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Green Energy Jobs in the US: What Are They, and Where Are They?

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Abstract

Does the growth of renewable energy benefit US workers, and which workers stand to benefit the most? Until now, evidence on green energy jobs has been limited due to measurement issues. We use data on nearly all jobs posted online in the US, as collected by Burning Glass Technology, and we create a new measure of green jobs, defined here as solar and wind jobs. We use job titles and task requirements to define green jobs. We find that both solar and wind job postings have more than tripled since 2010, with solar jobs seeing especially strong growth that precedes the growth of new installed solar capacity. In 2019, we identify approximately 52,500 solar job openings and 13,500 wind job openings. Solar jobs are mostly (33%) in sales occupations, and in the utilities industry (16%). Wind jobs are most represented among installation and maintenance occupations (37%), and in the manufacturing industry (29%). Green jobs are created in occupations that are about 21% higher paying than average. The pay premium is even higher for jobs with a low educational requirement. Finally, green jobs tend to locate in counties with high shares of employment in fossil fuel extraction. Overall, our results suggest that the growth of renewable energy leads to the creation of relatively high paying jobs, which are more often than not located in areas that stand to lose from a decline in fossil fuel extraction jobs.

Keywords: Renewable Energy, Green Jobs, Future-of-Work

JEL Codes: Q52, J23

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1 Introduction

The massive challenges presented by climate change are already forcing large shifts in the global economy. In December 2021, President Joe Biden signed an Executive Order "Catalyzing America's Clean Energy Economy Through Federal Sustainability," pledging among other goals that the federal government will use 100% carbon pollution-free electricity by 2030. In parallel, total wind and solar energy production has grown tremendously in the US since the mid-2000s. This shift to a low carbon future will certainly create new jobs and raises a number of questions important for our understanding of local labor markets and the future-of-work. What new jobs does a low-carbon economy create? What are the distributional implications of this transition for workers? Will areas of the US that specialize in shrinking carbon-intensive industries be able to benefit from these new jobs in a green economy?

Until now, evidence on these questions has been limited due to the lack of systematic data on green jobs. Prior research has found it challenging to identify green jobs, which span many industries and occupations. For instance, solar and wind jobs include positions in manufacturing, installation, sales, engineering, finance, and electricians among many others. Identifying green jobs therefore requires far more detailed information about a job than traditional datasets with standard industry and occupation codes are able to provide. The strength of our analysis lies in leveraging a unique dataset on individual job vacancies. The Burning Glass Technologies (BGT) job vacancy posting data we use contain the near-universe of US online job vacancies, and includes the position's title as well as detailed skill and task requirements.

We focus on green jobs, and separately analyze the trends in solar and wind jobs. Looking at these two types of jobs separately is important because, as we will see, both the geographic location and job types differ markedly between solar and wind. These differences imply that different types of people and regions are likely to benefit from the expansion of wind vs. solar jobs. Our definition of wind and solar jobs encompasses all jobs that require skills related to these energy sources, and all jobs posted by firms specializing in these energy sources. Specifically, we define wind and solar job postings using three different elements. If any of these elements is present, the job is classified as green. First, a job is a wind or solar job if the job title and/or occupation include "solar," "photovoltaic" or "wind." Importantly, BGT re-codes past job postings and occupations so that even if a new green job title or occupation was added recently, it can still be assigned to jobs in earlier time periods. Second, a job is wind or solar if it explicitly requires a skill that relates to wind or solar energy. Third, a job is wind or solar if it is posted by a firm that posts a relatively high share of jobs that require wind or solar skills.

Using this definition of green jobs, we find that green job postings in the US have seen strong growth, especially in recent years. Between 2013 and 2019 the number of wind job vacancies increased roughly three-fold to 13,438, while the number of solar job vacancies increased roughly five-fold to 52,474. This growth is in line with the expansion of solar and wind electricity: in particular, the growth of new solar electric capacity follows very closely the growth of solar jobs. About a third of solar jobs are in sales occupations, while about a third of wind jobs are in installation and maintenance occupations. In terms of industries, green jobs are naturally found in utilities: about 10% of solar and wind jobs are in utilities. However, manufacturing is the most common industry for wind jobs, representing over 20% of all wind jobs. Green jobs are created in occupations that pay about 21% more than average, when assigning to each job posting the median earnings of the 6-digit SOC occupation in the Occupational Employment Statistics BLS dataset. The occupational earnings premium is highest for jobs with lower educational requirements. Further, the occupational wage premium for wind and solar jobs is higher than the occupational wage premium for jobs in the fossil fuel (oil, coal and natural gas) extraction industries.[1] In terms of geography, solar and wind jobs are geographically dispersed, and are more likely to be located in areas with a high share of employment in fossil fuel extraction industries. Overall, our results suggest that the renewable energy boom will create high paying job opportunities, especially for low skilled workers and workers who live in areas with a high share of employment in the oil & gas industry.

[1] We define fossil fuel jobs according to the NAICS industry of the employer. We use all job postings in oil, natural gas and coal extraction and related industries. Specifically, we define fossil fuel jobs as every posting in the NAICS 21 sector except those in 2122 and 2123 which cover mining in non fossil fuel categories such as iron, copper and limestone.

The research performed in this study is part of an important shift in our understanding of the labor market effects of transitioning to a low carbon economy. Until recently, most literature at the intersection of environmental and labor economics has emphasized the lost jobs and lost wages that result from transitioning to a cleaner economy (Greenstone, 2002; Walker, 2011; Curtis, 2018; Hafstead and Williams, 2018; Hafstead and Williams III, 2020). While findings vary in their magnitude, this literature suggests that workers and communities will bear significant costs when policies designed to discourage polluting activity lead to reductions in certain industries and jobs. Far less research has explored the new jobs that will be created and the benefits that will accrue to workers and communities as a result of transitioning to a renewable energy future. Estimating these benefits and identifying their distributional implications across workers and communities is equally important to understanding the labor market effects of transitioning to a cleaner economy.

In light of this, we make three contributions to the literature. First, we offer a new measurement of renewable energy jobs using the near-universe of US job postings from BGT that allows us to identify solar and wind jobs.[2] Prior literature used occupational or industry classifications to identify green jobs (Consoli et al., 2016; Bowen, Kuralbayeva, and Tipoe, 2018; Vona et al., 2018; Vona, Marin, and Consoli, 2019; Rutzer, Niggli, and Weder, 2020).[3] For the O*NET and SOC definitions, green jobs are based on specific occupations that are defined as green by O*NET or SOC occupational classification.However, occupation and industry definitions have been slow to change over the years and new green occupations (e.g. "solar panel installer") can only appear once the occupation has been created in O*NET and used to categorize jobs in new surveys. Our green job definition is based on firms' *own* description of their jobs as requiring green skills (specifically wind or solar), no matter what the specific O*NET occupation is. Further, the BGT data has the advantage of going backward in time to identify green jobs, so the birth of new green occupations and jobs is not missed.[4] Second, we show using our data that green jobs tend to be higher paying

[2] Recently, scholars have exploited the rich information found in BGT data to better understand the labor market effects of new technologies, such as the adoption of artificial intelligence (Acemoglu et al., 2020).

[3] For example, Vona, Marin, and Consoli (2019) defines a "greenness" score for each occupation according to the number of green tasks that the typical worker in that occupation performs.

[4] A second source of data on green jobs comes from the Solar Jobs Census (2022), an industry-sponsored phone and email survey of firms. This data has received limited attention from academics but has recently received funding from the Department of Energy (DOE) and is now included in the DOE's United States

jobs, based on the occupation-level earnings. While O*NET-based definitions of green jobs lead to the finding that green jobs require more education (Consoli et al., 2016; Vona et al., 2018; Bowen, Kuralbayeva, and Tipoe, 2018; Vona, Marin, and Consoli, 2019), we find that green jobs specifically advertised as such do not require more education than other jobs, at least conditional on explicitly requiring a level of education. In fact, the occupational pay premium for green jobs is *higher* for jobs requiring less education; in terms of the wage premium for green jobs and how it varies by education, our findings using explicit job skill requirements are consistent with the O*NET-based findings of Vona, Marin, and Consoli (2019). Third, we establish new results on the geography of green jobs in the US, which are enabled by our granular data on job postings. In particular, we find that green jobs tend to locate in areas with a high share of employment in the oil and gas industry.

The rest of the paper is organized as follows. Section 2 describes our data from Burning Glass Technologies, and our definition of solar and wind jobs. Section 3 presents the results on the characteristics and location of solar and wind jobs. Finally, section 4 concludes.

2 Data

The primary data source comes from Burning Glass Technologies, which contains the near-universe of US online job vacancy postings.

Burning Glass scrapes every online posting, de-duplicates postings that are made on multiple sites and creates a job-posting level data set with variables that include the job title, employer, job location, occupation, industry of employer, education requirements and earnings. Job posting data is first available in 2007. Burning Glass paused collecting data in 2008 and 2009 before starting again in 2010. As a result, the analysis of this paper uses data from 2007 and 2010-2019. Burning Glass is widely considered to be a comprehensive and accurate measure of job postings. Research by Carnevale, Jayasundera, and Repnikov (2014) shows that BGT job postings in the US track closely with more aggregate surveys such as the JOLTS, CPS and OES. Hershbein and Kahn (2018) show that industry and occupation trends of BGT also match trends found in those surveys. Below we discuss some important caveats, but on the whole BGT data has been shown to accurately track demand

Energy and Employment Jobs report (Department of Energy and BW Research Partnership, 2022).

for different segments of the US economy. Recent studies have used the data to track the effect of other new labor market trends such as increased demand for data scientists and artificial intelligence skills (Acemoglu et al., 2020; Goldfarb, Taska, and Teodoridis, 2020; Bloom et al., 2021). Our work applies techniques similar to those employed in these papers to gain insight into renewable energy jobs.

Many of the variables, provided by BGT such as the job title, employer, education requirement, earnings and location, are directly scraped from the job posting. Additionally, Burning Glass processes each job posting and assigns jobs to standardized NAICS industry and SOC occupation codes when not directly stated in the job posting. For every posting, Burning Glass scrapes the full text of the job description and extracts a detailed list of "skills" that the employer requests of applicants. In practice, this list of "skills" includes both skills as well as job tasks that the employer expects the new hire to perform. This list of skills and tasks provides an in-depth look into what the job entails and allows us to identify jobs in which the worker will be tasked with activities associated with renewable energy. The average posting contains more than eight skills and tasks ranging from experience with specific hand tools such as circular saws and micrometers to computer programming knowledge such as C++ and Python. This information gives a far more nuanced understanding of the position than can be provided by the occupation or even job title. These skills prove useful in identifying solar and wind jobs which otherwise may not have been classified as such. For example, while most electricians will be performing tasks unrelated to solar energy, a sizable minority of electrician job postings list "solar installation" as a requested skill.

Our process of identifying solar and wind jobs takes advantage of the full range of job posting variables that are provided. We first scan job titles for three key words. These words are "solar", "photovoltaic" and "wind." After removing potential confounding words and phrases we find well over 1,000 unique job titles with these solar and wind terms.[5] BGT provides a "cleaned" job title variable, but we also search the raw job titles. We often find many variations on common job titles. For example, in 2019 alone, our algorithm finds over 60 different versions of the title "Solar Panel Installer."

[5] We extensively check these titles (and the skills) to remove listings that will provide false postives. For example, listings in which the title (or skill) included "wind instrument" "window" "windshield" "solarwinds", "woodwind" and over 30 others.

Next, we use the BGT occupation categories to identify solar and wind jobs. BGT occupation categories are more detailed than Standard Occupational Classification (SOC) and O*NET occupations which are also provided in the data. BGT occupations include Solar Energy Installation Managers, Solar Energy Systems Engineers, Solar Photovoltaic Installers, Solar Sales Representatives and Assessors, Solar Thermal Installers and Technicians, Wind Energy Development Managers, Wind Energy Engineers, Wind Energy Operations Managers and Wind Turbine Service Technicians. This detailed level of BGT occupational categories stands in contrast to SOC occupational categories which did not include any any solar occupations until 2013 and did not define any wind occupations until 2019. Importantly, Burning Glass also retroactively defines jobs in past years according to current year occupational categories ("dynamic taxonomy update"). To update its skill taxonomy, BGT uses a combination of algorithmic methods, qualitative methods based on in-house experts, and the input of client firms with relevant expertise (Burning Glass Technologies, 2019). Thanks to this dynamic taxonomy update, we are able to identify wind engineers, for example, in all years of our data even though the official occupation category was just recently identified. By retroactively identifying occupations based on current occupational definitions we are able to identify solar and wind job postings from the earliest years of data that might otherwise have been missed.

After identifying renewable jobs based on their title and occupation, we then turn to the skills/tasks that the job posting lists. We scan the full set of skills listed by every posting in all years of our data. Overall, we search through approximately 2.2 billion skills listed in these postings, searching for words with the strings "solar", "photovoltaic" and "wind." The specific skills for wind and solar are found in Table 1.

Finally, we identify jobs as solar or wind if they are posted by firms we define as solar or wind firms. A firm is defined as solar or wind if more than 40% of the firm's job postings in that year are solar/wind jobs as defined above. Additionally, we allow the threshold to drop to 10% if the firm name contains the words "solar", "sun", "renewable", "green" or "sol."

In total, approximately 43% of our solar jobs are identified by either title or occupation. An additional 29% are identified through the "skills" of the job and the remaining 28% are jobs which do not have a solar job, title or skill but are listed at a solar firm. For wind jobs these numbers are 59%, 27% and 14% respectively.[6]

Before moving to the results, it is worth keeping in mind a few caveats regarding our methodology for identifying solar and wind jobs. First, these definitions are necessarily based on job postings rather than actual jobs. As a reference point, there were approximately 44.5 million online job postings in 2019 while overall US employment was 158 million. We refrain from making statements on the total number of solar and wind jobs in the economy because job vacancies may not be representative of overall employment for the following reasons. Occupations and industries with high turnover rates may be overly represented in the data as they need to hire more often. Additionally, job openings that are posted online may not be representative of all job openings in the economy and have the potential to be skewed towards jobs requiring more education and those located in urban areas. Finally, in the data we do not observe the skills, educational requirements, tasks and earnings of the workers that actually end up filling them. Employers may not fill some postings and for others, the workers that fill them may end up performing different tasks and requiring different skills than are listed in the posting.

Nonetheless, we believe our definition of solar and wind jobs marks a substantial improvement over past attempts to measure labor market activity in these solar and wind sectors. By using detailed job-posting level data on job titles, skill and task requirements, retroactive measures of occupations and firm hiring details, our definition allows us to gain a number of insights into these positions that previous, more aggregated measures have not been able to capture.[7]

3 Results

3.1 Green jobs and renewable energy production over time

Figure 1 plots the evolution in the number of solar and wind job postings over time. In 2007, when our BGT dataset starts, there were almost no wind and no solar jobs in the

[6]Many of the biggest manufacturers and installers of solar panels and wind turbines are large firms such as Tesla, General Electric and Siemens. Our definition of solar and wind firms will not include these companies. As a result, jobs in these businesses that support renewable activity but are not directly related to it, will not be included in our measure.

[7]See Department of Energy and BW Research Partnership (2022) and Solar Jobs Census (2022) for other survey based measures of renewable jobs.

US. After 2013, we see an accelerating growth of green jobs, with solar job postings growing particularly rapidly. Between 2013 and 2019, the number of wind jobs roughly tripled to 13,438 while the number of solar jobs roughly quintupled to 52,474. Overall, by 2019, 0.17% of new job postings are solar and 0.03% are wind. These may seem like a small numbers, but one has to remember that these are *new* jobs, and that our definition only counts as wind and solar jobs that explicitly require those skills, or that belong to a firm specialized in wind or solar energy. As another comparison, the total number of job openings in the fossil fuel extraction sector in 2019 is 44,163. Further, as we will soon see, wind and solar jobs are very unevenly distributed across the US territory: there are commuting zones where as many as 6.94% of job postings are solar, and other commuting zones where as many as 9.66% of job postings are wind-energy related.

The growth of green and solar job postings over time follows a similar overall trajectory to the growth of total solar and wind electricity production in the US (Figure 2). Interestingly, total wind production is considerably larger than total solar production, while solar jobs are more numerous than wind jobs. This likely reflects different production technologies in the two sectors. Cameron and van der Zwaan (2015) review the literature on the job intensity of wind and solar energy: they find a larger number of workers per MWh in the solar relative to the wind sector, and this solar job advantage holds within both the manufacturing & installation job types, and within the operation & maintenance job types. When comparing job postings with new capacity of solar and wind energy (Figure 3), we can see that solar jobs closely track the trajectory of newly installed solar capacity. In particular, a strikingly large spike in new solar jobs in 2015 (Figure 1) is echoed in a similarly large spike in new installed solar capacity in 2016. This time series pattern validates our definition of solar jobs as being closely linked to solar energy production.

3.2 Occupation, occupational wages, and industry for green jobs

3.2.1 Occupation and industry distribution among green jobs

The broad occupational distribution of solar and wind jobs in 2019 can be seen in Figure 4A. Solar jobs are heavily concentrated in sales: about 33% of all solar jobs are in sales vs. just above 11% of all jobs. The next most common occupational category for solar jobs is management and finance, with a share that is similar to the share of these jobs in the overall economy. Finally, about 29% of solar jobs are in installation, manufacturing, maintenance and construction occupations, which is about three times the share of these jobs in the overall economy. The occupational distribution of wind jobs is markedly different from both that of solar jobs and that of all jobs. About 50% of all wind jobs are in installation, manufacturing, maintenance and construction occupations, which is almost double the share of these occupations in solar jobs, and almost four times the share of these occupations in all jobs. Management and finance is the second most common occupational category for wind jobs, with a share that is broadly similar to both solar jobs and all jobs. In contrast to solar jobs, sales are not a common occupation for wind jobs: sales represent only 2% of wind jobs, compared to nearly 33% of solar jobs. Broadly then, solar jobs are vastly overrepresented in sales, while wind jobs are vastly overrepresented in installation, manufacturing, maintenance and construction occupations. This different occupational profile may reflect the different production process of wind and solar energy. Wind energy is more capital intensive than solar energy, with about 30% larger capital costs per kilowatt hour (International Energy Agency, 2021; U.S Energy Information Administration, 2022), which may explain the large share of wind jobs that are related to capital building and maintenance based on their occupational classification (Figure 4A). Further, about 80% of solar workers work on projects at the residential and commercial scale, not the utility scale, which may explain why there is a greater need for people selling solar energy to these residential and commercial customers (Department of Energy and BW Research Partnership, 2022).

We can also compare the occupational distribution of wind and solar jobs to that of fossil fuel jobs (Figure 4A). Fossil fuel jobs are identified based on NAICS industry of the employer. We include every job in NAICS sector 21 except those in 2122 and 2123 which cover mining in non fossil fuel categories such as iron, copper and limestone. While we will be comparing fossil fuel jobs and green jobs, it's important to keep in mind the different ways in which we define the two categories: wind and solar jobs are largely defined by job titles and skill requirements, while fossil fuel jobs are entirely defined by the industrial classification of the firm that posts the job. Broadly, the distribution of occupations for fossil fuel jobs is similar to that of solar jobs. The one noticeable difference is that solar jobs are somewhat overrepresented in sales relative to fossil fuel jobs. Still, even fossil fuel jobs are over-represented in sales relative to all jobs (17.1% vs. 11.4%), in marked contrast to the under-representation of wind jobs in sales (only 2% of wind jobs are in sales).

In terms of broad industries (Figure 4B), solar and wind jobs are not surprisingly over-represented in utilities: about 15% of solar and wind jobs are in utilities vs. 0.4% of all jobs. Solar and wind are also over-represented in blue collar industries, with about 40% of jobs in these industries vs. only about 20% of all economy-wide jobs belonging to these industries. The main difference between wind and solar jobs is that solar jobs are over-represented in trade industries, while wind jobs are under-represented. We do not separately identify industries of fossil fuel jobs because they are explicitly defined by industry.

In Figures 5 and 6 we show a more detailed occupational (2-digit SOC) and industry (2-digit NAICS) breakdown for solar and wind jobs in 2019. For solar jobs, the more detailed occupational breakdown allows us to see that the second most common detailed occupation after sales is construction and extraction, though this still represents less than half the share of sales related occupations among solar jobs (Figure 5). In terms of industry (Figure 6), solar jobs, not surprisingly, are most common in utilities. Interestingly, however, utilities account for only 16% of all solar jobs, with the next two industries (Administrative Support and Waste Management, and Construction) being almost as common at 15 and 13% respectively of all solar jobs. The substantial combined share (about 23%) of Retail Trade and Wholesale Trade industries can help explain why most solar jobs are in sales occupations.

Similarly, the more detailed breakdown for wind jobs seen in Figures 5 and 6 allow us to see that Installation and maintenance occupations account for 36% of all wind jobs (Figure 5). In terms of industries (Figure 6), the most common industry is manufacturing, which represents about 29% of all wind jobs, vs. only about 5% of all jobs in the economy. Professional, scientific and technical services is almost as common an industry for wind jobs as manufacturing. Interestingly, utilities, while substantially overrepresented in wind jobs compared to the overall economy, only come in as the third most common industry, with just under 16% of wind jobs. Manufacturing is by far the most common industry for wind jobs, with 29% of all wind jobs (Figure 6).

Are solar jobs more durable than wind jobs, or vice-versa? In general, maintenance types of jobs are more durable than jobs related to the installation of renewable energy capacity. Wind jobs are over-represented in installation and maintenance occupations, but the occupational classification does not allow us to cleanly break down further installation from maintenance as even more detailed 6-digit SOC occupational categories are typically described as "installation and maintenance". Solar jobs are over-represented in sales, and those jobs may be less durable to the extent that they are related to the installation of new solar capacity.

How do wind and solar jobs differ from fossil fuel jobs in terms of detailed occupations (Figure 5)? Fossil fuel jobs tend to differ from all jobs in ways that are similar to wind and solar jobs: for example, fossil fuel jobs are also over-represented in installation & maintenance and in sales and related occupations relative to all jobs, even though the degree of over-representation is not as large as for solar and wind jobs. In that sense, wind and solar jobs are more "unique" than fossil fuel jobs.

Overall, we find that there are some significant differences between wind and solar jobs in terms of their occupation and industry classification. About a third of solar jobs are in sales occupations, while a third of wind jobs are in installation and maintenance occupations. For wind jobs, manufacturing is the most common industry, with slightly under 30% of all wind jobs, vs. only about 10% of all solar jobs in manufacturing.[8] Solar and wind jobs are also similar to each other and different from the rest of the economy in some respects: most notably, utilities account for a similar 15-16% share of wind and solar jobs. Finally, we've learned that green jobs are more similar to fossil fuel jobs than to all jobs in terms of their occupational classification.

3.2.2 Occupational wages and educational requirements in green jobs

Are green jobs good jobs? Do they pay more? Even if green jobs did pay more, it might be because they require more skill, so they would not be accessible for many workers. Overall, conditional on explicitly requiring any education, green jobs have roughly the same educational requirements as other jobs (Figure 7, Panel A): about 40% of solar and wind jobs only require a high school degree. The absence of an educational requirement may be due

[8] We note here that some of the largest wind employers are large conglomerates such as General Electric and Siemens.

to employers not explicitly requiring any education, or it may sometimes be due to BGT data failing to pick up on the required education level. Based on our earnings results by education below, jobs without an explicit educational requirement look similar to high school jobs. Therefore, it is likely that most jobs without an educational requirement have a low educational requirement. If we take no education requirement to mean a low level of educational requirement, then solar jobs clearly require far less education than all jobs, while wind jobs require slightly more education than all jobs (Figure 7, Panel B). However, even for wind jobs, the main reason why they have higher educational requirements than all jobs is that they are more likely to require a high school degree. Therefore, while wind jobs may require slightly more education than all jobs, the difference is likely not very substantial.

Then, we analyze wages for green jobs based on their occupational classification. The goal of this analysis is to determine the extent to which green jobs were created in high-earning or low-earning occupations. For example, it could be that green jobs were predominantly lower paying construction jobs, or predominantly higher paying engineering jobs. We take 2000 as a base year to determine occupational earnings, since there were very few green jobs at the time. We ask whether green jobs were added to the kinds of occupations that were high-earning in 2000. For each job posting, we assign the 2000 median earnings in the 6-digit SOC occupation based on the Occupational Employment Statistics from the Bureau of Labor Statistics.[9]

Occupational earnings results are reported in Table 3. In all columns, we include separate dummies for solar jobs, wind jobs, and fossil fuel jobs. In the first column, we do not add any controls: on average, solar and wind jobs are created in occupations that pay about 21% more than average (Column 1). We then control for required education fixed effects (Column 2), then for county fixed effects (Column 3), then for broad occupation (2-digit SOC) fixed effects (Column 4), and then for required education, county and broad occupation fixed

[9] We use the median 2000 earnings of the SOC code of the job posting. Most SOC occupations in the 2019 job posting data are also present in 2000. Two notable exceptions are Wind Turbine Service Technician and Solar Photovoltaic Installer. For these job postings, we assign their earnings to the 2000 earnings of Telecommunications Line Installers and Heating, Air Conditioning, and Refrigeration Mechanics and Installers respectively. In 2019 these occupations had nearly identical identical earnings to their green energy job counterparts. Wind Turbine Service Technician and Solar Photovoltaic Installer are the only SOC occupations that would be considered a green energy occupation in 2019. Results reported in the Appendix show that findings are robust to using 2019 median occupational earnings.

effects together (Column 5). The purpose behind these fixed effects is to better understand why wind and solar jobs are created in higher paying occupations. The positive green occupational earnings premium is not due to these jobs requiring higher education: Column 2 shows that the premium is roughly the same after we control for the education required by the employer in their job posting (including a dummy for the case when no education level was explicitly required). In Column 3 we control for the location of the job, demonstrating that the earnings premium is not due to these jobs being created in high-income counties. Next (Column 4), we control for the broad occupational type by using 2-digit SOC dummies. This answers the following question: within broad occupational type (e.g. management, or sales and related occupations), are green jobs created in more specific occupations that have higher earnings? For solar jobs, controlling for broad occupational type reduces the green job premium to 15% (Column 4), which is still a large premium equivalent to over two years of schooling. For wind jobs, controlling for broad occupation reduces the green job premium from 22% to 7%. We then control for educational requirements, geographic controls and broad occupation: this gives a 15% occupational earnings premium for solar jobs and a 5.5% occupational earnings premium for wind jobs (Column 5). Controlling for education requirement, county and 2-digit SOC code fixed effects (Column 5) yields very similar results to just controlling for 2-digit SOC fixed effects (Column 4), which is consistent with educational controls having little effect on occupational wages (Column 2 vs. Column 1). In all specifications, we also include a dummy for fossil fuel extraction jobs. These jobs have no significant occupational earnings premium: in other terms, while green jobs come with a positive premium, fossil fuel jobs do not yield any earnings premium on average.[10]

In Table 4, we break down the data into jobs with different education requirements. For each educational requirement, we run a regression without controls, and a regression with 2-digit SOC fixed effects; the latter regression accounts for the broad job type. We find that occupational earnings premiums for green jobs tend to be largest for jobs with lower educational requirements. For jobs that require a high school degree, the green job premium is about 30% (Panel A, Column 1) overall, and of the order of 15% if we look within broad

[10]Many observations do not report any educational requirement. In separate results not reported here we impute education for these observations based on the most common level of education within the occupation according to OES data. Imputing education in this way does not meaningfully impact the estimates.

2-digit SOC occupation (Panel A, Column 2). For jobs that require a bachelor's degree, the green job premium is only 5% for solar and 10% for wind (Panel D, Column 1). For fossil fuel extraction jobs, the occupational premium is almost always smaller than for renewable energy jobs. Interestingly, in jobs that list no educational requirement (Panel F) the fossil fuel job premium is statistically insignificant but large and *negative*, in contrast to the positive and significant premium for green jobs. Given that jobs with no education requirement are predominantly low skill, this suggests that, for less skilled workers, green jobs are far preferable to fossil fuel extraction jobs.[11]

Overall, we find that solar and wind jobs have broadly similar educational requirements to all jobs, and are created in occupations with earnings about 21% more than average. Even controlling for broad job type (2-digit SOC), job location and the educational requirement of each job, we still find a positive occupational earnings premium for green jobs. Finally, green jobs with lower education requirements tend to have much higher occupational earnings premiums. This suggests that green jobs are likely to be especially good prospects for less educated workers.

3.3 Where are the green jobs?

Green energy jobs are very unevenly distributed over the US territory in 2019 (Figure 8): most commuting zones have a green job share of less than 0.5%, while the maximum share of solar jobs is 6.94% and the maximum share of wind jobs is 9.66%. Commuting zones with a higher share of solar jobs are mostly in the south of the country, from Southern California to Arizona, Texas, Florida and Georgia. However, most states in the traditional South have a low share of solar jobs despite the sunny weather, while a number of areas in the Northeast have a relatively high share of solar jobs in spite of the less favorable weather. Commuting zones with a high share of wind jobs are concentrated on a vertical stripe in the middle of the country from Texas to North Dakota. Columns 1 and 2 of Table 2 lists the top twenty-five commuting zones in the US for solar and wind jobs according to the number of job postings in 2019. Columns 3 and 4 rank commuting zones according to the percentage of their job

[11] Appendix Tables A2 and A3 report the same regressions used in Tables 3 and 4 but use 2019 median occupational earnings rather than 2000 median occupational earnings. Results are robust to using current occupational earnings as the outcome variable.

postings that are solar and wind. Interestingly, Texas is one of the few states that has a high share of both wind and solar jobs. Thus, Texas is already an energy hub for both fossil fuel and renewable energy.[12]

Next, we examine whether there is a correlation between a commuting zone's share of solar or wind job postings and the characteristics of that commuting zone. We calculated the Solar / Wind Job Share as the average share over our sample period and then correlate that with various demographic and economic characteristics of the commuting zone.

We begin by asking whether green jobs are created in areas that already have strong employment growth (Figure 9)? For solar jobs, there is a strong and highly statistically significant positive correlation between the share of solar jobs in a commuting zone and the growth of employment between 2000 and 2018. In the figure we report both the coefficient and standard error for the best fit line. For wind jobs, there is a positive but very weak and statistically insignificant correlation with commuting zone level employment growth. Another way of investigating this issue is to ask whether green jobs were created in areas with strong employment growth *prior* to the big increase in green jobs (Figure 10). There is essentially no relationship between solar jobs and prior employment growth, while there is a negative and highly statistically significant correlation between the share of wind jobs and employment growth in the commuting zone in 1980-2000. Relative to solar jobs, wind jobs thus have a higher potential for redressing geographic inequalities in job creation, as they tend to appear in areas of the country with a history of lower employment growth.

As the case of Texas suggests, there may be a correlation between fossil fuel production and the location of renewable energy. At the national level, we do indeed see a positive statistically significant correlation between the share of oil and natural gas employment in a commuting zone and the share of solar or wind jobs (Figure 11). This correlation may be due to a correlation in geographic conditions that favor renewables and fossil fuels (e.g. more wind in the mountains where coal is being extracted), and/or to the local know how in the energy industry that facilitates workers' movement between fossil fuel jobs and green jobs. The occupational distribution of fossil fuel jobs is somewhat similar to that of green jobs

[12] Table A1 provides a list of commuting zones that are in both the top 10% of percentage solar jobs and top 10% of percentage fossil fuel extraction jobs.

(Figure 4A), so worker skill may well be part of the reason for the correlation. Whatever the cause behind the co-location of green and fossil fuel jobs, this pattern suggests that the decline in fossil fuel related jobs at the commuting zone level could be offset by the increase in renewable energy jobs.

Since there have been concerns about the decline in manufacturing jobs (Autor, Dorn, and Hanson, 2016), we also examine the geographical correlation between the share of employment in manufacturing and green jobs (Figure 12). The share of either solar or wind jobs is negatively and significantly correlated with the share of employment in manufacturing in 2000. Therefore, even though solar and wind jobs are overrepresented in blue-collar industries (Figure 4, Panel B), the growth of green jobs has not been particularly helpful to address the problems faced by geographic areas where manufacturing jobs were in decline.

Finally, we examine the correlation between the location of green jobs and the percentage of the population in the commuting zone that is non-white (Figure 13). Solar jobs are significantly more likely to locate in commuting zones with higher non-white population, while the opposite is true for wind jobs. One of the immediate explanations for this pattern is that solar jobs are more likely to be in the Southern part of the United States, from California through Florida, while wind jobs are more likely to be in the middle of the country (Figure 8).

4 Conclusion

In this paper, we have developed a new measure of green jobs, defined as solar and wind jobs. We used the near-universe of US job postings from Burning Glass Technologies, and defined green jobs based on job titles, and on the skill requirements that firms attached to job postings. We find that solar and wind jobs grew very strongly since 2013, with solar jobs taking the lead and following closely new solar capacity installed. About a third of solar jobs are in sales occupations, while about a third of wind jobs are in installation and maintenance occupations. In terms of industry, utilities account for about 15-16% of both solar and wind jobs, but the most common industry for wind jobs is manufacturing, with over 29% of wind jobs. Green jobs are created in occupations that pay about 21% more than average, and this is true even when accounting for educational requirements posted by firms.

In fact, the green job occupational premium is larger for jobs that require lower education. Further, the green job occupational premium is higher than the premium for jobs in the fossil fuel extraction industry (oil, coal and natural gas). In terms of geography, we find that green jobs are more likely to locate in areas with a high share of oil & gas employment, such as Texas. Thus, policies that promote the growth of renewable energy will likely lead to relatively high paying job opportunities for less educated workers and for US regions that currently have a high share of employment in the fossil fuel extraction industry. This is likely to facilitate the green transition.

References

Acemoglu, Daron, David Autor, Jonathon Hazell, and Pascual Restrepo. 2020. "AI and Jobs: Evidence from Online Vacancies." Working Paper 28257, National Bureau of Economic Research. URL `https://www.nber.org/papers/w28257`. Series: Working Paper Series.

Autor, David H., David Dorn, and Gordon H. Hanson. 2016. "The China Shock: Learning from Labor-Market Adjustment to Large Changes in Trade." *Annual Review of Economics* 8 (1):205–240. URL `https://doi.org/10.1146/annurev-economics-080315-015041`. _eprint: https://doi.org/10.1146/annurev-economics-080315-015041.

Bloom, Nicholas, Tarek Alexander Hassan, Aakash Kalyani, Josh Lerner, and Ahmed Tahoun. 2021. "The Diffusion of Disruptive Technologies." Working Paper 28999, National Bureau of Economic Research. URL `http://www.nber.org/papers/w28999`.

Bowen, Alex, Karlygash Kuralbayeva, and Eileen L. Tipoe. 2018. "Characterising green employment: The impacts of 'greening' on workforce composition." *Energy Economics* 72:263–275. URL `https://www.sciencedirect.com/science/article/pii/S0140988318300963`.

Burning Glass Technologies. 2019. "Mapping the Genome of Jobs." Tech. rep. URL `https://www.burning-glass.com/research-project/skills-taxonomy/`.

Cameron, Lachlan and Bob van der Zwaan. 2015. "Employment factors for wind and solar energy technologies: A literature review." *Renewable and Sustainable Energy Reviews* 45:160–172. URL `https://www.sciencedirect.com/science/article/pii/S1364032115000118`.

Carnevale, Anthony P, Tamara Jayasundera, and Dmitri Repnikov. 2014. "Understanding online job ads data." *Georgetown University, Center on Education and the Workforce, Technical Report (April)* .

Consoli, Davide, Giovanni Marin, Alberto Marzucchi, and Francesco Vona. 2016. "Do green jobs differ from non-green jobs in terms of skills and human capital?" *Research Pol-*

icy 45 (5):1046–1060. URL https://www.sciencedirect.com/science/article/pii/S0048733316300208.

Curtis, E. Mark. 2018. "Who Loses under Cap-and-Trade Programs? The Labor Market Effects of the NOx Budget Trading Program." *The Review of Economics and Statistics* 100 (1):151–166. URL https://doi.org/10.1162/REST_a_00680.

Department of Energy and BW Research Partnership. 2022. "The U.S Energy and Employment Report." URL https://www.energy.gov/sites/default/files/2022-06/USEER%202022%20National%20Report_1.pdf.

Goldfarb, Avi, Bledi Taska, and Florenta Teodoridis. 2020. "Artificial Intelligence in Health Care? Evidence from Online Job Postings." *AEA Papers and Proceedings* 110:400–404. URL https://www.aeaweb.org/articles?id=10.1257/pandp.20201006.

Greenstone, Michael. 2002. "The Impacts of Environmental Regulations on Industrial Activity: Evidence from the 1970 and 1977 Clean Air Act Amendments and the Census of Manufactures." *Journal of Political Economy* 110 (6):1175–1219. URL https://www.journals.uchicago.edu/doi/full/10.1086/342808.

Hafstead, Marc A. C. and Roberton C. Williams III. 2020. "Jobs and Environmental Regulation." In *Environmental and Energy Policy and the Economy, volume 1*. University of Chicago Press, 192–240. URL https://www.nber.org/books-and-chapters/environmental-and-energy-policy-and-economy-volume-1/jobs-and-environmental-regulation.

Hafstead, Marc A.C. and Roberton C. Williams. 2018. "Unemployment and environmental regulation in general equilibrium." *Journal of Public Economics* 160:50–65. URL https://www.sciencedirect.com/science/article/pii/S0047272718300136.

Hershbein, Brad and Lisa B Kahn. 2018. "Do recessions accelerate routine-biased technological change? Evidence from vacancy postings." *American Economic Review* 108 (7):1737–72.

International Energy Agency. 2021. "World Energy Model- Techno-economic inputs." URL https://www.iea.org/reports/world-energy-model/techno-economic-inputs.

Rutzer, Christian, Matthias Niggli, and Rolf Weder. 2020. "Estimating the Green Potential of Occupations: A New Approach Applied to the U.S. Labor Market." URL https://edoc.unibas.ch/76063/. Publisher: WWZ.

Solar Jobs Census. 2022. "National Solar Jobs Census 2021." URL https://irecusa.org/resources/national-solar-jobs-census-2021/.

U.S Energy Information Administration. 2022. "Cost and Performance Characteristics of New Generating Technologies, Annual Energy Outlook 2022." URL https://www.eia.gov/outlooks/aeo/assumptions/pdf/table_8.2.pdf.

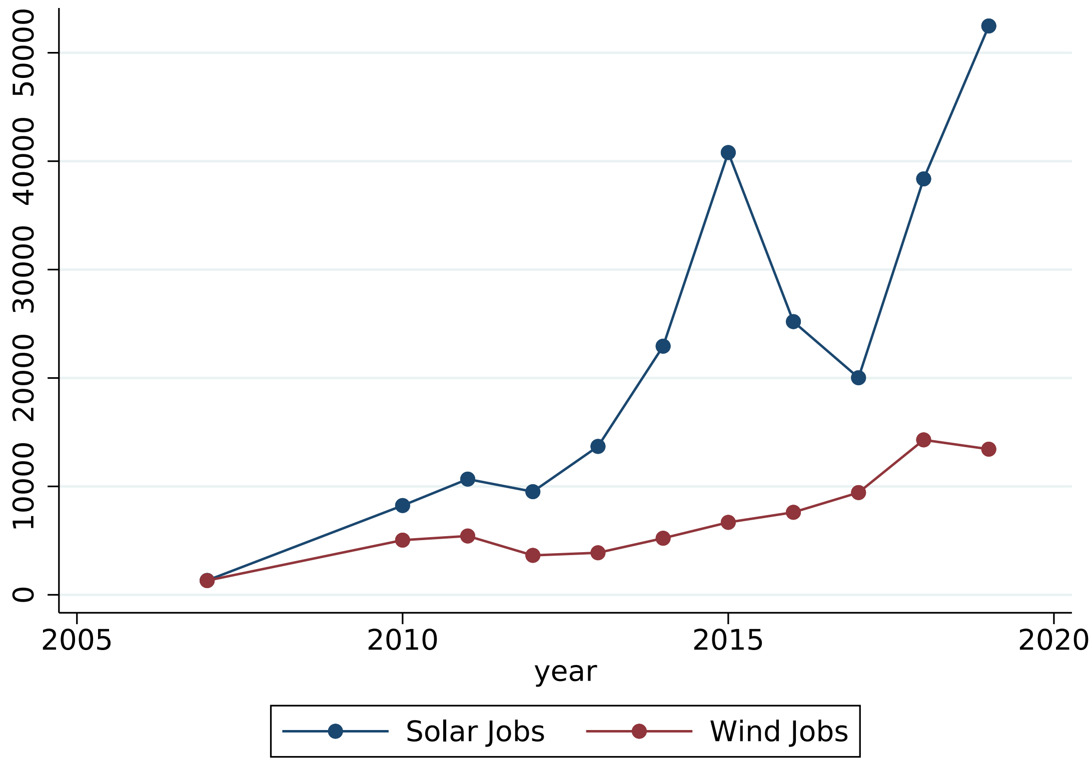
Vona, Francesco, Giovanni Marin, and Davide Consoli. 2019. "Measures, drivers and effects of green employment: evidence from US local labor markets, 2006–2014." *Journal of Economic Geography* 19 (5):1021–1048. URL https://doi.org/10.1093/jeg/lby038.

Vona, Francesco, Giovanni Marin, Davide Consoli, and David Popp. 2018. "Environmental Regulation and Green Skills: An Empirical Exploration." *Journal of the Association of Environmental and Resource Economists* 5 (4):713–753. URL https://www.journals.uchicago.edu/doi/full/10.1086/698859. Publisher: The University of Chicago Press.

Walker, W. Reed. 2011. "Environmental Regulation and Labor Reallocation: Evidence from the Clean Air Act." *American Economic Review* 101 (3):442–447. URL https://www.aeaweb.org/articles?id=10.1257/aer.101.3.442.

Figure 1

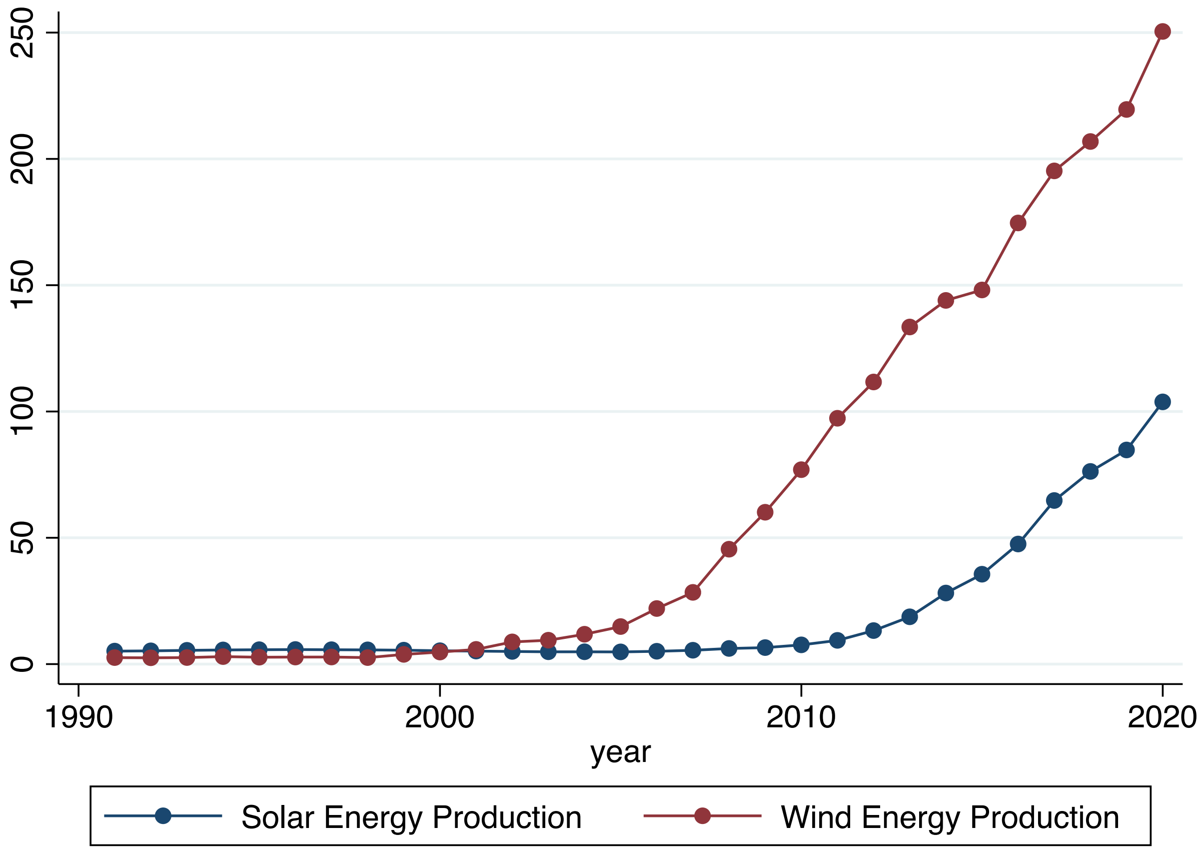
(A) Solar and Wind Job Postings



Notes: The above figure shows number of job postings in Solar and Wind between 2007 and 2020. The figure shows a decline in job postings in 2016. We note two reasons for this. First, Solar City which was the largest solar employer at the time, underwent a large workforce reduction and was subsequently purchased by Tesla in 2016. Second, as seen below in Figure 3, new solar capacity declined in 2017 due to the expiration of a large federal subsidy program for solar. Source: Authors calculations from Burning Glass job posting data.

Figure 2

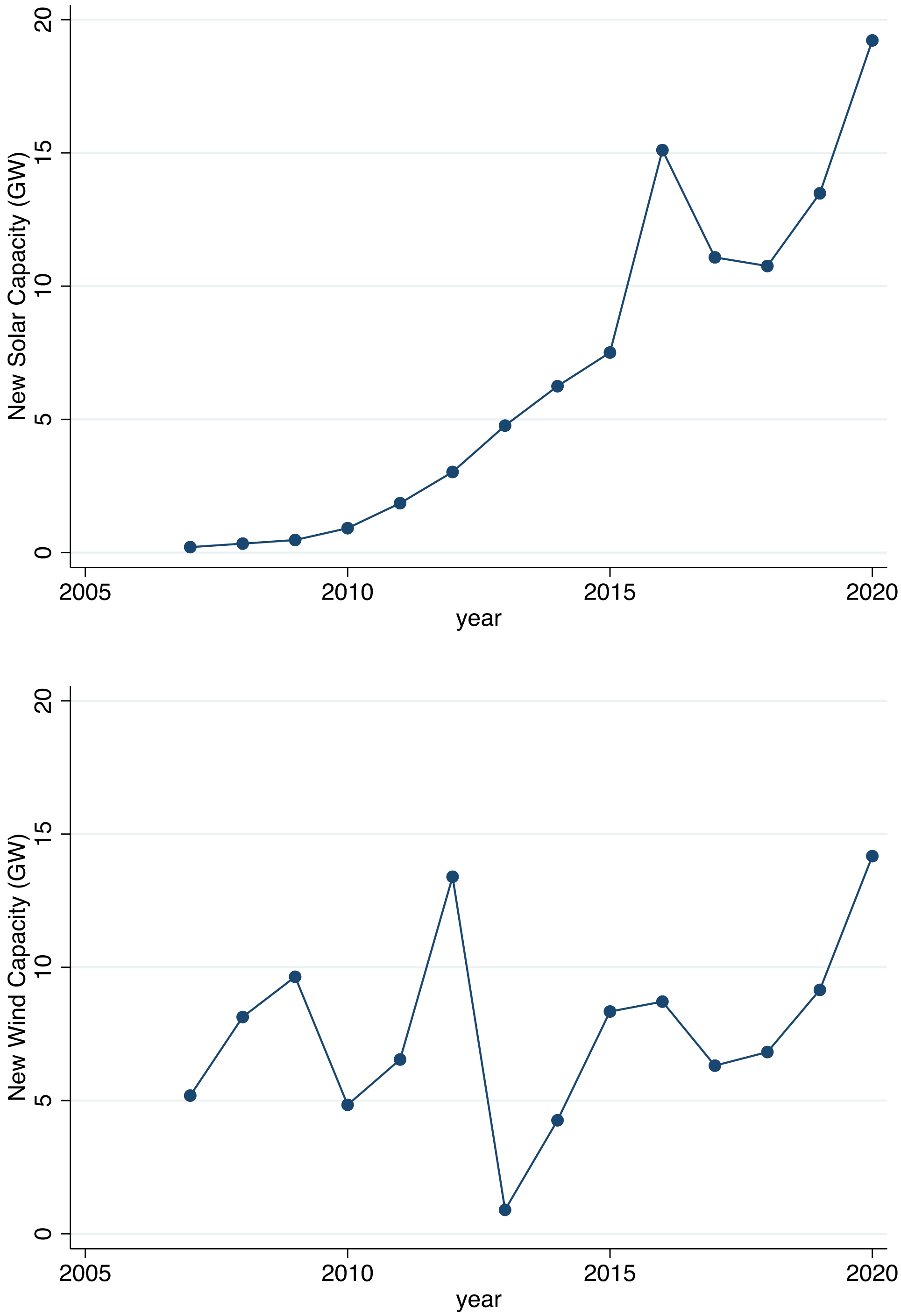
(A) Total Electricity Production: Solar and Wind



Notes: The above figure shows electricity production from Solar and Wind between 2007 and 2020. Source: EIA.

Figure 3

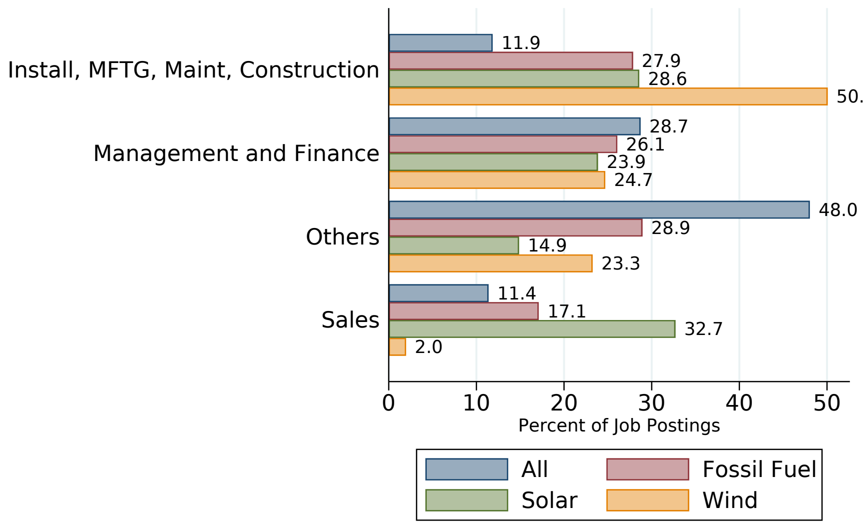
(A) New Capacity: Solar and Wind



Notes: The above figures show new capacity for Solar and Wind between 2007 and 2020. Source: EIA.

Figure 4: Solar and Wind Job Occupation and Industry Breakdown in 2019

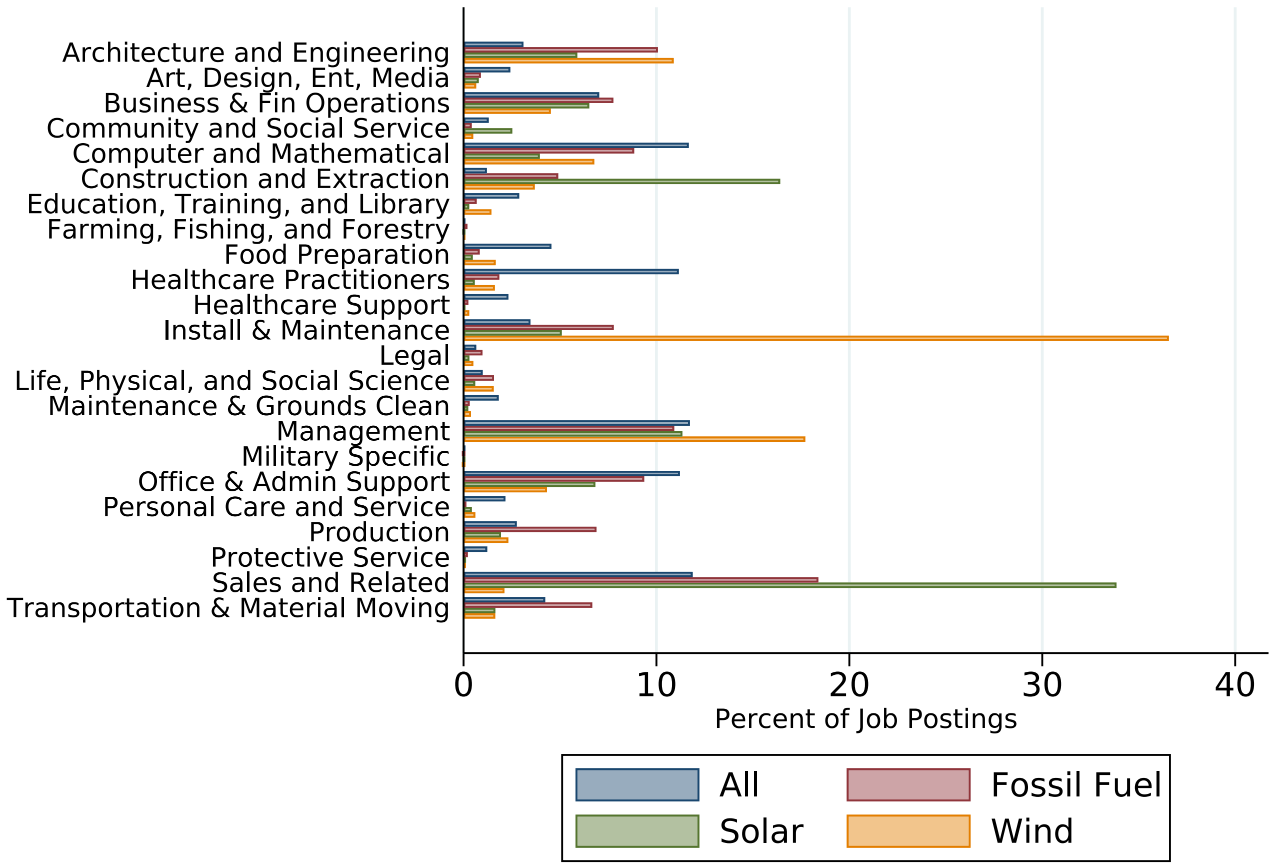
(A) Occupation breakdown



(B) Industry breakdown

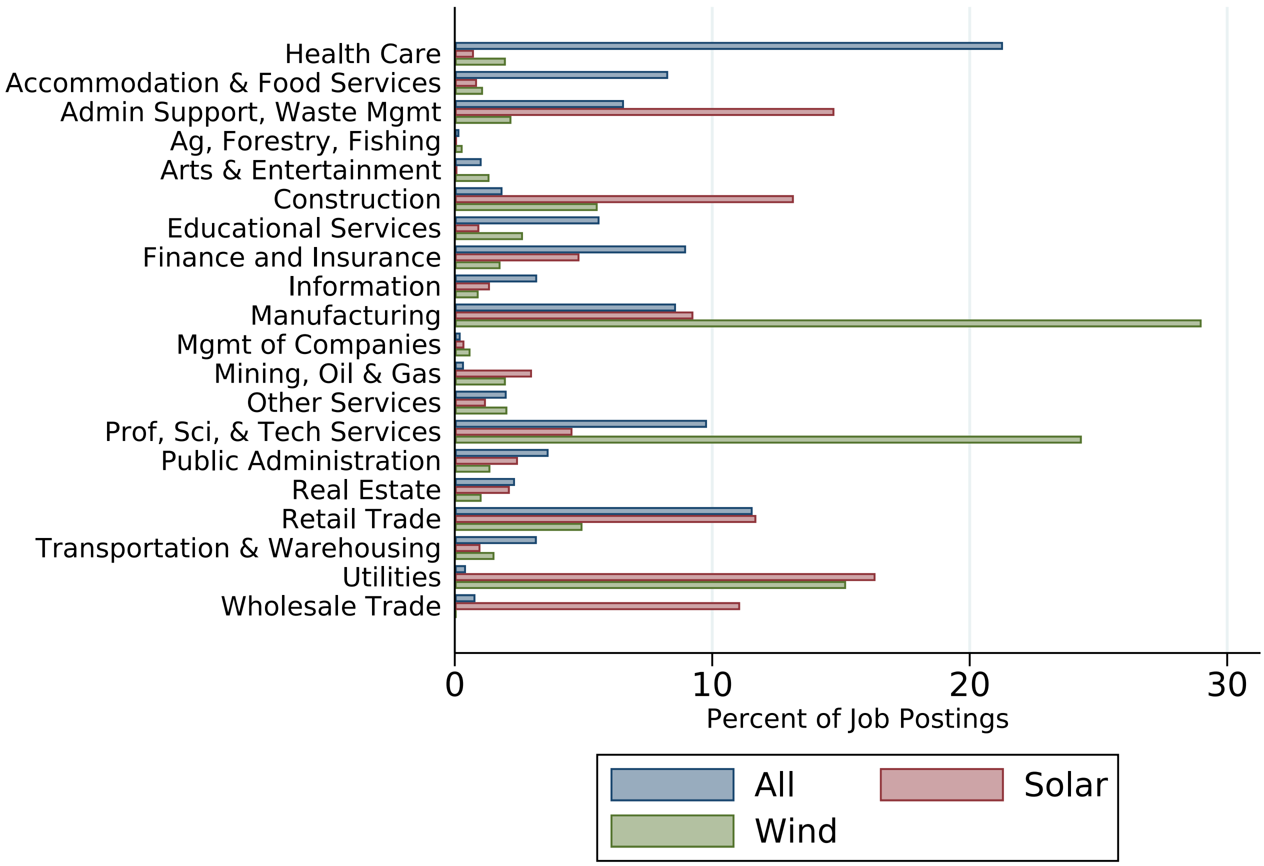
Notes: Figure 4 provides a breakdown of the industry and occupational distribution of Solar, Wind and All jobs using using highly aggregated definitions of industry and occupation constructed by the authors. We create four broad occupational categories that reflect common classifications of solar and wind jobs. Sales is defined as SOC 21, "Install, MFTG, Maint, Construction" includes those SOC categories as well as Building and Architecture. "Management and Finance" include management, office and business occupations. We define "Blue Collar" industries as those in construction, manufacturing, mining, agriculture, transportation and admin and waste services. Healthcare and Services consist of health care, arts and rec, accommodation and other services. Trade consists of retail and wholesale trade. The remaining NAICS sectors are placed in the "White Collar" category. Panel B omits fossil fuel jobs as these are defined by industry.

Figure 5: Detailed Solar and Wind Job Occupation (2-digit SOC) Breakdown in 2019



Notes: Figure 5 provides a breakdown of the occupational distribution of Solar, Wind, Fossil Fuel and All jobs using 2-digit SOC categories.

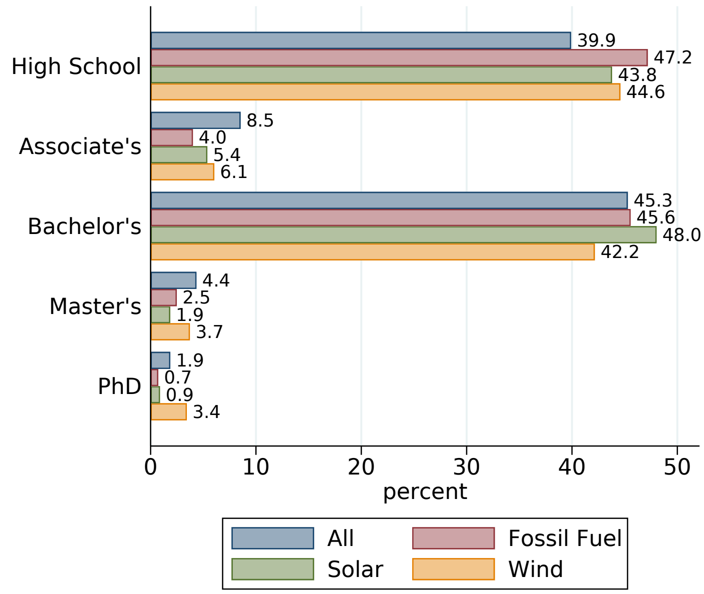
Figure 6: Detailed Solar and Wind Industry (2-digit NAICS) Breakdown in 2019



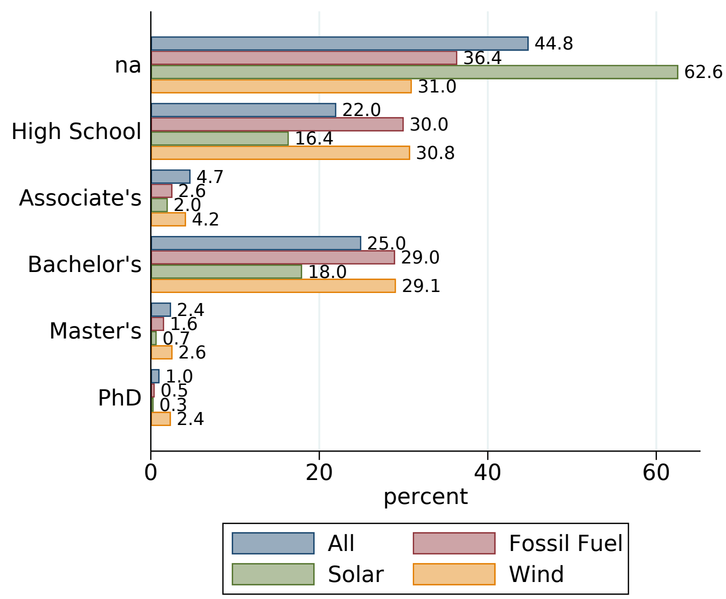
Notes: Figure 6 provides a breakdown of the industry distribution of Solar, Wind, and All jobs using 2-digit NAICS categories.

Figure 7: Education Breakdown for Solar and Wind Jobs in 2019

(A) Jobs with an education requirement

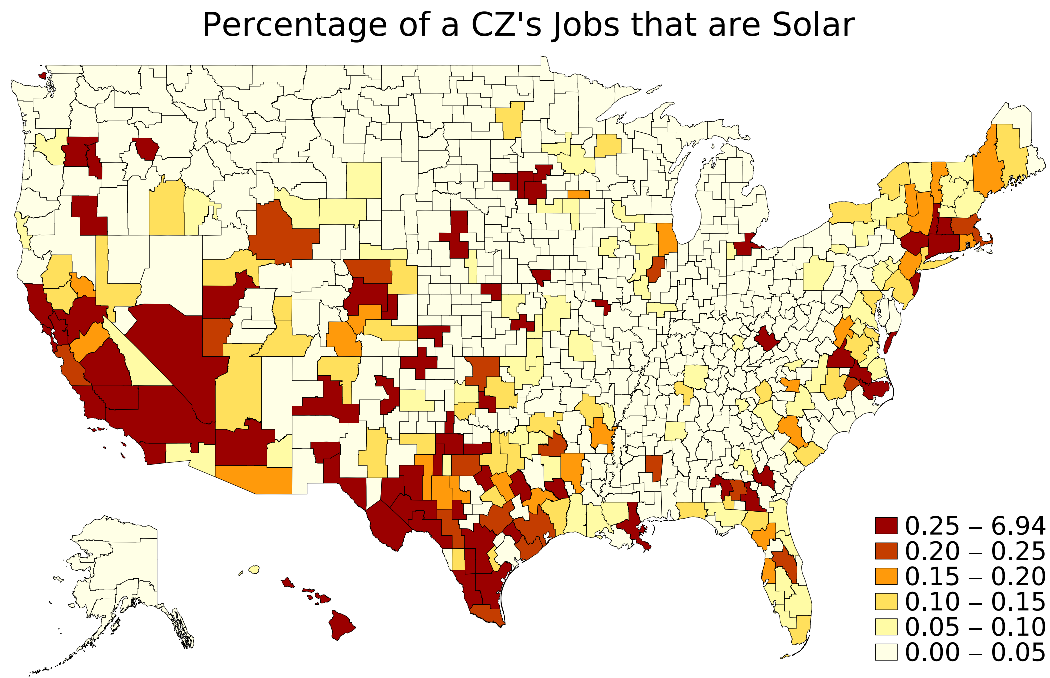


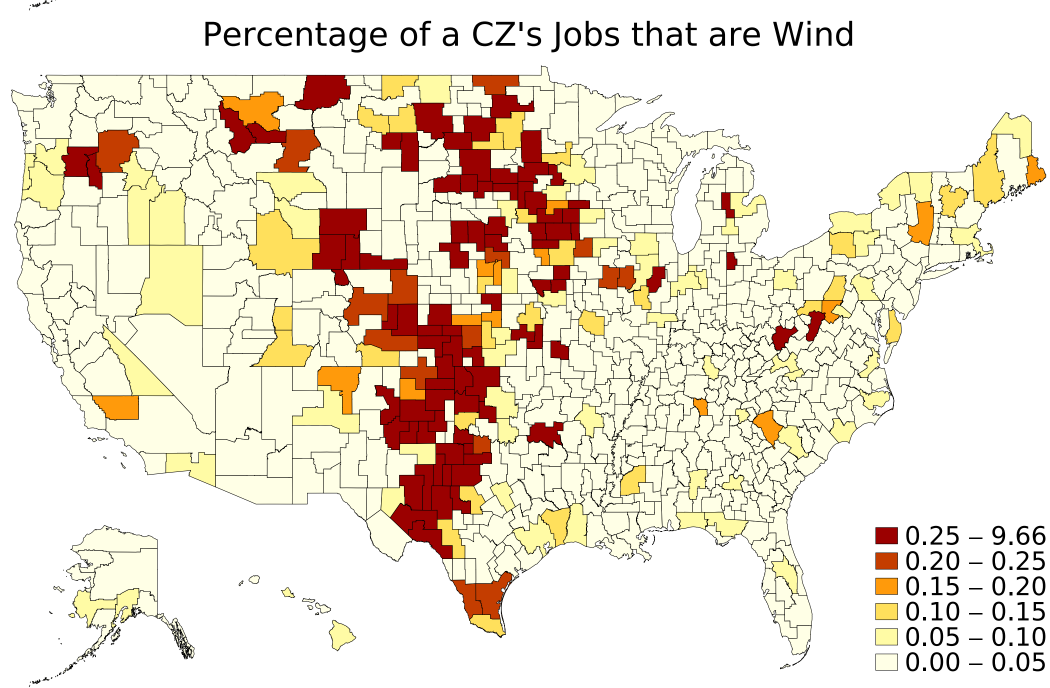
(B) Jobs with or without an education requirement



Notes: For each type of job (Solar, Wind, Fossil Fuel and All), Panel A reports the percent of job postings in that type that require High School, Associates, Bachelors, Masters and PhD degrees. Panel A limits the sample to only jobs that report an education requirement. Panel B reports the same statistics for all jobs, including a separate category for those that do not list an education requirement.

Figure 8: Percent of Solar / Wind Job Postings by Commuting Zone

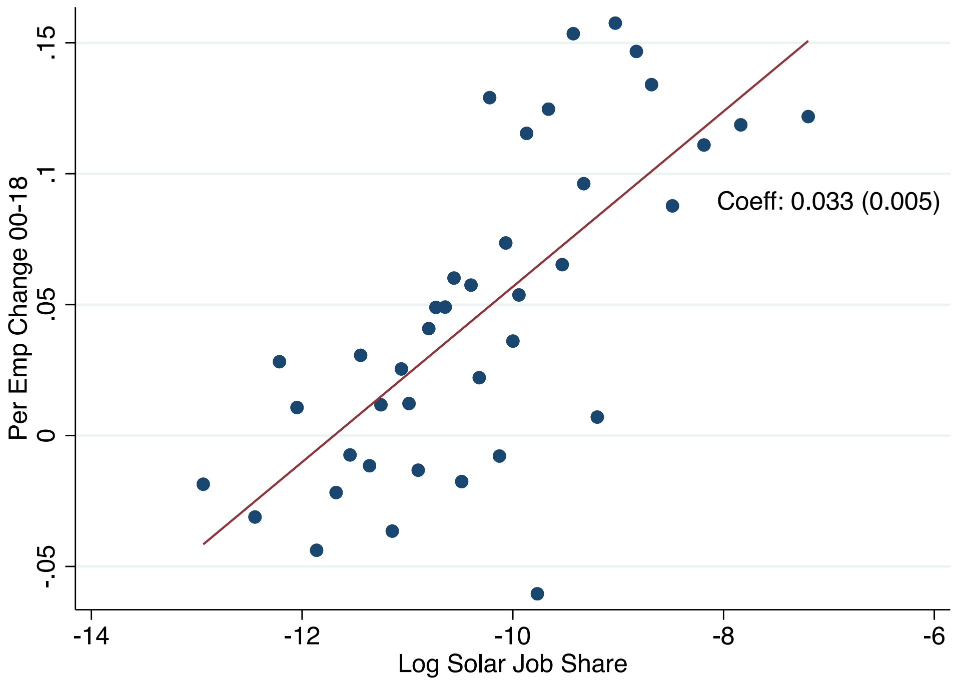




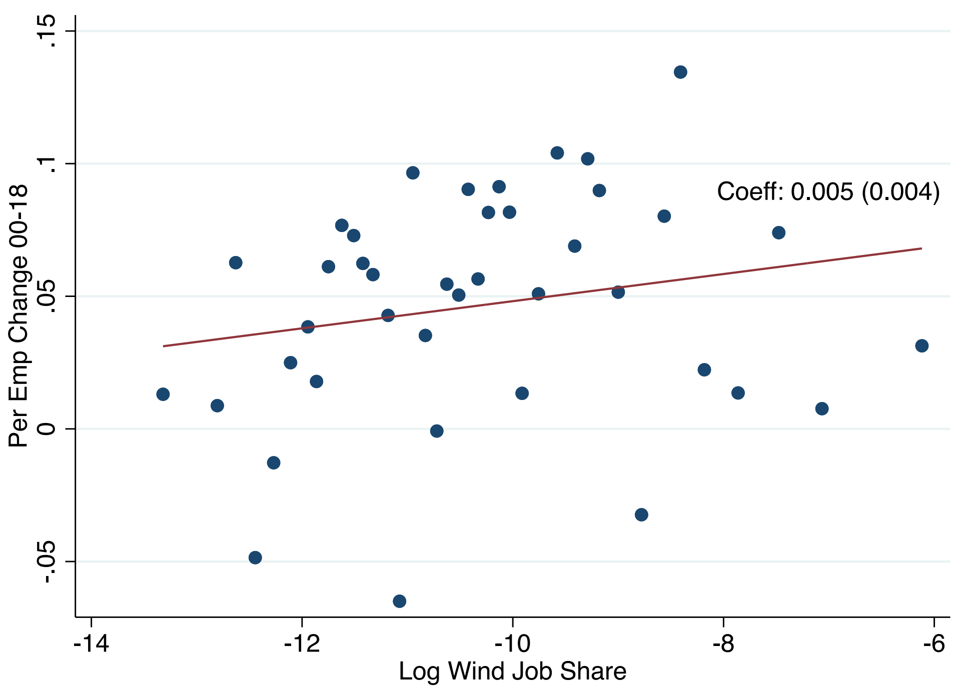
Notes: Figure 8 shows the percent of job postings in a commuting zone that are solar / wind. Northern Texas has the highest percent solar jobs. North Central Oregon has the highest percent of Wind Jobs. Appendix Table A1 shows commuting zones that are high in the share of renewable job postings and fossil fuel job postings.

Figure 9

(A) Bin Scatter Plot: Solar and 2000-2018 Emp Change



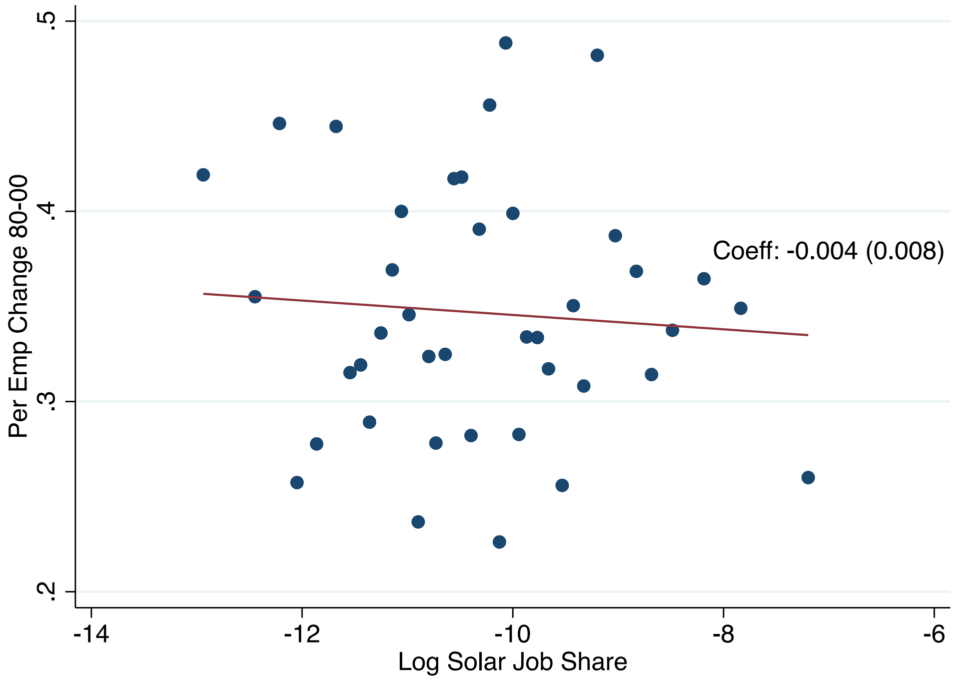
(B) Bin Scatter Plot: Wind and 2000-2018 Emp Change



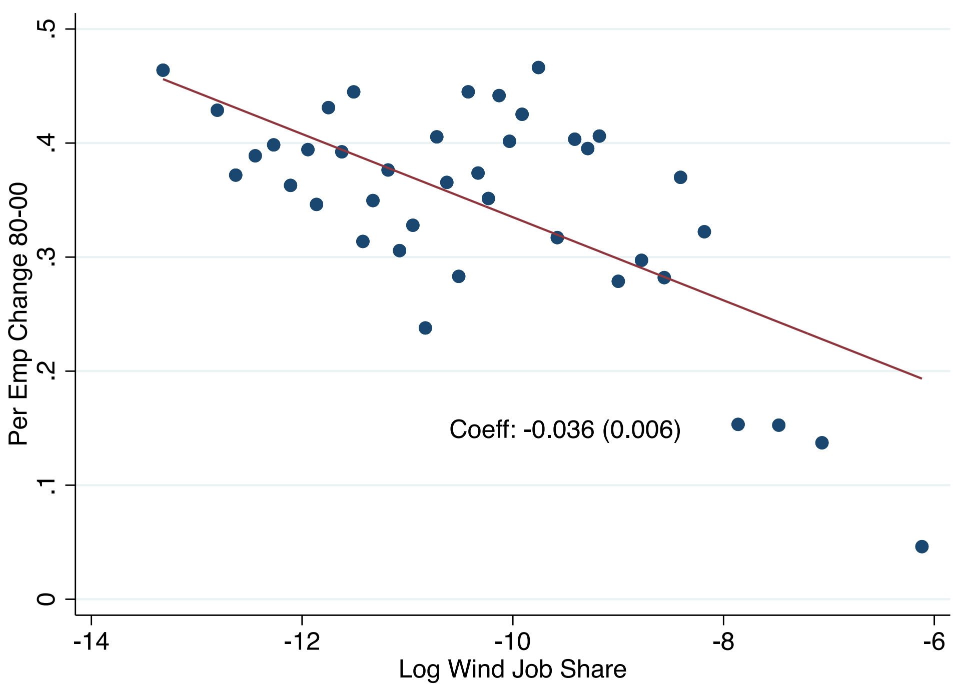
Notes: Data on solar and wind jobs are constructed from BGT job posting data. Employment change data is constructed from the County Business Patterns.

Figure 10

(A) Bin Scatter Plot: Solar and 1980-2000 Emp Change



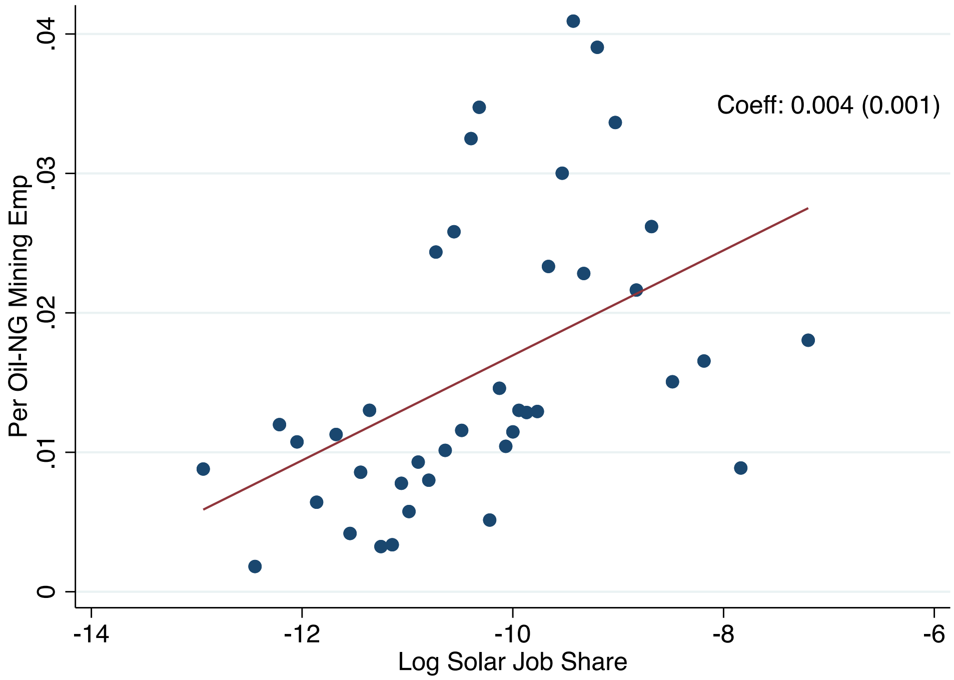
(B) Bin Scatter Plot: Wind and 1980-2000 Emp Change



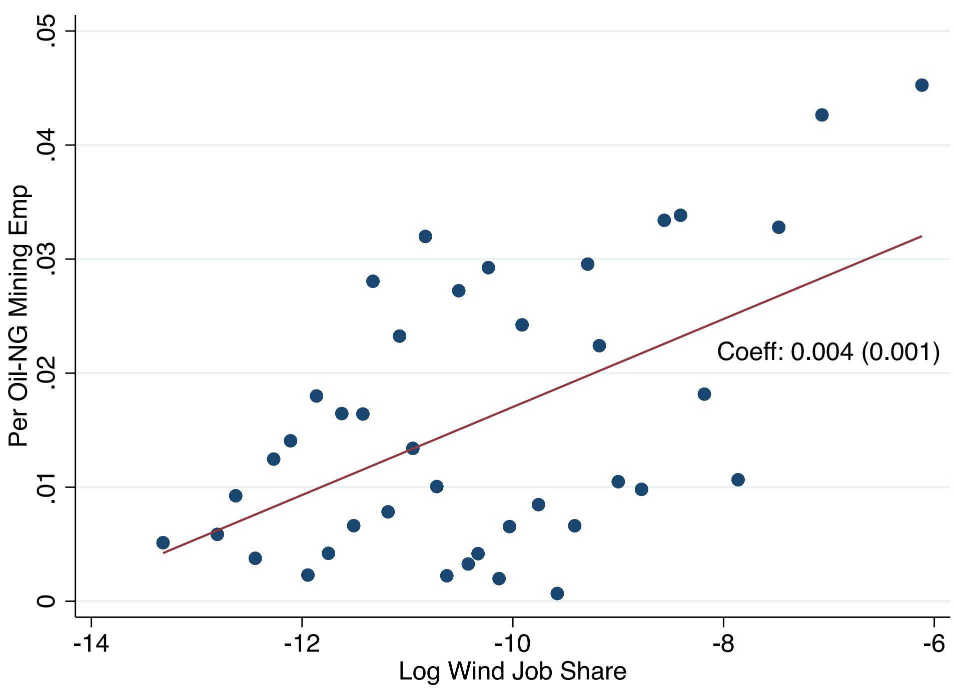
Notes: Data on solar and wind jobs are constructed from BGT job posting data. Employment change data is constructed from the County Business Patterns.

Figure 11

(A) Bin Scatter Plot: Solar and Fossil Fuel Extraction Job Share



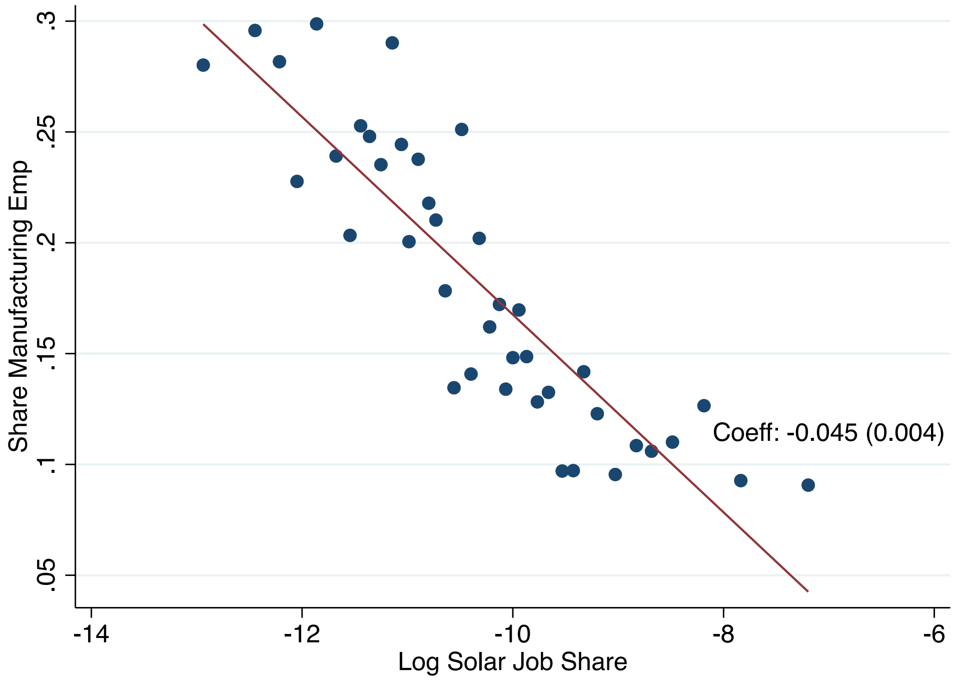
(B) Bin Scatter Plot: Wind and Fossil Fuel Extraction Job Share



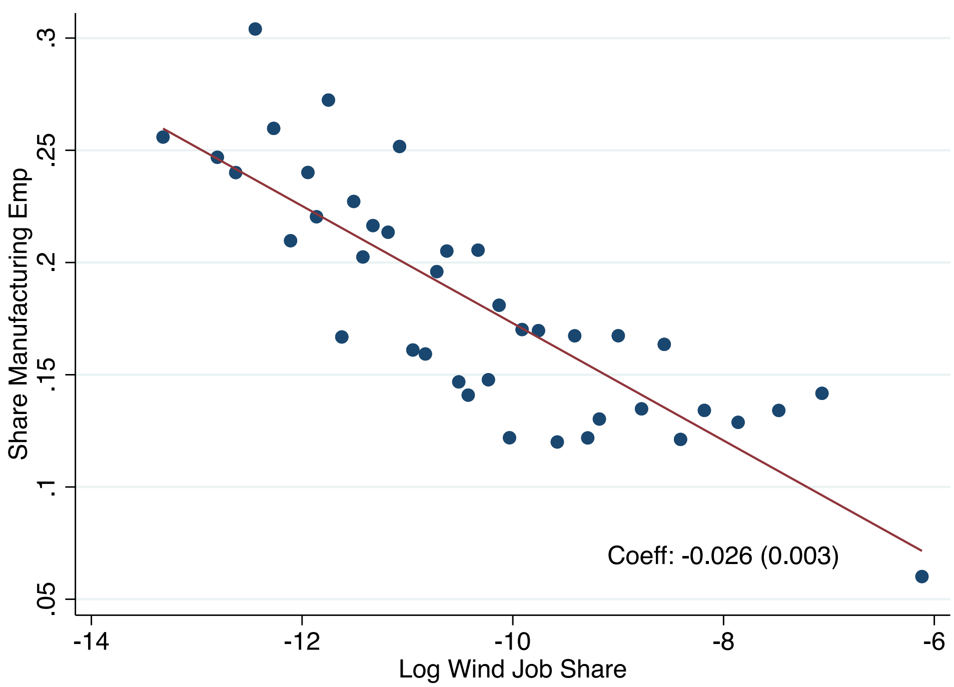
Notes: Data on solar and wind jobs are constructed from BGT job posting data. Data on Fossil Fuel Extraction job share are obtained from the County Business Patterns and include all Coal, Natural Gas and Oil Extraction jobs.

Figure 12

(A) Bin Scatter Plot: Solar and 2000 MFTG Share



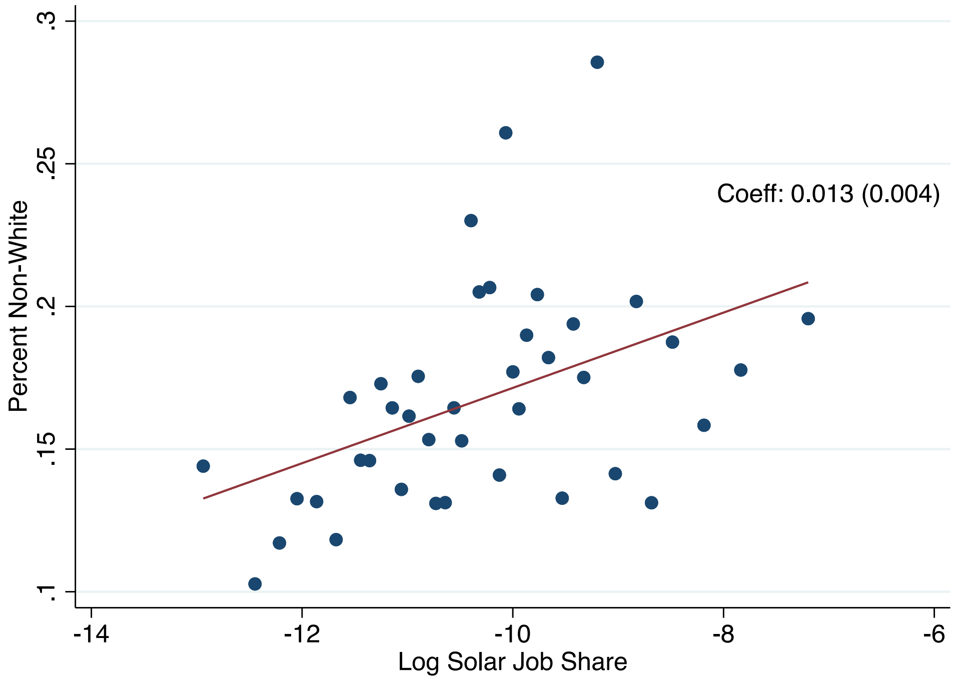
(B) Bin Scatter Plot: Wind and 2000 MFTG Share



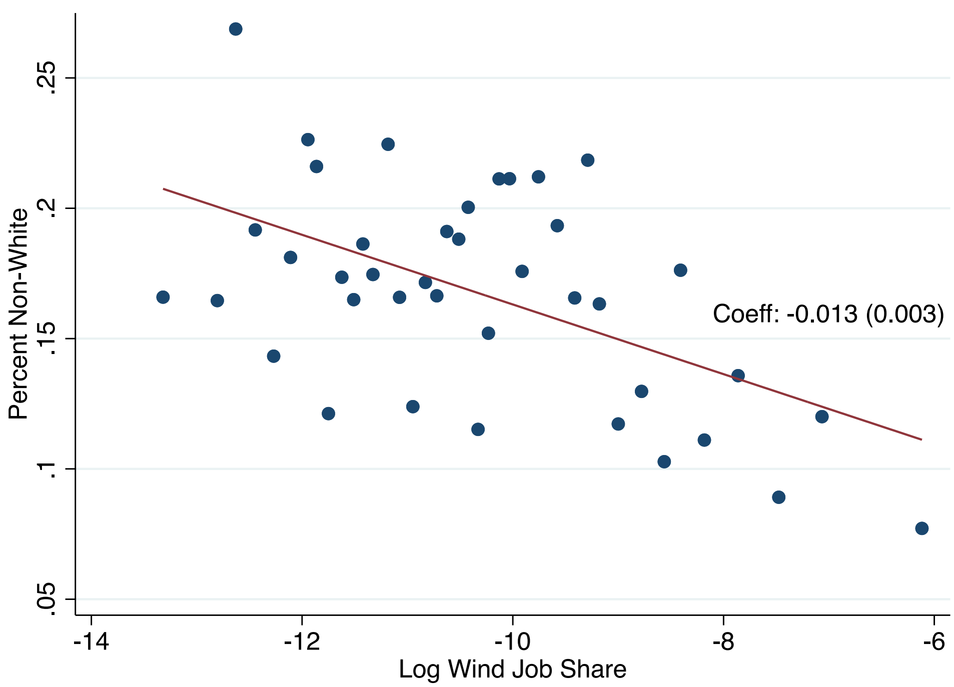
Notes: Data on solar and wind jobs are constructed from BGT job posting data. Data on the manufacturing job share are constructed from the 2019 County Business Patterns.

Figure 13

(A) Bin Scatter Plot: Solar and Percent Non-White



(B) Bin Scatter Plot: Wind and Percent Non-White



Notes: Data on solar and wind jobs are constructed from BGT job posting data. Racial composition data is constructed from 2010 Census county-level population estimates.

Table 1: List of Wind and Solar Skills in BGT

Wind Skills	**Solar Skills**	
Wind Farm Construction	Solar Heating	Solar Consultation
Wind Farm Design	Solar Cell Manufacturing	Solar and Wind Energy
Wind Field Operations	Solar Heat Absorption Reduction	Solar Farm
Wind Turbine Equipment	Solar Electric Installation	Solar Application
Wind Power Development	Solar Photovoltaic Technology	Solar Photovoltaic Panels
Wind Power	Solar Thermal Installation	Solar Photovoltaic Engineering
Wind Energy Engineering	Solar Photovoltaic Installation	Solar Module Assembly
Wind Turbine Construction	Solar Sales Management	PVsyst
Wind Commissioning	Solar Panels	Photovoltaic (PV) Equipment
Wind Energy Industry Knowledge	Solar Cell	Solar Panel Assembly
Wind Turbine Technology	Photovoltaic (PV) Systems	Solar Engineering
Wind Turbine Control System	Solar Roofs	Solar Development
Wind Farm Analysis	Solar Installation	Photovoltaic System Design
Wind Project Construction	Solar Thermal Systems	Solar Products
Wind Turbine Service	Solar Photovoltaic Design	Solar Sales
Wind Turbines	Solar Roofing System Installation	Solar Collector Installation
	Commercial Solar Projects	Photovoltaic Energy
	Solar Energy Industry Knowledge	Solar Energy
	Solar Manufacturing	Organic Photovoltaics (OPV)
	Commercial Solar Sales	Solar Energy Components
	Solar Boilers	Solar Technology
	Solar Energy Systems	Solar Equipment
	Solar Contractor	Solar Design
	Solar Energy System Installation	Solar Systems
	Photovoltaic Solutions	

Notes: Table 1 lists the wind and solar skills and tasks that are identified in the Burning Glass data.

Table 2: Top Wind and Solar Commuting Zones

(1) Top 25 Solar by Job #		(2) Top 25 Wind by Job #		(3) Top 25 Solar by Job %		(4) Top 25 Wind by Job %	
Los Angeles, CA	6181	Denver, CO	1564	Childress, TX	6.94	Condon, OR	9.66
San Francisco, CA	3527	Houston, TX	583	Stephenville, TX	2.35	Vernon, TX	4.76
Denver, CO	3154	Boston, MA	508	Fort Stockton, TX	2.3	Ness City, KS	4.65
Sacramento, CA	2210	Seattle, WA	338	Junction, TX	2.02	Limon town, CO	3.72
Phoenix, AZ	2090	Minneapolis, MN	334	Pikeville, KY	1.86	Rawlins, WY	3.07
Boston, MA	2034	Chicago, IL	318	Stamford, TX	1.83	Maryville, MO	2.97
San Diego, CA	1737	Portland, OR	303	Ainsworth, NE	1.78	Woodward, OK	2.95
Chicago, IL	1626	New York, NY	245	Provo, UT	1.56	Snyder, TX	2.84
San Jose, CA	1400	San Diego, CA	230	Roanoke Rapids, NC	1.21	Sweetwater, TX	2.68
New York, NY	1338	Orlando, FL	213	Condon, OR	1.13	Scott City, KS	2.56
Houston, TX	1321	Los Angeles, CA	203	Maryville, MO	0.955	Burlington, CO	2.19
Newark, NJ	1270	Dallas, TX	194	Enterprise, OR	0.943	Marshall, MN	2.16
Dallas, TX	1182	Philadelphia, PA	185	Chickasha, OK	0.832	Memphis, TX	2.14
Bridgeport, CT	1038	Newark, NJ	183	Fresno, CA	0.787	Colby, KS	2.04
Fresno, CA	965	Detroit, MI	175	Bakersfield, CA	0.749	Graham, TX	1.9
Las Vegas, NV	889	San Francisco, CA	169	Guymon, OK	0.738	Big Spring, TX	1.86
Austin, TX	801	Albany, NY	162	Snyder, TX	0.631	Stamford, TX	1.83
Philadelphia, PA	799	Des Moines, IA	161	Sacramento, CA	0.615	Tucumcari, NM	1.82
San Antonio, TX	768	Phoenix, AZ	144	Hilo CDP, HI	0.607	Ainsworth, NE	1.78
Provo, UT	731	Austin, TX	135	Corsicana, TX	0.594	Bowman, ND	1.73
Tampa, FL	725	Corpus Christi, TX	130	Toledo, OH	0.588	Plainview, TX	1.56
Albuquerque, NM	629	Atlanta, GA	127	Broken Bow, NE	0.568	Seymour, TX	1.53
Orlando, FL	617	Oklahoma City, OK	125	Tucumcari, NM	0.522	Chickasha, OK	1.53
Arlington CDP, VA	587	Buffalo, NY	116	Albuquerque, NM	0.514	Fort Stockton, TX	1.48
Raleigh, NC	535	Odessa, TX	110	Emporia, KS	0.465	Pierre, SD	1.45

Notes: Columns 1 and 2 of Table 2 provide the top 25 commuting zones based on the number of Solar and Wind job postings in 2019. Columns 3 and 4 provide the top 25 according to the percentage of total job postings. Commuting zones are named based on the largest city located inside the commuting zone boundaries.

Table 3: Are Green Jobs Created in High Earning Occupations?

	(1) Log Earnings	(2) Log Earnings	(3) Log Earnings	(4) Log Earnings	(5) Log Earnings
Solar Job	0.210***	0.226***	0.206***	0.156*	0.149*
	(0.068)	(0.075)	(0.069)	(0.084)	(0.085)
Wind Job	0.224***	0.196***	0.226***	0.069*	0.055
	(0.046)	(0.063)	(0.045)	(0.037)	(0.040)
Fossil Fuel Job	0.043	0.027	0.060	-0.047	-0.046
	(0.122)	(0.106)	(0.116)	(0.092)	(0.090)
Required Education FE's	N	Y	N	N	Y
County FE's	N	N	Y	N	Y
2-Digit SOC Code FE's	N	N	N	Y	Y
Observations	23,035,633	23,035,633	23,035,633	23,035,633	23,035,633
R^2	0.000	0.226	0.031	0.609	0.643

Notes: Table 3 assigns the earnings of every job to the 2000 median earnings of their occupation. Column 1 includes no controls. Column 2 includes Required Education FE's. Column 3 includes County FE's. Column 4 includes 2-digit SOC FE's. Column 5 includes Required Education, County and 2-digit SOC FE's. Standard errors are clustered at the 6-digit SOC level. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$ *Source:* BGT data and Occupational Employment and Wage Statistics data.

Table 4: Are Green Jobs Created in High Earning Occupations?

	Panel A		**Panel B**	
	High School Requirement		**Associates Degree Requirement**	
	(1)	(2)	(1)	(2)
	Log Earnings	Log Earnings	Log Earnings	Log Earnings
Solar Job	0.337***	0.188*	0.172***	0.108
	(0.072)	(0.098)	(0.063)	(0.066)
Wind Job	0.300***	0.095**	0.109**	0.021
	(0.089)	(0.045)	(0.046)	(0.035)
Fossil Fuel Job	0.211***	0.083*	0.063	-0.005
	(0.051)	(0.045)	(0.050)	(0.021)
2-Digit SOC Controls	N	Y	N	Y
Observations	5,904,326	5,904,326	663,741	663,741
R^2	0.002	0.473	0.000	0.556

	Panel C		**Panel D**	
	Bachelors Requirement		**Masters Degree Requirement**	
	(1)	(2)	(1)	(2)
	Log Earnings	Log Earnings	Log Earnings	Log Earnings
Solar Job	0.050*	0.026	0.100**	0.082*
	(0.028)	(0.017)	(0.046)	(0.044)
Wind Job	0.103***	0.002	0.178***	-0.004
	(0.038)	(0.018)	(0.062)	(0.024)
Fossil Fuel Job	0.080**	0.017	0.093**	0.040*
	(0.035)	(0.016)	(0.044)	(0.021)
2-Digit SOC Controls	N	Y	N	Y
Observations	4,632,737	4,632,737	456,729	456,729
R^2	0.000	0.662	0.000	0.679

	Panel E		**Panel F**	
	PhD Requirement		**No Requirement Listed**	
	(1)	(2)	(1)	(2)
	Log Earnings	Log Earnings	Log Earnings	Log Earnings
Solar Job	0.114**	0.070**	0.249***	0.196*
	(0.048)	(0.030)	(0.096)	(0.105)
Wind Job	0.023	0.087***	0.223***	0.079*
	(0.075)	(0.033)	(0.049)	(0.040)
Fossil Fuel Job	0.064	-0.001	-0.183	-0.212
	(0.095)	(0.013)	(0.200)	(0.161)
2-Digit SOC Controls	N	Y	N	Y
Observations	219,808	219,808	11,158,292	11,158,292
R^2	0.000	0.587	0.001	0.588

Notes: To understand how the earnings premium varies by educational requirement we run specifications from Table 3 separately for jobs requiring different educational attainments. We again assign the earnings of every job to the 2000 median earnings of their occupation. Column 1 includes no controls, Column 2 includes 2-digit SOC controls. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$ *Source:* BGT data and Occupational Employment and Wage Statistics data.

Table A1: Commuting Zones with High Renewable and High Fossil Fuel Jobs

Transitional Commuting Zones
Corsicana, TX
Corpus Christi, TX
San Angelo, TX
Odessa, TX
Casper, WY
Abilene, TX
Pampa, TX
Enid, OK
Elkins, WV
Bowman, ND
Pikeville, KY
Big Spring, TX
Burlington, CO
Graham, TX
Chickasha, OK
Woodward, OK
Snyder, TX
Stamford, TX
Fort Stockton, TX
Ness City, KS

Notes: Table A1 lists commuting zones in the top 10% of both renewable jobs and fossil fuel jobs as a percent of overall job postings. Commuting zones are named based on the largest city located inside the commuting zone boundaries.

Table A2: Are Green Jobs Created in High Earning Occupations?
2019 Occupational Wages

	(1) Log Earnings	(2) Log Earnings	(3) Log Earnings	(4) Log Earnings	(5) Log Earnings
Solar Job	0.185**	0.201**	0.180**	0.153*	0.147
	(0.073)	(0.078)	(0.074)	(0.090)	(0.090)
Wind Job	0.190***	0.161***	0.194***	0.043	0.030
	(0.059)	(0.045)	(0.057)	(0.034)	(0.035)
Fossil Fuel Job	0.049	0.032	0.071	-0.026	-0.024
	(0.117)	(0.100)	(0.110)	(0.083)	(0.080)
Required Education FE's	N	Y	N	N	Y
County FE's	N	N	Y	N	Y
2-Digit SOC Code FE's	N	N	N	Y	Y
Observations	23,037,723	23,037,723	23,037,723	23,037,723	23,037,723
R^2	0.000	0.237	0.033	0.642	0.676

Notes: Table A2 is identical to Table 3 but assigns the earnings of every job to the 2019 median earnings of its occupation. Column 1 includes no controls. Column 2 includes Required Education FE's. Column 3 includes County FE's. Column 4 includes 2-digit SOC FE's. Column 5 includes Required Education, County and 2-digit SOC FE's. Standard errors are clustered at the 6-digit SOC level. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$ *Source:* BGT data and Occupational Employment and Wage Statistics data.

Table A3: Earnings Regressions by Education Level
2019 Occupational Wages

	Panel A High School Requirement		Panel B Associates Degree Requirement	
	(1)	(2)	(1)	(2)
	Log Earnings	Log Earnings	Log Earnings	Log Earnings
Solar Job	0.321***	0.189*	0.164**	0.115
	(0.077)	(0.102)	(0.066)	(0.071)
Wind Job	0.247***	0.059	0.070	0.008
	(0.068)	(0.041)	(0.047)	(0.043)
Fossil Fuel Job	0.214***	0.099**	0.043	-0.007
	(0.052)	(0.040)	(0.050)	(0.019)
2-Digit SOC Controls	N	Y	N	Y
Observations	5,904,749	5,904,749	663,800	663,800
R^2	0.002	0.507	0.000	0.594

	Panel C Bachelors Requirement		Panel D Masters Degree Requirement	
	(1)	(2)	(1)	(2)
	Log Earnings	Log Earnings	Log Earnings	Log Earnings
Solar Job	0.039	0.022	0.095*	0.098**
	(0.031)	(0.019)	(0.056)	(0.046)
Wind Job	0.091**	-0.009	0.189**	-0.011
	(0.046)	(0.020)	(0.083)	(0.030)
Fossil Fuel Job	0.076*	0.020	0.080	0.040
	(0.039)	(0.019)	(0.053)	(0.027)
2-Digit SOC Controls	N	Y	N	Y
Observations	4,633,264	4,633,264	456,752	456,752
R^2	0.000	0.704	0.000	0.720

	Panel E PhD Requirement		Panel F No Requirement Listed	
	(1)	(2)	(1)	(2)
	Log Earnings	Log Earnings	Log Earnings	Log Earnings
Solar Job	0.086*	0.069**	0.216**	0.188*
	(0.045)	(0.029)	(0.101)	(0.111)
Wind Job	0.083	0.074***	0.174***	0.048
	(0.064)	(0.028)	(0.045)	(0.036)
Fossil Fuel Job	0.002	0.002	-0.167	-0.173
	(0.084)	(0.012)	(0.186)	(0.143)
2-Digit SOC Controls	N	Y	N	Y
Observations	219,810	219,810	11,159,348	11,159,348
R^2	0.000	0.627	0.001	0.615

Notes: This table runs the same regressions as Table 4 but assigns the earnings of every job to the 2019 median earnings of its 6-digit SOC code instead of its 2000 median earnings. Column 1 includes no controls, Column 2 includes 2-digit SOC controls. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$ *Source:* BGT data and Occupational Employment and Wage Statistics data.