



Defining Wind Energy Experience

Corrie Christol, Chloe Constant, and Jeremy Stefek

National Renewable Energy Laboratory

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List of Acronyms

NEPA	National Environmental Policy Act
O&M	operations and maintenance
TIG	tungsten inert gas

Executive Summary

Since 2015, the U.S. wind installed capacity has grown from 73 to over 120 gigawatts, creating jobs across many sectors and educational levels (American Clean Power 2021). Figure ES-1 shows the increase in both wind capacity and wind industry employment from 2015 to 2020. The growth of the wind workforce will need to continue to meet the goal of 20% wind by 2030 (U.S. Department of Energy 2015), as well as the Biden administration’s goals to reduce greenhouse gas pollution by 2030, reach 100% carbon-free electricity by 2035, and achieve net-zero greenhouse gas emissions no later than 2050 (The White House 2021).

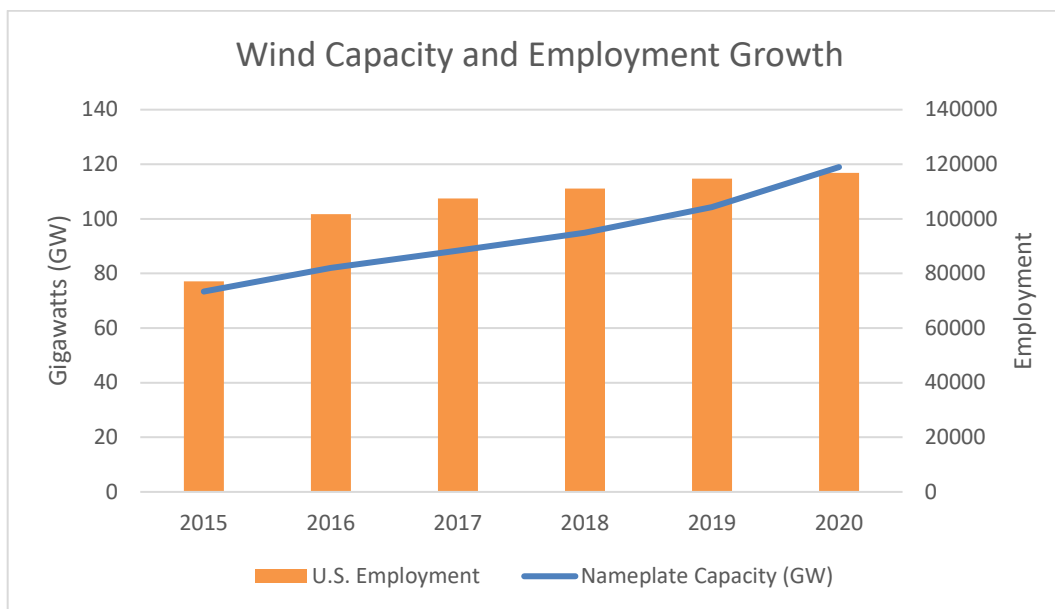


Figure ES-1. Recent trends for wind capacity and employment growth. Image from Wiser et al. (2020)

Despite the needed and anticipated growth, there are challenges to meeting this demand. Research has consistently shown that it has been a challenge finding qualified applicants for open wind industry jobs. Between 2012 and 2018, the difficulty of finding qualified applicants increased from 62% to 68% according to industry respondents (Leventhal and Tegen 2013; Keyser and Tegen 2019). In 2017, educational institutions and training programs reported that 67% of their students did not enter the wind energy industry (Keyser and Tegen 2019). Research conducted in 2020 showed that 83% of interested workers had some or great difficulty finding job opportunities (Stefek, Christol, and Smith 2022). In exploring reasons for this gap, the researchers found that challenges were primarily influenced by education, experience, and geography. This difficulty for wind industry employers, educational institutions, and the potential workforce is known as the “wind energy workforce gap” (Stefek, Christol, and Smith 2022). This report further investigates the experience aspect of this gap.

The authors selected three high-priority wind energy occupations for further review: environmental scientist, power systems engineer, and welder. These three occupations were selected because they met the following criteria:

- Compose more than 5% of the total workforce.

- More than 75% of employers indicated *some or great* difficulty when hiring for these roles.
- More than 75% of employers prefer industry experience for these roles.

Though these three occupations are from distinctly different work categories (applied and field scientists, engineers, and trade workers), the investigation provided valuable insights into company practices, the challenges of finding relevant entry-level positions, and the variety of career pathways for these occupations in the wind industry.

By examining job postings, company employment websites, and the career pathways of individuals who work or have worked in the selected occupations, we sought to gain insights on how experience is defined. The investigation also highlighted examples of practices that are helping to link the wind energy industry and potential workforce, opportunities to better support workforce connections, observations about the availability of entry-level and early-career opportunities, and the work experience pathways of those employed in each occupation. Some of these insights include:

- Internship and graduate-focused programs create clear pathways for those looking for employment as power systems engineers and environmental scientists.
- The use of job posting labels such as “entry level” or “junior” are not used consistently, nor are the definitions of these terms, making it difficult for the potential workforce to identify suitable positions.
- Job portals can help connect industry and the potential workforce by offering a central location for applicants to submit resumes and track their application status. However, portals being used are primarily internal to individual companies that require unique logins, which could be cumbersome for candidates.
- Experience with the National Environmental Policy Act (NEPA) and other environmental laws, regulations, and policies was one of the most frequently listed requirements in environmental scientist job postings, making it an important skill for the potential workforce to acquire and for academic institutions to incorporate into coursework.
- Power systems engineers were more likely to have held internship and assistant roles than environmental scientists or welders.
- Welders worked in multiple sectors, using their skills and certifications to transition into and beyond the wind energy industry.
- Power systems engineers and welders had a higher position turnover rate than environmental scientists, indicating a need to consider factors affecting worker retention.

Findings from this research show that investigating high-priority wind energy occupations provides valuable and actionable insights that could be utilized by the potential workforce, employers, and academic institutions. Applying these findings can improve the connection between the wind industry and potential workforce—a key need for the nation to be successful in transitioning to a clean, low-cost energy future. Continued research on wind energy occupations and company practices may provide new information that can further help mitigate the wind workforce experience gap.

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1 The Wind Energy Workforce Gap

The “wind energy workforce gap” is defined as a disconnect between wind industry employers, the workforce, and educational institutions. Wind energy employers report having difficulty finding qualified candidates, whereas the potential wind energy workforce (e.g., students and recent graduates) report having difficulty finding jobs in the wind industry, and educational institutions report having difficulty placing students in jobs (Stefek, Christol, and Smith 2022).

The challenge for wind industry employers to find qualified, experienced workers was first reported in 2012, when 62% of firms surveyed indicated difficulty finding qualified applicants for a variety of occupations (Leventhal and Tegen 2013). A follow-up survey in 2017 found that an average of 68% of wind industry respondents reported having the same difficulty finding qualified applicants (Keyser and Tegen 2019). Appendix A includes two tables from these reports, showing the continued difficulty industry has experienced finding qualified workers.

In addition to challenges finding workers, the 2019 report also discussed the quantity of workers that will be needed to meet potential future employment needs. It has been predicted that the wind industry workforce will need to have increased growth to meet the emissions reductions targets. Meeting these levels of growth, as well as the Biden administration’s goals to reduce greenhouse gas pollution by 2030, reach 100% carbon-free electricity by 2035, and achieve net-zero greenhouse gas emissions no later than 2050, will require the successful connection of wind industry employers and the potential workforce (The White House 2021). However, the most recent research effort conducted in 2020 found that many of these challenges still exist for industry and documented the difficulty that the potential workforce and energy education and training programs are having in connecting to the wind energy workforce. Figure 1 summarizes the findings for each group.

Students and potential workforce are not entering the wind industry and employers are reporting difficulty finding qualified applicants.

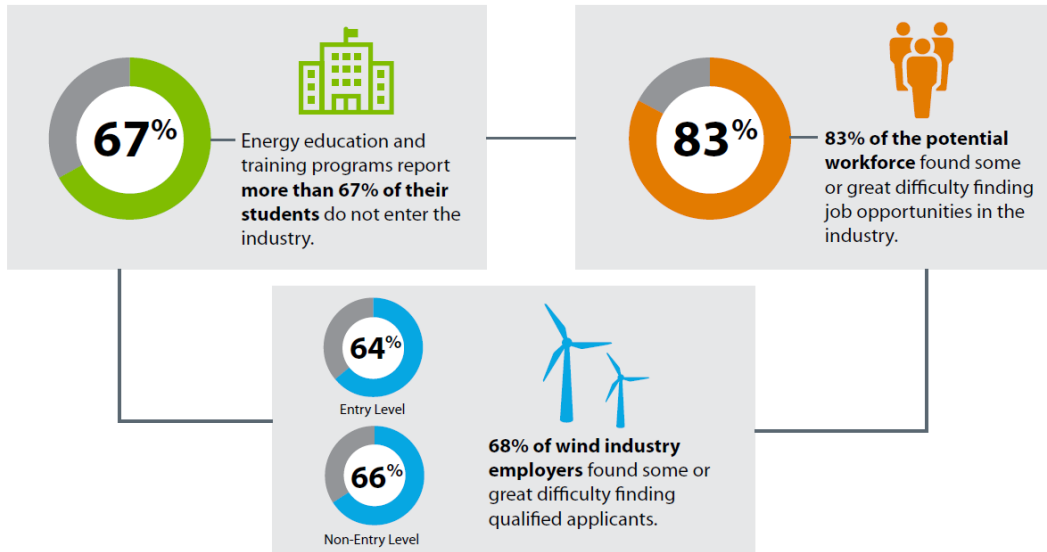


Figure 1. Summary of challenges identified during the 2020 wind workforce survey. Image from Stefek, Christol, and Smith (2022)

1.1 Reasons for the Wind Energy Workforce Gap

In addition to documenting the continued challenges for the industry, potential workforce, and energy education and training programs, the 2020 research effort also investigated the source of these challenges (Stefek, Christol, and Smith 2022). Through questionnaires to industry representatives and students, the results indicated that education, experience, and geography were the primary reasons for the wind workforce gap. Figure 2 shows the industry responses, and Figure 3 shows the student challenges.

Please select the statement which best describes the reason for your difficulty finding qualified entry-level and nonentry-level job applicants. (n=376)

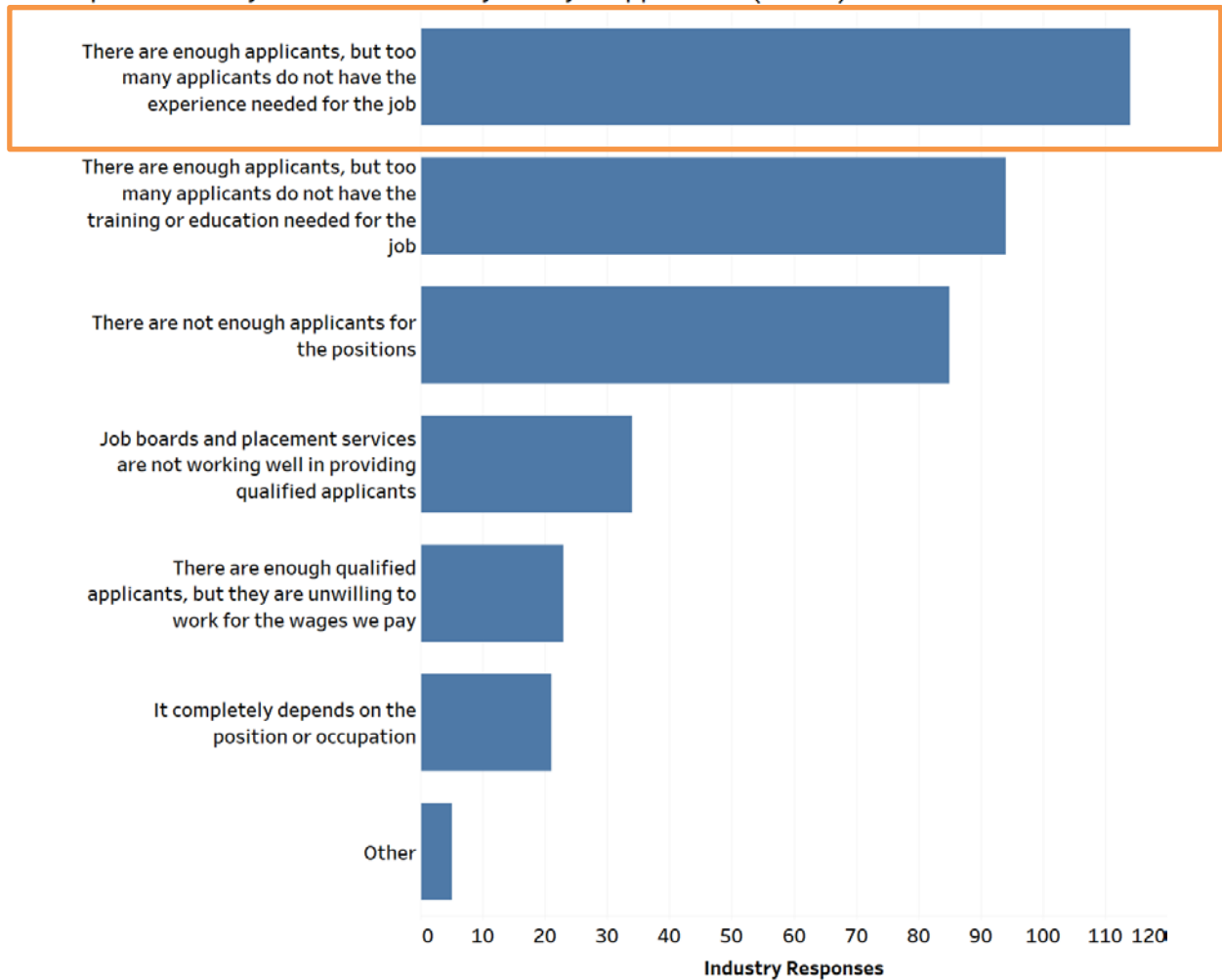
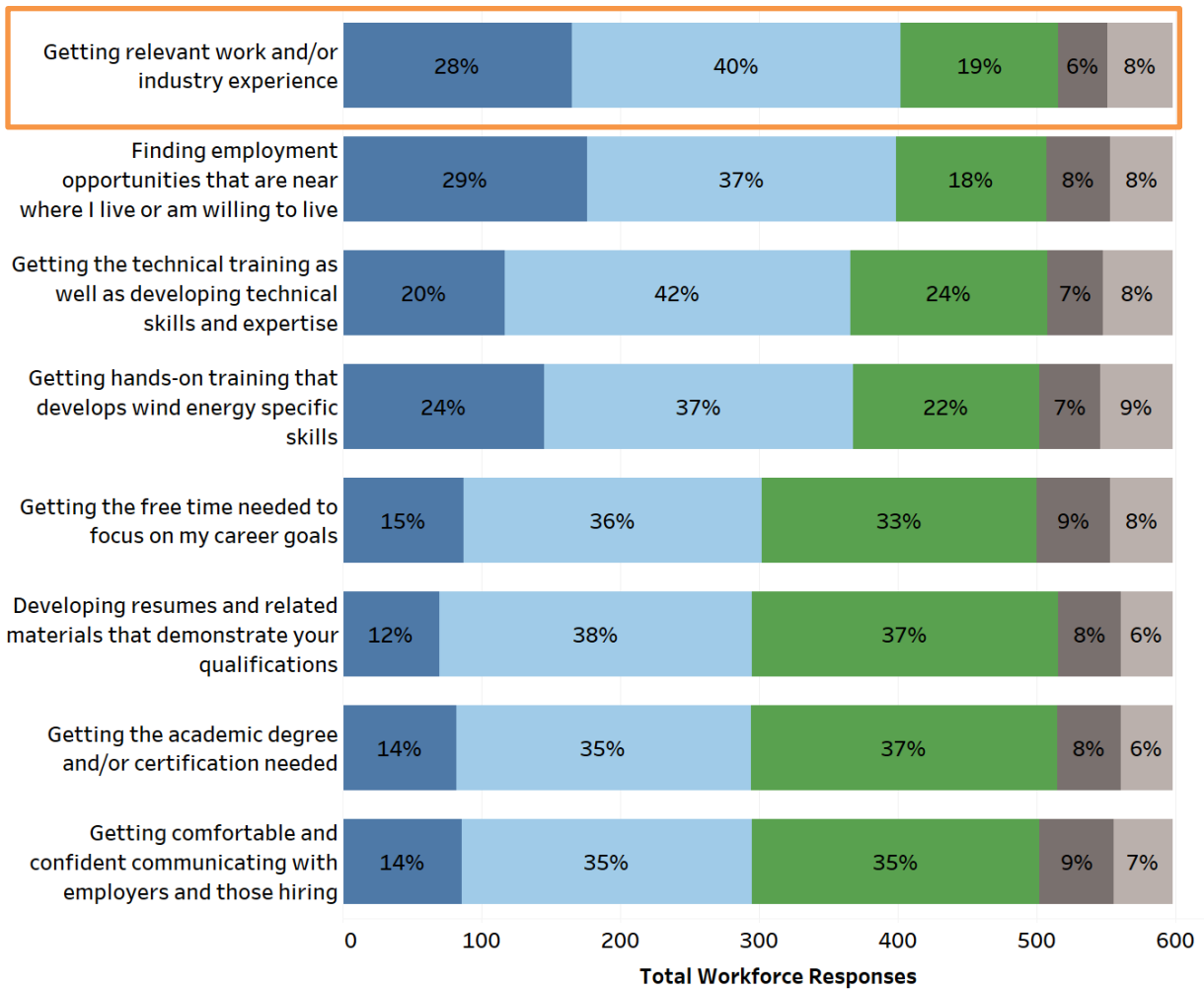


Figure 2. Top reasons for hiring difficulty as indicated by wind industry employers include experience, education or training, and not enough applicants. Image from Stefek, Christol, and Smith (2022)

What have been the challenges or obstacles you faced finding relevant work opportunities in the wind energy industry? (n=600)



Challenge Levels

- Don't Know/ Refused
- It Depends
- Not a Challenge
- Somewhat of a Challenge
- Considerable Challenge

Figure 3. Challenges and obstacles experienced by the total wind workforce. Image from Stefek, Christol, and Smith (2022)

The orange boxes in Figure 2 and Figure 3 highlight the top-ranking challenges for industry and the potential workforce, both showing experience as one of the primary factors for the workforce gap. Applicants do not have the experience desired by industry employers, and the potential workforce struggles to gain relevant experience. This disconnect creates a challenge for future growth in wind and renewable energy industries (Stefek, Christol, and Smith 2022).

2 Methodology

Connecting wind energy organizations and the potential workforce is critical to supporting the anticipated growth of the wind industry, both on land and offshore. To better understand the experience gap and gain insights on how experience is defined, we selected three high-priority occupations for deeper investigation: environmental scientist, power systems engineer, and welder. Investigating these occupations entailed searching through job postings, viewing company websites and job portals where available, and examining the education and work experience for individuals employed in those occupations. The data were analyzed for similarities, differences, and insights that might be helpful for those seeking to connect to the wind energy workforce.

2.1 Occupation Selection

When considering occupations for this research effort, we narrowed the scope of possible occupations to focus on entry-level and land-based wind energy positions. Occupation categories were chosen after reviewing data used in the 2019 workforce report (Keyser and Tegen 2019). Table 1 combines data from multiple tables in that report. The criteria used for identifying these high-priority occupations included the percentage of the total wind workforce, the level of difficulty that employers cited in finding qualified applicants, and the importance of wind-specific experience. Occupation categories were considered if they met the following requirements:

- More than 5% of the total workforce
- More than 75% of employers indicated *some* or *great* difficulty
- More than 75% prefer industry experience.

Table 1. Workforce Report Data Used To Select Occupation Categories

Source: Keyser and Tegen (2019). Note that figure and table labels refer to the labels used in the 2019 report.

	<i>Percentage of Total Workforce Figure ES-1</i>	<i>Some or Great Difficulty Table 2</i>	<i>Prefer Experience in the Wind Industry Table 5</i>	<i>Prefer Experience in General Table 5</i>
Trade workers (electricians, welders, etc.)	14%	94%	77%	94%
Wind technicians	9%	33%	64%	64%
Attorneys	8%	89%	15%	99%
Transportation and logistics workers	8%	80%	38%	43%
Construction laborers	8%	39%	91%	96%
Applied and field scientists (biologists, environmental, archaeologists, etc.)	6%	94%	94%	99%
Administrative and clerical workers	6%	46%	23%	64%
Sales and marketing professionals	5%	61%	68%	85%
Professors and teachers	5%	30%	92%	96%
Developers	3%	80%	87%	95%
Engineers	12%			
<i>Civil engineers</i>		84%	35%	40%
<i>Other engineers</i>		77%	71%	83%
<i>Power systems/transmission engineers</i>		77%	97%	89%
<i>Electrical and mechanical engineers</i>		66%	71%	77%

From the identified occupations and corresponding workforce data, we selected the categories trade worker, applied and field scientist, and engineer as a focus for this research effort (Table 1). Because these categories are high level and further delineation is needed to best understand the experience required, we selected specific occupations from these categories. Except for the engineering category, data are not available to inform the selection of specific occupations, so they were chosen to represent the category, as the research process can be replicated for additional occupations. For engineering, the occupation selection was based on the high preference for wind experience and anecdotes from Wind Application Center monthly calls.¹ The occupations selected were:

- Applied and field scientists: environmental scientist
- Engineers: power systems/transmission engineer
- Trade workers: welder.

2.2 Employment Pathway Review

For each occupation selected, we conducted a review of current job postings, companies, and each individual’s education and work history. We reviewed job postings to understand the availability of internships and entry-level positions. We examined company websites to determine if they offered specific opportunities for internships or other early-career positions.

¹ Wind Application Centers are a network of universities whose mission is to support technical assistance to rural schools and train the next generation of wind workforce by offering coursework and educational programs.

Lastly, we identified 30 individuals from these or similar companies who were employed in the occupation and evaluated their education and work experience to highlight similarities and differences that might provide insight for the future wind energy workforce. These 30 individuals include 5 environmental scientists, 10 power systems engineers, and 15 welders.

2.2.1 *Selecting Job Postings*

We identified job postings for consideration by conducting general internet searches, using job and career websites (e.g., Simply Hired, LinkedIn) and company websites. Primary factors for selecting a job posting for further review focused on whether the posting included wind or renewable energy, if it appeared to be an entry-level position, and if the position was based in the United States.

2.2.2 *Selecting Companies*

We initially identified companies through the job posting selection process, with additional companies added during the review of individuals employed in the industry. We conducted further research on those companies that work in wind or renewable energy.

2.2.3 *Selecting Individuals*

Identifying individuals working in one of the selected occupations at companies that include wind or renewable energy was primarily conducted through searches on LinkedIn. By combining the occupation title and previously selected companies in searches, we were able to identify individuals that are currently employed at that firm, as well as employees in that position at similar companies. Selecting individuals was determined by their position's relevance to wind or renewable energy, their years of experience, and uniqueness of career pathway.

3 Occupations

This section details the findings from the review of job postings, companies, and individuals employed in the identified field.

3.1 Environmental Scientist

Environmental scientists (Figure 4) work with wind power plant developers to help them comply with environmental regulations and policies to ensure that physical and wildlife sensitivities, as well as cultural impacts, are mitigated. They use their knowledge of the natural sciences, understanding of human behavior, and local cultural importance to minimize impacts to the health of the environment and the population. These scientists are heavily involved in the research and permitting phases of development.²



Figure 4. Environmental scientist at a wind power plant. Photo from U.S. Bureau of Labor Statistics

The minimum education requirement for an environmental scientist is a bachelor's degree in environmental science, natural resources, biology, ecology, or a related field.

3.1.1 Job Postings

Postings for an environmental scientist occupation, paired with other search terms such as “renewable energy” or “wind,” returned results for a variety of different job titles. Some of the titles reviewed were biologist, energy analyst, sustainability specialist, environmental scientist, environmental planner, renewable energy environmental analyst, environmental scientist – renewable energy, environmental specialist – renewable energy, National Environmental Policy Act (NEPA)³ specialist, and environmental scientist/ecologist. Of the job titles identified, nine were selected for continued review based on their determined relevance to the scope of this project.

² For more information, see the Environmental Scientist Career Map: <https://www.energy.gov/eere/wind/career-map-environmental-scientist>.

³ More information about NEPA can be found at <https://www.epa.gov/nepa>.

3.1.2 Experience

Although the positions reviewed did not include labels in their titles such as “senior” or numbers (“II”) to indicate they were listings for more advanced positions, most postings indicated that they required at least 5 years of relevant experience. Requirements included:

- Leading field teams in natural resource inventories and surveys.
- Knowledge of NEPA and environmental laws, regulations, policies, and guidance applicable to preparing NEPA documents and associated environmental reports.
- Experience in environmental, regulatory, or environmental law sectors; permitting significant infrastructure projects; participation on a multidisciplinary (renewable energy or power generation) team; and permitting energy or large-scale projects.
- Experience with threatened and endangered species and mitigation strategies.
- Working in natural resources.
- Familiarity with federal laws, especially NEPA.
- Renewable energy development and/or environmental consulting.

3.1.3 Companies

Companies reviewed for the environmental scientist role included those associated with the selected job postings: TRC Companies, Competitive Energy Services, Spire Inc., Corporate Environmental Advisors, Environmental Management and Planning Solutions Inc., SWCA Environmental Consultants, Timmons Group, Acciona Services Energy, Boston Government Services, and Stantec. Additional companies—AECOM, Ørsted, and Eastern Research Group—were added to the list during the review of individuals currently working in an environmental scientist position.

Of these 13 companies, 10 were consulting firms offering engineering, environmental, technology, or design solutions for clients and were hiring environmental scientists. Three were energy companies and 10 had a renewable energy or wind energy focus.

All the companies had career websites including job listings, though not all listings were found in job search sites such as Indeed, Simply Hired, and Glassdoor. Many of the firm’s websites included options for staying connected to the company and hearing about new jobs through email lists. Five of the companies offered “talent communities” that allow potential applicants to upload their resume for consideration of future positions.

In addition to regular job postings, 6 of the 13 companies also offered a section with information for applicants looking for internships or jobs for recent university graduates. A few of the companies reviewed offer graduate-specific positions, and others included “junior” and “entry-level” labels for their job postings. Four of the companies included search filters with “intern” categories to easily identify entry-level positions.

Four of the companies offered programs targeted at recent graduates that help entry-level employees transition into their companies and gain needed experience to continue work at that company and be better prepared to contribute to the industry. For example, Ørsted created an “Ørsted Global Graduate Program,” a 2-year program available to bachelor’s- or master’s-level graduates with a degree in business development and finance, engineering, or digital and

information technology. Program participants can work on several projects, collaborate with subject matter experts, and establish their own network. Participation in this program can lead to a permanent position. Acciona offers a similarly named 1-year training program that helps develop the emerging workforce. AECOM and TRC both offer programs, a graduate development program and a Student Training in Engineering Program, that provide interns and recent university graduates with support such as mentoring and networking in addition to working with industry leaders on a variety of projects. Though not a formal program, Eastern Research Group includes posts for “junior” and “entry-level” positions with minimum experience required of 0–5 years. Positions under these programs can be searched in the regular job search sections of most company websites.

3.1.4 Work Experience Pathways

To better understand how individuals currently employed as environmental scientists gained experience and moved into their current positions, National Renewable Energy Laboratory analysts researched companies and those in the selected role. Five individuals were selected based on their company and position’s relevance to the inquiry and years of experience. Companies represented include engineering and environmental consulting firms, energy developers, and energy infrastructure and energy research organizations that are based in multiple regions of the United States. Years of experience ranged from 9 to 34 years, with four of the five individuals having between 9 and 13 years of experience.

Initial jobs for those who currently have a career as an environmental scientist included an environmental field consultant, laboratory assistant, outreach coordinator, contract and proposal associate, environmental intern, permitting and environmental affairs intern, and environmental scientist. Four of the five individuals appear to have experience relevant to their current positions. Only one of the individuals identified an internship position as one of their first positions, and this is the only individual to have stayed at the same company.

All individuals have worked for between three and six companies. Most spent 1–2 years at their first positions except for one individual, who held their first position for 7 years. Once all five progressed further into their work experience (more than 4 years), all individuals began to stay at companies for durations longer than 4–6 years.

3.1.5 Insights

The review of job postings, companies, and individuals currently employed as environmental scientists identified some potential challenges to identifying relevant postings. One possible challenge was that 5 of the 10 job titles used the language “environmental scientist.” Another challenge was identifying entry-level positions within the job postings. Approximately half of the 13 companies included labels such as “junior” and “entry level.” The definition of these terms varied across companies, generally in the range of 0–3 years, though for some it started at 1 and ranged up to 5 years. Label definitions also varied within companies. For one company, two “junior” job postings required 1–3 and 1–5 years of experience. At another company, “entry level” was 0–1 years, whereas “early career” was 1–3 years. Inclusion of this type of label, using common position titles and consistent definitions of entry-level terms, would make it easier to identify relevant positions to better align with experience levels.

One of the most frequently identified requirements in job postings was experience with NEPA. Knowledge of NEPA and other environmental laws, regulations, and policies was highly desired. As a result, those seeking employment as an environmental scientist should seek out opportunities to familiarize themselves with NEPA and related regulations.

We anticipated that more individuals currently employed as environmental scientists would have identified internships as part of their work experience. However, individuals from this sample were able to acquire jobs related to their field of study without internships.

The finding that four of the companies reviewed offer programs targeted at recent university graduates to help transition them into the workforce was unexpected and a great example of options for connecting industry and the potential wind energy workforce.

3.2 Power Systems Engineer

A power systems engineer, sometimes referred to as a transmission or interconnection engineer, may work for a wind owner/developer, turbine manufacturer, or electric utility. They may be responsible for evaluating interconnection standards and transmission feasibility, system impact and facility studies, or testing new electrical components of wind turbine designs. Their responsibilities may also include working on transmission and/or distribution systems.

Power systems engineers typically have a bachelor's degree in electrical engineering, but may also qualify for positions with a civil, industrial, mechanical, or construction management degree.⁴



Figure 5. Engineers examine the design of the power block at the National Renewable Energy Laboratory in Golden, Colorado. Photo by Dennis Schroeder, NREL 19357

3.2.1 Job Postings

When searching for power systems engineering job postings, the search terms “transmission engineer,” “power engineer,” and “grid connection engineer” were used both alone and paired with “wind energy.” “Power engineer” and “transmission engineer” returned the most relevant and highest quantity of results. “Grid connection engineer” did not bring back many results.

⁴ Power systems/Transmission Engineer Career Map: <https://www.energy.gov/eere/wind/career-map-power-systemstransmission-engineer>

From the results, we selected 10 postings for further review. Criteria used to select postings were company focus related to wind or renewable energy, experience requirements, and offering of graduate or internship opportunities.

Six of the postings for this position included identifiers such as “associate” or “entry level” that indicated the position is geared toward those with less than 2 years of experience. Some of the postings also included “graduate” and were used to identify postings targeted at recent university graduates—both undergraduate and higher degrees. Titles for selected postings included transmission planning engineer, assistant associate engineer – electrical planning and design, substation engineer – protection and control, electrical engineer (entry level), transmission engineer, transmission and distribution engineer – power delivery, associate supervisory control and data acquisition engineer, and field engineer 1 (upcoming grads).

3.2.2 Experience

When evaluating job postings for power systems engineers, companies that were hiring for this role required a wide range of degree and certification requirements. Because many of the postings selected were targeted at entry-level candidates, the majority required a bachelor’s degree in electrical engineering. Other fields such as industrial, mechanical, civil, and structural engineering were mentioned, as well as the desire for a degree with a power systems focus. Two of the postings preferred a master’s degree, and one had a minimum requirement of an associate degree, though a bachelor’s degree was preferred. Another mentioned a few options including a bachelor’s or high school/GED plus 2–4 years in a related construction field. Other certifications that companies preferred were project management, construction, professional engineer, engineer in training,⁵ or the ability to achieve engineer in training within a year.

Postings identified knowledge that candidates should have. This knowledge commonly included codes and standards (e.g., Institute of Electrical and Electronics Engineers, American National Standards Institute, National Electrical Safety Code), high or extra-high voltage, transmission and utility system planning, power systems economics, and interconnection management. Familiarity with conducting renewable grid integration studies, reliability assessments, and power flow analysis was also desirable, as was the ability to use power systems simulation tools (e.g., tsad, pss/e, gridview).

Although most postings were entry level, several of them still required years of experience ranging from 1 to 3 years for specific expertise such as power flow analysis or utility system planning. One posting highlighted that internship experience would be considered for the requirement.

3.2.3 Companies

We identified 12 companies for review during the search for power systems engineer postings. Those companies were 174 Power Global, EDF Renewables, Enerzinx LLC, Mott MacDonald, National Grid Co USA, Ørsted, Renewable Energy Systems, RRC Power and Energy, RWE

⁵ An “engineer in training” can be defined as an individual that has acquired 3 years of postsecondary school at an engineering program approved by ABET and has passed the Fundamentals of Engineering exam. For more information, visit: <https://www.indeed.com/career-advice/career-development/engineer-in-training>.

Renewables Americas LLC, Trimark Associates Inc., Wanzek Construction Inc., and Westwood Professional Services.

Companies represented multiple types of firms including developers, owner-operators, engineering and technical consulting firms, energy providers, heavy industrial construction, and operations and maintenance (O&M). Those selected had a wind or renewable energy aspect to their company.

When searching for internships or early-career opportunities, several of the companies hosted internship-specific pages on their website (e.g., National Grid has a “Gridtern” program that has a dedicated page within their website). Three of the companies offered graduate-specific programs or postings. Two of those were graduate development programs, and the other included graduate-specific postings. Although neither intern- nor graduate-specific, five of the companies included postings that were labeled “entry level,” “associate,” or “junior” to help identify early-career opportunities.

Two of the 12 firms offered the option to sign up for notifications for future postings and to upload a resume. Another company included a general interest posting for interns, allowing those interested to submit their resume and connect with the company anytime.

3.2.4 Work Experience Pathways

We selected 10 individuals working in power systems engineering to review their education and work history. They are employed by power companies, utilities, and consulting firms from locations across the United States, with half located in Texas and two in Colorado. Four of the five individuals working in Texas and both the individuals working in Colorado are employed by different companies. Two sets of two individuals work for the same company, though they hold different positions, and their work experience pathways are distinctly different.

Positions held by those reviewed included a spectrum of levels: a senior director, two managers, a senior engineer, a lead engineer, and five engineers. Their titles commonly included the terms “transmission,” “interconnection,” and “power systems,” though one also included “electrical engineering,” and another simply was titled, “Engineer IV.” A few titles indicated a specific focus such as transmission business or planning.

Those reviewed graduated with their latest degree between 2000 and 2017; three from 2005 to 2007, four between 2011 and 2015, and two in 2017. The highest education attained by those working as power systems engineers included four bachelor’s degrees, five master’s degrees, and one Ph.D. Two individuals held two degrees—one earned two bachelor’s degrees and the other earned two master’s degrees. All of those working as power systems engineers held bachelor’s degrees in electrical and/or electronics engineering. Those with master’s degrees included primarily electrical or power systems engineering, but also included energy management and a Master of Business Administration.

Four of the individuals working as power systems engineers acquired additional certifications, including three professional engineers, two engineers in training—one later achieved professional engineer—and one PJM⁶ certification who also had an engineer in training.

Experience for power systems engineers we reviewed ranged from 7 to almost 22 years. They had each worked for 4–10 companies and held 5–10 positions. The average number of companies was six, and the average number of positions was seven. First positions for those reviewed had a duration ranging from 3 months to 6.5 years. The median duration for a first position was 11 months. Six of the 10 workers had internship, apprentice, associate, or assistant positions as part of their career pathway, and those that did include these types of positions had at least two—and up to four—before acquiring a career staff engineering position.

Once individuals achieved a regular engineering position, they averaged staying at a job between 2 and 3 years. Excluding internship-type positions that generally last less than a year, positions were held for as little as 1 year and up to 6.5 years. One individual created his own consulting company after 13 years of experience and has been self-employed for just over 7 years.

3.2.5 Insights

Though many postings suggested that other degrees may qualify for positions, all of those working as power systems engineers held at least a bachelor's degree in electrical and/or electronics engineering. Advanced degrees included the related fields of business and energy management.

There were generally two ways for individuals to attain power systems engineering positions. Some individuals were able to immediately attain positions after completing their education, and others completed multiple internships (or similar) prior to being hired into a regular engineering position. This difference may be due to education level, as five of the six individuals with this type of work history had achieved a master's degree or higher.

Multiple companies offered internships and graduate development programs and included postings identifying them as early-career opportunities. The availability of dedicated websites and clearly labeled postings resulted in finding desired positions efficiently.

We anticipated that a requirement for professional engineer or engineer in training would be more commonly identified as required or preferred in postings; however, it was in very few. Four postings mentioned this certification as preferred. Three of those preferred engineer in training certification, including one that mentioned engineer in training or the ability to obtain it within a year, and one preferred a professional engineer certification.

⁶ PJM is a regional transmission organization that coordinates the movement of wholesale electricity in all or parts of 13 states and the District of Columbia. They state that the certification program was developed to ensure that there is a baseline level of knowledge, awareness, and familiarity with applicable PJM procedures, tools, tasks, rules, and concepts: <https://www.pjm.com/training/certification>.

3.3 Welder

Welders are skilled workers that use hand-held or remotely controlled equipment to join, repair, or cut metal parts and products.⁷ In the wind energy industry, welders are primarily needed during the fabrication and assembly of wind turbine parts such as the towers, as well as during installation (Figure 6). Welders or welding experience may also be needed for repair and maintenance of the turbines.

Welders usually complete a certificate or associate degree program, though there are entry-level positions that do not require experience.

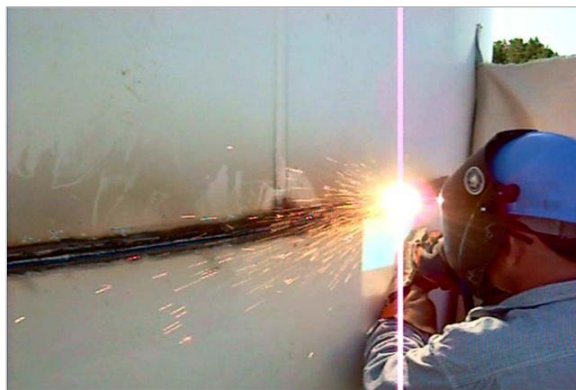


Figure 6. Welding technology student working on a wind turbine. Photo from Lower Columbia College

3.3.1 Job Postings

We selected postings for 11 welder positions for review. Companies offering positions included Bloom Energy, Hubbell Incorporated, IES (acquired Freeman Enclosure Systems LLC), Lincoln Electric, Pacific Gas and Electric Company, International Brotherhood of Electrical Workers, Tech Wind Services, Woodward Inc., World Oil Corp, and Worley. Tech Wind Services and Woodward Inc. were offering two positions. All the companies operate in the energy sector in some capacity such as manufacturing or maintenance. Multiple technologies were mentioned including hydropower, wind, and hydrogen fuel cell. Those that did not mention a specific technology indicated energy or renewable energy as being part of their portfolio.

Titles for job postings primarily included the term “welder.” Three of the nine welder positions also identified welding specialties: tungsten inert gas (TIG), metal inert gas, and pipe welder. The two positions reviewed that did not include “welder” in the title were a “wind technician assistant” and an “electrical machinist.” Though not included in the title, these two positions included welding in the job description.

Some postings were clearly targeted at entry-level applicants. Four of the 11 included labels such as “entry level” and “helper.” One of these postings included the terms “entry level” and “assistant” in the title. This same company mentioned they would provide on-the-job training for the position. The electrical machinist position, offered by Pacific Gas and Electric and identified

⁷ For more information, visit the U.S. Bureau of Labor Statistics: <https://www.bls.gov/ooh/production/welders-cutters-solderers-and-brazers.htm>.

as an International Brotherhood of Electrical Workers union posting, indicated the selected applicant would be part of their “Joint Apprenticeship Training Committee.” Four of the 11 positions required applicants to pass tests demonstrating their competency.

3.3.2 Experience

For 9 of the 11 welder postings, the minimum level of education was a high school diploma or equivalent. Two of the job postings did not indicate any education requirements, though they did identify preferred and required experience. Other education requirements included trade school (3), a mobile crane operator license (1), and a valid driver’s license (1). Three of the companies that required only a high school diploma preferred a trade school certificate from a welding program (2) or wind technician school (1). The company that required a mobile crane operator license also preferred applicants with a forklift certification.

We identified that experience was required for 6 of the 11 job postings reviewed. Potential employers required a certain number of years of experience, as well as experience with specific welding methods, positions, and products. The most common requirement was tacking and TIG welding. Four of the six postings that had required experience also had preferred experience. Of the five postings in which experience was not required, three indicated experience was preferred. Four of the 11 postings did not specify if experience was required or preferred. In addition to years of experience and welding methods, companies preferred that applicants also have experience with certain welding materials, equipment, and other skills, such as interpreting welding prints. Table 2 lists the experience identified as required or preferred in selected job descriptions.

Table 2. Required and Preferred Experience Identified in Welder Job Postings

	Experience Required	Experience Preferred ^a
Number of companies	6	7
Years of work experience	1–2 years	2–3 years
Welding methods	Tacking, TIG, DC and AC, pulsed TIG (gas tungsten arc welding), stick welding (shielded metal arc welding), oxy-acetylene torch	Metal inert gas
Welding positions	Flat, horizontal, vertical	
Products	Fillet or butt weld joints	
Welding materials		Inconel/stainless steel, aluminum
Equipment		Overhead crane, workshop, power tools
Skills/knowledge		Drawings and diagrams for materials and equipment, interpreting welding prints, industrial construction, maintenance industry, mechanical, electrical

^a Four of the seven companies that have preferred experience also have required experience for the same postings.

In addition to education and welding-related experience, postings identified desired skills applicants should have. These skills included basic knowledge of computers and common computer programs, strong communication skills both in reading and writing as well as working on a team, mathematical knowledge, and ability to use tools and equipment and maintain a safe working environment. Many of the positions (8 of the 11 postings) also included physical requirements, such as manual dexterity, ability to lift items or loads of specific weights, and fitness levels that enable them to perform in a variety of settings. Willingness and ability to work at heights or in confined spaces was stated in three positions, and one mentioned proficiency in a second language was a plus.

3.3.3 Companies

We reviewed 12 companies including Arcosa Towers, Axis Renewable Group (now a Pearce Services company), ESAB Welding & Cutting, Gemini Energy Services (part of Tetra Tech), Hubbell Incorporated, JMS Wind Energy, Lincoln Electric, Pearce Services (now Pearce Renewables), Tech Wind Services, Vestas, WindCom, and Woodward Inc. Five of the companies are manufacturing firms, five are O&M service providers, one does both manufacturing and O&M, and one offers wiring services during construction and repowering. All 12 companies work in wind or renewable energy sectors and were identified by reviewing those who had work experience as a welder (5), job postings offered by the company (5), and general internet searches for welding and the wind industry (2).

Entry-level positions were offered at 7 of the 12 companies. Postings at many of these companies were identified through labels such as “entry level” and “Level I.” Another label used to denote entry-level positions was “career.” The postings reviewed included a note that the position was a “great opportunity for recent graduates from welding technical programs.” Despite use of labels denoting entry-level positions, a few of the companies were inconsistent in their labeling, and the position level had to be identified through individual job postings. Labeling across organizations was also not consistent. For some companies, “welder” without any labels was the entry-level position, whereas others only used numerical labels such as “Welder I.” Two of the companies provided search filters—one offering a filter for “entry level,” and another filtered by “skilled” or “semi-skilled.”

To learn about open positions, more than half (7) of the companies reviewed offered internal job portals. They had different names such as “Talent Hub” or “Career Community” but generally offered a place to receive notifications, upload a resume, and apply for positions, and some allowed applicants to track submissions. One of the companies additionally offered an interactive module on the job website where an applicant could identify certifications, job skills, and desired positions and the results would be labeled for how high of a match they were. Two companies provided applicants with an option to receive notifications, and three required applicants to email the company directly to find out about current listings. One of those companies indicated applicants should contact human resources directly but gave no email or phone number.

Nearly half (5) of the companies reviewed offer some sort of in-house training programs and included both manufacturing and O&M service providers. Training programs for O&M service providers focused on wind energy technicians. Manufacturing programs included both continuing education opportunities for current welders to gain specialized training and comprehensive training programs.

3.3.4 Work Experience Pathways

We reviewed 15 individuals that are working or have worked as a welder. Their current positions include a variety of titles: pipeline technician, wind turbine technician, composite technician, senior composites fab and assembler, tower technician, solar installer, travel technician, resource technician, crew lead/welder, and lift maintenance. Seven of the 15 individuals are currently employed as wind turbine technicians.

The average years of work experience for individuals was 11.4 years, with a range of 6.5–24.4 years. Except for one individual, all had worked as a welder for just one position. For many, they worked as a welder early in their employment history, which led to subsequent positions as technicians of varying types. On average, the welder position was the first or second position held.

Education level varied. Four individuals held certificates, three had earned associate degrees, and five did not list any education. Of those that had listed they had completed postsecondary education, five earned certificates or associate degrees in wind energy technology/wind technician, three completed welding programs, and two had completed general energy certificates or education. Two individuals had finished programs in both welding and energy technology. One held three different associate degrees in autobody repair, electrical construction technology, and energy technology.

Individuals reviewed had worked for 1–8 companies, with an average of 4 companies. They held 2–8 positions, with a median of 4. Two individuals had worked more than one position at a single company. Workers employed as welders, technicians, and other skilled labor roles averaged 1.6 years at each position, with their first position averaging 2.4 years. Their current position averaged a duration of 4.5 years, and for 10 of the 15 individuals, this was their longest-held position.

Four of 15 started with or had early employment in general labor positions such as a ranch hand, dock worker, and boatswain mate, and one worked in sales. Five of the remaining individuals began their career paths with jobs in related occupations, such as torch operator, machine operator, and tower wiring tech. Only 6 of the 15 started their career paths as welders. Before starting positions as a welder, technician, or other roles, only two individuals worked as helpers—one welder helper and one electrician helper. The electrician helper also had a role as an electrician apprentice.

The work history for three individuals included experience gained in the military. Two served in the U.S. Navy and one in the U.S. Army. Other sectors that multiple individuals were employed by included rail and trailer companies.

Although not always indicated in the education section, six individuals identified skills and certifications in their bio such as forklift operation, lockout-tagout, safety certifications (CPR/first aid/automated external defibrillator, tower rescue, Occupational Safety and Health Administration), confined spaces, experience with certain materials and processes, and other specialties such as blade repair, machine technology, and warehouse operations.

3.3.5 Insights

Individuals with welding experience worked in multiple industries, gaining experience and skills that appeared to transfer from one industry to another. Those working in the wind energy industry were often employed as wind technicians or in manufacturing facilities.

For applicants looking for entry-level positions, there were welding jobs available that required no or minimal experience. Some of the companies offered education and training programs, and one offered on-the-job training. However, half of the welding positions reviewed required previous experience and/or demonstrated knowledge of welding methods, materials, equipment, and skills. In reviewing the work history of those that had worked as welders, 7 of 12 had completed at least one certificate or associate degree program that may have met the experience requirements.

There were some challenges to finding entry-level positions. One observation was that the labeling of entry-level positions was inconsistent, both in the chosen labels and in using labels for position titles. Additionally, a few companies did not list their positions on their websites, but rather directed applicants to reach out to human resources directly. Labeling inconsistency and unclear communication methods could make identifying positions a more time-consuming process for those seeking employment as welders in the wind energy industry and create a disconnect for the potential wind workforce.

The use of internal job portals made it easy for applicants to review postings, upload their resume, apply for positions, and track submissions. Although more than half of the companies reviewed used internal job portals, increased adoption by companies in the industry would decrease barriers to connect to the potential workforce.

It was expected that more of the individuals that had work experience as a welder would have completed an apprenticeship or another type of in-training position. With only two individuals holding “helper” or “apprentice” positions, it may be that the degree programs and experience from previous jobs or on-the-job training are the current paths being used by workers to meet the requirements for attaining entry-level positions.

It was also expected that job postings and those having worked as welders would include more union positions; however, many of the positions and individuals reviewed were wind technicians for land-based wind companies, which are largely nonunion. This may change with the growth of the offshore wind industry, as companies have already made agreements with labor unions for anticipated projects (Wasser and Storrow 2021).

4 Summary of Insights

Across all the job postings, companies, and individuals working in the selected positions, there were examples of practices that are helping to link the wind energy industry and potential workforce, as well as opportunities to better support workforce connections. Observations about the availability of entry-level and early-career opportunities and the work experience pathways of those employed in each occupation highlight additional opportunities for industry and workers to connect.

4.1 Examples

The use of internship and graduate-focused programs in companies that were hiring power systems engineers and environmental scientists is an example of a current practice that is creating clear pathways for those looking for employment in these fields. These programs can provide mentorship, exploration of a variety of company programs, and support for graduates as they begin their careers. The continued use and expansion of these types of programs to other companies and across wind industry sectors could help companies find and develop a qualified workforce.

Although not widely used by companies that employed power systems engineers, internal job portals were frequently used by companies hiring environmental scientists and welders. Increased use of these portals can help the potential workforce more easily connect to job opportunities and keep track of those they have applied for. At the same time, the use of portals can allow employers better access to potential employees. The challenge with these portals, however, is that they are individual to the company, so the potential applicant will need to create multiple accounts as they apply for jobs. Although some job board websites offer the ability to save jobs and even interact with recruiters, the application process is largely on individual company websites.

4.2 Opportunities

Opportunities to better connect the potential workforce to positions could include more consistent labeling of positions and consistent definitions of these labels, both within individual companies and across sectors. Clearly identifying job postings that are targeted toward entry-level and early-career workers, using common definitions of entry-level terms, and including filtering options by intern, graduate, or entry-level categories would further help candidates identify suitable positions.

Another opportunity to connect the potential workforce to positions in the industry would be a central list of open positions. Many regular jobs and some of the internship or graduate-level jobs were included on job search websites such as Indeed, Simply Hired, and LinkedIn, but not all of them. This requires the applicant to identify potential companies and search individual websites for opportunities. Although doing research on positions and companies can be beneficial, simplifying the job search process could help reduce barriers to connecting the industry and potential workforce.

4.3 Observations

The availability of internships and entry-level positions varied for the three occupations reviewed. For environmental scientists, there were fewer entry-level positions available at the time of research. Entry-level positions were more frequently available for power systems engineers and welders. Internships were more widely available at companies offering power systems engineering jobs than environmental scientists or welders. This finding is in alignment with the work history reviewed for those working in these positions. Few environmental scientists or welders included internships in their work experience, whereas approximately half of the power systems engineers had participated in an internship. For welders, the lack of internship experience may be due to the physical or hands-on nature of training programs and other work experience, as well as availability of on-the-job training.

Work history varied across the three occupations reviewed. Environmental scientists tended to work for fewer companies and for longer durations than power systems engineers and welders. Those that worked in the latter positions worked for more companies and changed jobs more frequently than environmental scientists. Power systems engineers held more short-term positions such as internships and assistant roles, which contributed to the high number of companies, though once in full-time regular positions they continued to change jobs about every 2 years. For environmental scientists and welders, individuals' current positions were most likely to be one of their longest-held jobs. Throughout their work history, environmental scientists and power systems engineers worked in similar types of jobs, whereas welders utilized their training in a variety of applications and industries, potentially using their certifications and experience as a means of transitioning into and beyond the wind energy industry.

Experience and education requirements differed for each position. A few requirements stood out that those looking for employment in these occupations should consider. Permitting experience was a high priority for environmental scientists and listed in seven of the eight positions reviewed. Of those, five specified that applicants should be familiar with NEPA. One of the most common requirements for welders was experience with TIG welding. For power systems engineers, job postings identified multiple degree programs as meeting the criteria for consideration; however, those working in the industry only held electrical or electronic engineering degrees. Those looking for employment in these occupations could make themselves more attractive to potential employers by acquiring this experience, training, and education needed.

Military service was included in the work history of those with experience as welders and those employed as power systems engineers. None of the environmental scientists reviewed had served in the military. Veteran participation in the wind workforce at 9% is higher than the national workforce average of 6%.⁸ In our sample, two of the three welders and one power systems engineer had served in the U.S. Navy, whereas the remaining welder served in the U.S. Army.

⁸ Calculated using data from the U.S. Department of Energy United States Energy & Employment Report (2022); 10,330 wind industry employed veterans out of the 120,164 total wind industry workforce in 2021 is 9%. The national workforce average of employed veterans is 6% of the national average.

5 Conclusions

Conducting this research provided valuable insights into company practices, the challenges of finding relevant entry-level positions, and the variety of career pathways for select occupations in the wind energy industry.

Individuals interested in pursuing a career as an environmental scientist, power systems engineer, or welder in the wind industry can use these insights to better understand the patterns of how people move into and through their careers. One of these findings was that individuals employed as power systems engineers primarily earned electrical engineering degrees. Those interested in this occupation should pursue electrical engineering rather than other engineering fields. The review of individuals with welding experience revealed that welding is often a steppingstone into different industries and applications. For welders that would like to work in the wind energy industry, one common job option is a wind technician.

Review of job posting requirements also revealed relevant information for individuals who would like to pursue a career in one of the occupations discussed in this report. Experience requirements showed that a common prerequisite included NEPA for environmental scientists and TIG welding for welders. Education requirements for power systems engineers were broad on postings, but as discussed earlier, those working in this occupation primarily held electrical engineering degrees. Dissemination of common experience and education requirements to those interested in these careers, as well to education and training institutions and industry employers, would help connect and prepare a more qualified workforce.

Experience, or lack thereof, for entry-level employees was considered a barrier for employment. Internships and apprenticeships are considered a way for the entry-level workforce to engage with firms and gain the experience desired by employers. Power systems engineers were observed to have access to more internships, allowing for increased job placement. Entry-level experience opportunities should be further developed and expanded for welders and environmental scientists to help increase career pathways into the wind industry, therefore decreasing the workforce gap.

For employers looking to connect with the potential workforce, these insights can be used to better communicate their job offerings and more clearly identify entry-level job postings for applicants. Examples include adopting practices such as consistent labeling and label definitions for entry-level job postings, incorporating internal job portals into the hiring process, and including category search filters on internal websites that can make it easier for the potential workforce to identify suitable jobs and for employers to reduce the number of unqualified applicants they may need to search through. Findings regarding availability of early-career options such as internships and university graduate programs can inform company decisions to offer these types of programs.

Beyond entry-level positions, review of work history indicated that if companies employ power systems engineers and/or welders, they should consider the turnover rate of individuals working in these positions, examining factors such as opportunities for career advancement and whether these can be altered to increase worker retention.

Many of the insights such as the use of job portals or establishing consistent and clear labels in job postings can be used across sectors in the wind energy industry. However, it is unknown how applicable the findings related to individuals' career pathways and employers' experience requirements are for other occupations. Further research on positions in the applied and field sciences, engineering, and skilled trade categories would reveal whether the observations for environmental scientists, power systems engineers, and welders can be used to draw conclusions about additional occupations in those categories. Similarly, it is unknown how applicable these findings are for offshore wind energy, and additional research will be needed to understand their relevancy to other occupations and technologies.

Continued research on high-priority occupations, especially those outside of engineering professions that have been a larger focus of recent wind workforce development efforts by the National Renewable Energy Laboratory, may provide new information that can help mitigate the wind workforce gap. Additionally, insights gained from this and future investigations can help define experience and offer pathways for reducing the experience gap. With increased understanding of the experience needed for occupations in the wind energy industry, employers, educational institutions, and federally funded workforce efforts will be better able to create opportunities for gaining experience. The potential workforce will also benefit from improved understanding of requirements, increasing their ability to anticipate and look for opportunities to acquire the identified experience. Lastly, findings from research on experience can be used to inform companies and educational partners on where to focus attempts to connect the wind industry and future workforce. Connecting wind energy employers and the potential workforce will be integral to mitigating the workforce gap, reducing the experience gap, and, moreover, increasing the availability of a qualified, domestic, wind energy workforce that can meet the demand to address climate needs, changing energy portfolios, and current administration goals.

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Appendix A: Level of Difficulty in Finding Qualified Applicants

The following tables show the continued level of difficulty in finding qualified applicants reported in Leventhal and Tegen (2013) and Keyser and Tegen (2019).

Table A-1. Level of Difficulty in Finding Qualified Applicants (by Occupation).

Source: Leventhal and Tegen (2013) and Keyser and Tegen (2019)

	Some or Great Difficulty (2012)	Some or Great Difficulty (2018)
Professors & teachers	84%	30%
Product designers and design engineers	75%	74%
Trade workers	71%	94%
Wind technicians	79%	33%
Professional trainers and industry educators	77%	53%
Programmers and computer scientists	74%	70%
Engineers	66%	-
Civil engineers	-	84%
Power system and transmission engineers	-	77%
Electrical and mechanical engineers	-	66%
Other engineers	-	77%
Research Scientists and Engineers	-	79%
Scientists	71%	-
Research engineers	69%	-
Attorneys	44%	89%
Paralegals	44%	-
Transportation/logistics workers	41%	80%
Land-leasing agents	46%	-
Developers	52%	80%
Construction managers	72%	-
Construction laborers	73%	39%
Resource assessors & surveyors	44%	91%
Admin/clerical	35%	46%
Government regulatory workers	73%	93%
Accountants, bookkeepers, and finance professional	-	50%
Development finance	40%	-
O&M accountants & bookkeepers	60%	-
Assembly workers	67%	72%
Economists and policy experts	-	70%
Sales and marketing professionals	-	61%
Manufacturing salespeople	64%	-
Manufacturing managers	74%	-
Managers of sales, operations, & training	61%	-
Supply chain & purchasing managers	54%	-
Applied and field scientists (biologists, environmentalist, archaeologists, etc.)	-	94%

Table A-2. Level of Difficulty in Finding Qualified Applicants (by Occupation).

Source: Keyser and Tegen (2019)

		No Difficulty	Some or Great Difficulty	Number of Workers Cited When Employer Indicated Difficulty
Applied and field scientists (biologists, environmental, archaeologists, etc.)		4%	94%	333
Trade workers (electricians, welders, etc.)		6%	94%	813
Government regulatory workers		7%	93%	41
Resource assessors and surveyors		6%	91%	119
Attorneys		11%	89%	442
Civil engineers		16%	84%	214
Transportation and logistics workers		19%	80%	418
Developers		15%	80%	129
Research scientists and engineers		13%	79%	30
Power systems and transmission engineers		23%	77%	58
Other engineers		21%	77%	59
Product designers and design engineers		25%	74%	103
Assembly workers		28%	72%	89
Programmers and computer scientists		26%	70%	82
Economists and policy experts		23%	70%	56
Electrical and mechanical engineers		31%	66%	249

This report is available at no cost from the National Renewable Energy Laboratory (NREL) at www.nrel.gov/publications.

		No Difficulty	Some or Great Difficulty	Number of Workers Cited When Employer Indicated Difficulty
Sales and marketing professionals		33%	61%	199
Professional trainers and industry educators		28%	53%	40
Accountants, bookkeepers, and finance professionals		45%	50%	120
Administrative and clerical workers		51%	46%	167
Construction laborers		61%	39%	205
Wind technicians		67%	33%	182
Professors and teachers		60%	30%	104
Communications and public relations professionals		65%	27%	29