy jobs is high, it is true that the transition from a fossil fuel job to a green energy job usually involves taking a pay cut. In 2022, the median wage for a fossil fuel job in the US was $47.25 per hour. On the other hand, the wages for solar and wind electric power generation were $38.96 and $34.31 respectively. There are some green technologies like nuclear and hydropower that have comparable (or higher) wages to fossil fuel jobs, but these form small slices of the electric power generation market and require high qualifications. It is hopeful that continuing demand for green energy jobs will push real wages up across all sectors. However, for now, many workers balk at the pay cut they would need to take, especially if they are raising a family.

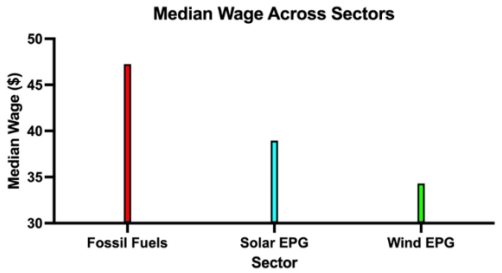

Figure 4: Graph of Median Wages in the United States across multiple sectors

Unions are a contributing factor as to why fossil fuel wages are higher. As stated earlier, 20% of fossil fuel workers are in a union. Unions allow workers to negotiate higher wages, and better worker conditions, especially for lower-level workers with lower skill levels. On the other hand, 4-6% of green energy workers are in a union, suggesting that the same union structure does not exist for green energy jobs. Many workers and union leaders are concerned that some of the jobs in green energy are unskilled labor and therefore may be difficult to unionize. In particular, concerns were expressed about solar panel installations, which do not require much welding training (and other specialized training) to do (Card, 1996).

Lastly, American job retraining is a very weak and outdated process that could use significant expansion and updating. American job retraining was created at a time when people would pursue one career their entire lives, and therefore get retraining likely soon after college. Therefore, American job retraining generally benefits people who haven't spent much time in one industry. The reason why job retraining benefits people in this category is that they are often young, healthy, and unattached. It is difficult to support a full family while retraining, and most young people have the advantage of only having to support themselves. The job retraining programs often require grueling hours and may involve significant manual labor, which suits healthy people better. Lastly, job retraining benefits people who don't have significant financial and emotional attachments to their past job. People who haven't spent a significant amount of time in a certain industry can often change their habits much quicker, and they can also learn new concepts more easily (Fadulu, 2018).

VII. Discussion

Suggested Solutions From Researchers and Energy Professionals

The concept of fossil fuel workers switching to green energy jobs has attracted the attention of major research and journalism institutions as they investigate possible ways to aid the transition. Major institutions are coming up with ways to help fossil fuel workers shift to green energy jobs. This both gives new insights as to how to move this shift along and also demonstrates a clear demand for this shift to happen. I examined some of these solutions and gave my thoughts/criticisms on them.

The Brookings Institution is a research-based think tank specializing in economics. In February 2021, they published a research article laying out a solution for governments to help the shift from fossil fuel jobs to green energy jobs. Their findings show that areas with high fossil fuel job dependency often have significant renewable energy potential. This could make the shift from green energy jobs to fossil fuel jobs incredibly efficient, as workers and their families would be able to stay where they are and simply work a different job (Tomer et. al, 2021). Brookings then lays out a three-part plan as a recommendation to the federal government.

Firstly, one needs to find helpful metrics to track progress, both qualitative and quantitative. The most important metric is to find out exactly how much each community (e.g., county) gains or loses from a transition to green energy jobs. The other major metric is understanding the barriers in switching to green energy jobs, including mismatch of skill sets and lack of pay and union structure. Then, one can create a plan (and an appropriate timeline) to aid the shift from fossil fuels to green energy jobs, while helping the areas most vulnerable to economic downfall from the fossil fuel job decrease.

Secondly, one needs to target retraining to certain "Goldilocks zones," as Brooking put it. There are many fossil fuel dependent areas that have extremely high renewable energy potential. Brookings says that it is essential that these areas are targeted for retraining, as these are the places where there is maximum potential for the shift to green energy and green energy jobs.

Lastly, there needs to be clear incentives from the government for everyone to aid this shift. Governments would incentivize educational institutions and companies to assist in and manage the retraining of fossil fuel workers, especially in these areas. This way, the government spends limited tax money/labor yet still helps in the green energy job transition.

Overall, Brookings gives a good outline to aid the shift from fossil fuel jobs to green energy jobs. The study correctly recognizes that fossil fuel jobs are concentrated in a few geographical areas, and without proper planning, these areas can be hurt by the shift to green energy jobs. Moreover, in these "Goldilocks zones", fossil fuel dependent communities can easily be transitioned to green energy communities. The study also emphasizes the need for the federal government to plan the shift and give it an appropriate timeline complete with goals to achieve by a certain year. Finally, the study encourages the government to formulate metrics to track how the shift to green energy jobs affects counties across the US.

However, I do have some criticisms. For one, the exact steps of the solution aren't laid out. Essentially, the "how" in each of the above steps is missing. First, how will the appropriate metrics be found at the county level, and how can we ensure that they are accurate? It seems difficult to isolate the effects of green energy job shift when looking at general economic data about a county. Also, how exactly will the government encourage retraining to areas with high renewable energy potential? It will have to first systematically identify these areas, then either incentivize the local educational institutions and businesses to provide training or create government-sponsored local job training programs. Both of these are very nontrivial steps. Finally, it is not clear how the

government should go about incentivizing educational institutions and companies in general. Should there be tax breaks, for example, and what could some of the negative repercussions of these policies be?

Also, the study does not discuss that there are currently financial disincentives for workers to shift from fossil fuel to green energy jobs. Despite a growing market, green energy jobs are largely not unionized, and their median pay is significantly lower than fossil fuel median pay (as reviewed previously). Thus, going through the effort of retraining can seem like a money sink to some workers. If one wants to encourage workers to transition on a large scale, this financial barrier needs to be addressed properly.

Despite the obstacles, it is clear that many fossil fuel workers want to make the transition to green energy jobs. Journalist Clifford Krauss of the New York Times wrote an article in February 2023 exploring the thoughts of various people in the energy industry about the shift to green energy jobs. Many of them talk about how green energy jobs offer more job security and how they would prefer to work in the green energy sector (Kraus, 2023).

One person they interviewed was named Jean Paul Beebe, who used to work in real estate for oil and gas companies. He was laid off during the COVID-19 pandemic and was then able to land a job with a renewable energy development company. When asked about his preference, he said "'Riding [the fossil fuel layoff] wave is a load, mentally. What I know now about renewables, it's absolutely more stable.'" Beebe found renewable energy work much more stable and comforting than fossil fuel jobs, continuing to show that the shift to green energy jobs is both possible and beneficial.

Another person they interviewed was named Emma McConville, who had a similar story to Beebe. She got a job as a geologist at Exxonmobil in 2017 but was also laid off during the pandemic. However, she was soon able to find a job at a geothermal energy company, which boosted her career. She now thinks of her ordeal as a blessing, stating that "'Covid was an impetus for renewables, not just for me but for many of my colleagues.'" McConville found similar job stability that Beebe found in the renewable energy sector, which was something that she wasn't quite able to achieve in the fossil fuel sector.

This article provides an insight into individual stories of people switching from fossil fuel jobs to green energy jobs. It shows that if we can create a structure in which fossil fuel workers can retrain and find green energy jobs easily, then likely many will make the switch.

VIII. Taking The Shift Online: A Possible Long-Term Solution

An online service that matches fossil fuel workers with green energy retraining and jobs could be a possible long-term solution for ensuring the shift from fossil fuel jobs to green energy jobs. This solution addresses some of the gaps in solutions presented in the previous section (Section 6).

Green energy employers want workers, and a shift towards green energy jobs would be beneficial for everyone involved. Major research and journalism institutions have taken notice of this. However, the lack of union structure in green energy jobs combined with rising unemployment rates in fossil fuel dependent communities shows that by and large, workers are not transitioning from fossil fuel to green energy jobs. This is because transitioned workers would have to take a pay cut, they would not have the same protections afforded by unions, and the green energy jobs have a different skill set.

An online tool that matches fossil fuel workers with green energy jobs and job training can address all these challenges. The service would work with green energy companies to list out available jobs and provide the training (in-person and/or online) for fossil fuel workers looking to switch to these jobs. These workers would be found using social media advertisements targeted towards them on Facebook, Twitter, Instagram, etc. Once the workers join the service, they can see all available job listings and pieces of training. If they find a job they like, they can complete the requisite training directly on the service, and then apply for the job. In addition, workers would also have the ability to voice concerns about things such as union structure in their new jobs so that they are satisfied with their work. As more workers make the transition from fossil fuel to green energy jobs, it is likely that the same union structures that already exist in fossil fuel work will materialize in the green energy sector.

This tool solves many of the problems in previously proposed solutions. Targeting the correct communities of workers is a problem that has already been solved in the world of social media advertising. Social media companies use a large base of data consisting of posts, liked posts, friend groups, and other data points. They feed it into artificial intelligence models to predict how users will respond to different ads, and the models prove remarkably effective at helping companies find their exact market and advertise to them. The social media analytics and AI models would allow finding workers in the fossil fuel sector who are looking to switch to green energy jobs, but may not have the resources to do so. This would allow targeting fossil fuel dependent economies and areas with high renewable energy potential, as the Brookings solution attempts to do. Moreover, social media advertising systems are designed to be cost-effective, so the online tool requires minimal overhead to set up and maintain.

Also, everyone participating in this online tool has a clear incentive. The workers we find will want to change to green energy jobs but need help doing so. The companies that post jobs and provide training modules want to hire green energy workers but are having trouble finding qualified and/or interested applicants. We saw

in Section 2 that most green energy employers are in this situation, with over half reporting difficulty finding workers. The online tool may be run on a 3rd party service. Costs associated with this 3rd party service can be paid by either donations or by charging a small fee to workers and companies that want to participate in the online tool. With this tool, we can set up an environment where everyone is financially incentivized to aid the shift from fossil fuel to green energy jobs. Being online and advertised through social media, it is extremely accessible to both workers and employers.

Overall, this would be a very in-demand service that would help a lot of people. This is an important topic to address, as communities dependent on fossil fuels are at risk. An online tool to help fossil fuel workers in switching to green energy jobs would be incredibly valuable to everyone involved.

IX. Conclusion

In summation, it is clear that a shift from fossil fuel jobs to green energy jobs is beneficial. Demand is increasing for green energy workers, and decreasing for fossil fuel workers. However, it is also clear that this shift is not happening. Unionization rates have yet to adjust, and there are many reasons why this shift is not happening. Research professionals such as Brookings and the New York Times give potential solutions to aid this transition. A good potential idea is to take the transition online, consolidating all of the necessary information in one place. Overall, more research and resources into both creating green energy jobs and aiding the shift would be extremely beneficial for people and the environment.

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