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PNNL-36420

Toward a Workforce Roadmap for Distributed Wind

Phase 1 – Identifying Needs and Barriers

August 2024

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U.S. DEPARTMENT OF ENERGY

Prepared for the U.S. Department of Energy
under Contract DE-AC05-76RL01830

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Abstract

Despite recent policy, research efforts, and resources available for utility-scale and offshore wind workforce development, the distributed wind (DW) industry has yet to make similar advances to address its workforce challenges. This report initiates the phased development of a DW workforce roadmap to provide a foundation for roadmap development. Phase 1, contained in this report, uses desk-based research on clean energy workforce approaches and a DW interested-party survey to discuss needs and barriers hindering the workforce from expanding. Findings are summarized into goals and solutions for Phase 2 of roadmap development, which identifies actors responsible for implementing solutions identified in Phase 1.

Phase 1 results suggest that the sector's small size and limited growth motivate the short-term need for skilled workers or candidates with well-rounded and multifaceted abilities. Long-term expansion plans must diversify positions while capitalizing on existing utility-scale wind and offshore workforce efforts, as well as other renewable sector best practices where possible. The findings in this report can advance workforce development in the DW sector by aligning interested industry parties around common goals to address challenges. Training providers, installers, operators, manufacturers, federal agencies, national laboratories, academic partners, and labor unions can utilize the findings to help promote sustainable growth of the DW sector.

Executive Summary

The shift toward cleaner energy in the United States, including adoption of distributed wind (DW) technologies, has heightened the need for a skilled DW workforce. Recent federal initiatives, like the Inflation Reduction Act tax credits and joint Rural and Agricultural Income & Savings from Renewable Energy Initiative grants by the U.S. Departments of Agriculture and Energy, have bolstered financial and technical support for DW, paving the way for industry expansion. To effectively prepare for future DW growth under these initiatives, focused efforts are needed to develop the DW workforce successfully. A strategic roadmap can align with industry demands and unique characteristics to support sustainable growth in the sector.

This report aims to initiate development of a workforce roadmap for the DW sector. Phase 1 identifies current needs and barriers hindering sector expansion through desk-based research and an interested-party survey. Various interested parties involved in DW workforce development, such as training providers like academic institutions and labor unions, turbine manufacturers, federal agencies, and national laboratories, can use the findings to inform future policy around DW and workforce diversity initiatives to facilitate sector growth. There are three key takeaways from this phase:

A comprehensive approach to mapping workforce skills and educational needs to DW positions is necessary for roadmap development. This mapping can fill the documented gaps between installer recruitment and applicant availability to fill high-priority positions and ensure a qualified workforce. Knowing what skills and competencies to prioritize for DW helps interested parties make informed decisions about where to invest resources to support workforce development initiatives effectively.

Results from an interested-party survey underscore the importance of human capital development in sustaining and advancing a DW workforce. The top five elements recommended in a DW workforce roadmap were skills, knowledge area descriptions, educational attainment levels, current wind workforce programs or initiatives, and job descriptions. Clear and accurate job descriptions are essential for attracting qualified candidates and ensuring alignment between employer expectations and employee responsibilities.

The sector's small scale has created the need for multifunction workers or employees with broad abilities, though this model may not be sustainable for long-term sector growth. This need creates a high degree of employee versatility and flexibility, as employees may be required to perform various tasks, from installation and maintenance to troubleshooting and customer service. Transferring utility-scale wind workforce approaches to DW is also hindered by this structure since employers may need to invest in comprehensive training programs to ensure that workers have the knowledge and expertise to perform their duties effectively.

Acronyms and Abbreviations

DEWWind	Diverse and Equitable Workforce in Wind Energy
DOE	Department of Energy
DOL	Department of Labor
DW	distributed wind
IEA	International Energy Agency
IRA	Inflation Reduction Act
NREL	National Renewable Energy Laboratory
PNNL	Pacific Northwest National Laboratory
RAISE	Rural and Agricultural Income & Savings from Renewable Energy
SEND	Strategize, Engage, Network, Deploy
USDA	U.S. Department of Agriculture

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1.0 Introduction

The shift toward cleaner energy sources in the U.S., including the adoption of distributed wind energy technologies, has created a growing need for a skilled workforce.[1] Recent federal initiatives, such as the Inflation Reduction Act (IRA), have boosted financial and technical support for distributed wind, setting the stage for further industry expansion(Hallett, 2024; Office of Energy Efficiency and Renewable Energy, 2023). The IRA enhances the clean energy Investment Tax Credit by offering up to 30% credit for eligible investments in wind projects that adhere to prevailing wage standards and employ many apprentices from Department of Labor (DOL) registered apprenticeship programs. The IRA allocates grant funding to the U.S. Department of Agriculture (USDA) for underutilized technologies like DW through the Rural and Agricultural Income & Savings from Renewable Energy (RAISE) Initiative. Under this initiative, in collaboration with the Department of Energy (DOE), USDA aims to assist 400 individual farmers in deploying smaller scale wind projects (Hallett, 2024). Greater attention must be given to developing a skilled workforce in the DW energy sector to adequately prepare for future deployments facilitated by these efforts. A workforce roadmap can help align DW's unique characteristics and growing demand with workforce development efforts to support long-term sustainability in the sector.

To date, DW workforce development has received fragmented attention. Some DW installers and manufacturers have led periodic efforts to enhance the workforce in recognition of growing sector needs. However, the absence of initiatives and policy directives leaves a significant gap in holistically addressing workforce development. While the National Renewable Energy Laboratory (NREL) conducted a comprehensive national assessment of the utility-scale and offshore wind energy workforce, outlining actions to close industry-wide gaps (McDowell et al., 2024), DW-specific considerations were absent from their findings. By not addressing factors such as smaller turbine sizes, unique application spaces, and siting and permitting differences, the assessment makes it difficult to fully extend its findings to DW. The DOE has online workforce resources for the wind industry as a whole, including a summary of training and education programs around the country and a wind career map (Office of Energy Efficiency and Renewable Energy, 2024). These resources can apply to DW but do not address specific workforce challenges. The Wind for Schools project, operating through the REpowering Schools organization, addresses the need to educate the next generation of wind workers through classroom studies, field assessments, and small turbine installations at rural schools (REpowering Schools, 2024). Though the Wind for Schools program is helping fill the DW workforce gap in 12 states, more work remains to understand what is necessary to close the gap at an industry-wide scale. The Diverse and Equitable Workforce in Wind Energy (DEWWind) project led by Pacific Northwest National Laboratory (PNNL) is a DOE Wind Energy Technologies Office funded effort to advance partnerships with post-secondary institutions and DW companies to build workforce development programs. The focus is on partnerships in the Northeast and Midwest, but more work is needed to scale capacity in the Southwest and Southeast regions.

[1] Distributed wind refers to wind turbines installed close to where the power will be used at the distribution level of an electricity delivery system. In comparison, utility-scale wind refers to large wind farms that generate significant amounts of electricity, typically for supply to the grid rather than local consumption. In addition, offshore wind refers to wind turbines installed in bodies of water, typically in coastal areas or open seas.

The Strategize, Engage, Network, Deploy (SEND) DW Project at PNNL uses targeted strategic and technical engagement to lay the groundwork for a future workforce supporting increased DW deployment. This report addresses the workforce gap as part of the SEND DW project by initiating a phased approach to an industry workforce roadmap. Phase 1, discussed in this document, identifies the workforce needs and barriers hindering expansion. The outcome of this phase is a preliminary set of roadmap goals to be investigated further in Phase 2. Figure 1 provides an overview of each phase of the roadmap.

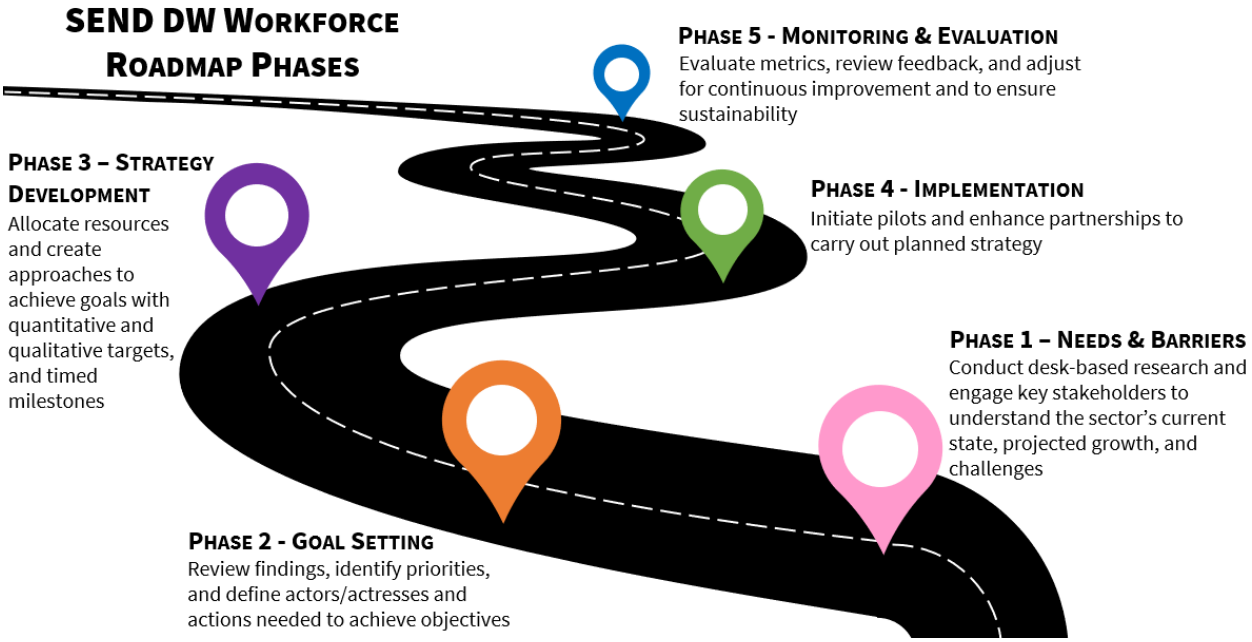

Figure 1. An overview of each phase of the DW workforce roadmap.

This document is relevant to various parties involved in DW workforce development. Training providers, including academic institutions and labor unions, can use this information to develop targeted educational programs and certifications that align with sector needs. Turbine manufacturers and installers can use this roadmap to align product development strategies with workforce requirements, ensuring new technologies meet market demands and regulatory standards. Federal agencies and national laboratories can use the findings to inform future policy around DW and workforce diversity initiatives to facilitate sector growth.

Results from desk-based research of existing workforce roadmaps are in Section 2.0. Section 3.0 assesses the transferability of utility-scale and offshore wind workforce approaches to the DW industry. Section 4.0 presents and discusses the results from a survey shared with key DW interested parties. A summary of findings and recommendations for Phase 2 of roadmap development is provided in Section 4.0.

2.0 Desk-Based Research Results

To explore the topic of DW energy workforce development, a web-based search for literature included keywords and their combinations, including ‘distributed wind energy,’ ‘workforce development,’ and ‘labor roadmaps.’ This search aimed to gather information on existing workforce efforts and roadmap structures in the wind and broader clean energy industry. This approach streamlined the research process by targeting specific terms related to wind workforce planning, development, and strategies. Using a well-refined set of keywords ensures comprehensive coverage of relevant literature across various sources, including academic journals, industry reports, government publications, and conference proceedings.

Results came from DOE’s Office of Scientific and Technical Information, the *Energy, Sustainability, and Society* journal, and several policy and energy organizations, such as the Federation of American Scientists, National Clean Energy Workforce Alliance, University of Michigan Renewable Energy Policy Initiative, Massachusetts Institute of Technology Energy Futures Initiative, and International Energy Agency (IEA). In addition, the results considered roadmaps outside of the United States. International results help broaden perspectives on how different regions address workforce needs, and this comparative analysis can provide valuable insights into what strategies have been successful. It also enriches the depth and breadth of the desk-based research to strengthen the validity and relevance of findings. Next, the key takeaways shed light on the following topics and inform the DW workforce roadmap structure:

- Gaps in employer and employee perspectives
- Use of demographics in roadmap development
- How workforce transitions were discussed for clean energy initiatives
- How granular workforce needs were described (e.g., skill descriptions versus job descriptions)
- The role of policy as a driver for roadmap construction.

2.1 Gaps in Employer and Employee Perspectives

Surveys of employers, employees, and potential employees in the offshore and utility-scale wind industry revealed gaps between candidate qualifications and industry needs. Garnering qualified applicants for wind roles has been difficult for installers and manufacturers due to a lack of hands-on experience. Operations and asset management sectors struggled to find entry-level applicants, while manufacturing, education, development, and siting areas had difficulty finding nonentry-level applicants (Stefek et al., 2022). Both applicants and employees mentioned difficulty gaining wind energy-specific skills and work experience, and identifying positions aligned with their skills based on keywords or job titles. Educational institutions reported having difficulty placing students in wind jobs due to the geographic disconnect between where wind industry jobs are located and where the potential workforce is willing to live, and a lack of relationships between educational institutions and industry (Stefek et al., 2022). The findings highlight a missing link between wind industry employers, the potential workforce, and educational institutions that should be considered for DW workforce development.

2.2 Use of Demographics in Roadmaps

Considering demographics when developing a DW workforce roadmap can provide a foundational understanding of the workforce landscape and enable strategic decision-making and effective planning for deploying DW technologies. Demographics provide insights into skilled labor's current and future availability by identifying regions or populations with a concentration of relevant skills (such as electrical engineering or construction) essential for DW projects. Demographics can also help forecast workforce needs. For example, understanding the age distribution within relevant skill sets can indicate potential retirements or turnover rates, which are important for succession planning and ensuring a continuous supply of qualified personnel. Demographics highlight diversity within the workforce, which can lead to a broader talent pool. Including demographic characteristics in the roadmap can help tailor training and development programs to address specific needs and gaps.

Desk-based research reviewed existing workforce roadmaps across various energy industries to understand how demographics were used in establishing initiatives. Demographics were often initially used to understand the current workforce's ethnic makeup, educational attainment level, and age. Further investigations considered how addressing workforce gaps could diversify or ensure the inclusion of certain populations that may get left behind in an energy transition (Foster et al., 2020; Kotarbinski et al., 2020; McDowell et al., 2024; Michaud, 2020). Examples of these groups include workers in fossil-fuel-based industries experiencing economic displacement; historically marginalized populations such as minorities, women, and low-income communities facing historical inequities in education, resource access, and hiring practices; and rural communities with barriers due to their geographic location. Active involvement of these groups requires targeted training programs, outreach initiatives, and policy frameworks.

2.3 Workforce Transitions in Clean Energy Initiatives

Additional roadmaps and strategies to transition the declining fossil fuel workforce into clean energy industries identified workforce development opportunities through education, training, and private partnerships and pipelines. For instance, Canada's Energy Advisor Requirement, Training, and Mentorship program is a targeted effort to meet the needs of Canada's Greener Homes Initiative for home energy auditors. Similar to DOE's requests for proposals, the Canadian government's call for proposals among local and Indigenous governments and private and not-for-profit entities generated workforce development programs supporting training, mentorship, recruitment, upskilling and professional development, or supporting evaluations to help builders and developers understand residential energy use to identify retrofits (IEA, 2022). The Romanian Wind Energy Association's Valea Jiuliui Academy retrains and reskills workers from the coal industry to work in the wind industry. The courses are supported by industry firms with specific wind and renewable energy skills, culminating in a certificate that qualifies participants for work (IEA, 2022). The European Union RES-SKILL project identified a three-step methodology defining synergies and misalignment between the coal and renewable industries to help coal workers transfer their skills to renewable industries and bypass lengthy training. Step one identifies the main occupation profiles in the coal industry and renewables sector, step two documents skills in the coal industry and renewables sector, and step three develops transition profiles based on skills matching. This project produces a tailored curriculum and improves coordination between program participants (IEA, 2022).

2.4 Granularity of Workforce Needs

There is a pressing need for an updated, comprehensive approach to mapping workforce skills and educational needs in the wind energy industry at large to effectively address the challenges of filling high-priority positions and ensuring a qualified workforce. During desk-based research, an important evaluation element was what components were included in workforce roadmaps and what structures were used to communicate needs. Researching these components helps understand how companies plan to align their workforce with their long-term goals. Knowing what skills and competencies are prioritized allows organizations to tailor their talent acquisition and development efforts accordingly. It also identifies skill gaps that need to be filled through hiring or training initiatives and helps leaders make informed decisions about where to invest resources to support workforce development initiatives effectively.

Outlining workforce needs by skills and degrees was uncommon, but many workforce strategies called for a mapping of this nature to aid their industry. For example, courses offered in Pennsylvania State University's wind certificate and degree programs, which include Wind Turbine Systems and Wind Turbine Aerodynamics, do not list specific skills (Lesieutre et al., 2013). NREL's wind energy workforce study describes occupations based on wind market segment (e.g., operations and maintenance versus sales) and breaks down educational attainment levels by occupation (e.g., assembly workers, electrical and mechanical engineers, civil engineers, trade workers); however, it does not fully detail the skills needed for each position. (D. J. Keyser & S. Tegen, 2019). Comparatively, a later NREL study selected three high-priority wind occupations and reviewed their job postings, employment websites, and career pathways to identify skills, knowledge, and experience needed for each position (Christol et al., 2022). Seventy-five percent of employers identified environmental scientist, power systems engineer, and welder as particularly challenging positions to fill, emphasizing preference for candidates with industry experience. This underscores the significant obstacles in securing relevant entry-level positions discussed in Section 2.1. Further research and collaboration are needed to fully outline the specific skills and educational needs of the DW workforce.

2.5 Policy's Role in Roadmap Construction

Policy is a key workforce driver. Clear and supportive policies encourage investment in DW technologies. This support is essential for businesses to confidently plan for workforce needs, including hiring and training. In addition, policies often include incentives, subsidies, tax credits, or grants. These financial incentives reduce barriers to entry for developers and operators, stimulating demand for skilled labor. Workforce development policies may also fund training programs to build the necessary skills within the labor pool—for example, the RAISE initiative and IRA tax credit for eligible investments in wind projects that adhere to prevailing wage standards and employ many apprentices from DOL-registered apprenticeship programs. One can look to federal and state initiatives to motivate roadmap structure and close workforce data gaps.

A few authors have made specific recommendations on balancing existing federal and state initiatives with clean energy workforce efforts to improve impact. Some recommended policy interventions are state unemployment benefits extensions, free workforce training for in-demand energy industries, sales tax exemptions for energy companies providing workforce development at high schools or summer programs, state K-12 curriculum that includes advanced energy

courses and learning labs, and advanced energy workforce tax credits to clean energy companies hiring and training marginalized/underrepresented communities (Michaud, 2020). DOL can be a key workforce development partner to the DW sector by helping to standardize and update job classifications and collaborating with private entities to increase the visibility of "career exploration resources" (Davignon et al., 2023). DOL can also use their Trade Adjustment Assistance Community College and Career Training program that identifies and analyzes skill gaps with the private sector, increasing public-private-social partnerships to address skills gaps, standardizing and sharing data on workforce training programs and needs, and authorizing training grant funding as a model (Vance & Sullivan, 2023). An international example of government-led or partnered initiatives to spur workforce development in the clean energy transition is Greece's lignite power plant and mine decommissioning which is a key part of its energy transition. To help manage the transition for impacted communities, Greece created a fund to support job creation and diversification in lignite dependent areas (IEA, 2022).

2.6 Summary of Desk-Based Research

In summary, web-based literature searches gained insights from various publications and organizations, shedding light on existing efforts, gaps, and potential strategies for DW workforce roadmap development. Surveys among wind industry interested parties revealed persistent challenges in recruitment and experience alignment. Reviewing existing workforce roadmaps across energy sectors emphasized the importance of demographics and transition strategies. While mapping skills and degrees remain underutilized, a growing interest and appetite exists for their necessity. Policy emerges as a pivotal driver, with recommendations ranging from state interventions to federal initiatives, indicating that a multifaceted approach is required for effective workforce development. These findings underscore the imperative for a structured workforce roadmap informed by diverse perspectives and aligned with existing tax credits and initiatives to navigate the evolving DW landscape.

3.0 Transitioning Wind Workforce Approaches to Distributed Wind

Workforce development approaches for DW can leverage existing utility-scale and offshore wind efforts and other renewable technologies to support industry growth and success. Because of this and the thoroughness of existing workforce assessments for utility-scale and offshore wind, Phase 1 of roadmap development includes an assessment of the transferability of workforce approaches. There is potential for training programs to be tailored and scaled down to meet the needs of DW projects, providing workers with essential skills and knowledge.

3.1 Opportunities to Capitalize on Existing Efforts

Utility-scale wind energy perceptions, gaps, and successes could be easily applied to DW. Successful workforce development strategies implemented in utility-scale and offshore wind sectors, such as apprenticeship programs, vocational training partnerships, and career pathways, can be adapted and scaled down for DW since many of the required technical skills, such as electrical engineering, turbine maintenance, project management, and safety protocols, are also relevant for DW installations. Workers with experience in utility-scale or offshore wind can often transfer these skills to smaller scale DW projects with minimal additional training. Lessons learned and best practices developed in utility-scale and offshore wind operations, such as site assessment, installation techniques, grid integration, and maintenance strategies, can also inform similar practices in DW. Further, the current perceptions of wind industry jobs reported by NREL could be leveraged to improve attractiveness to potential employees in DW (Stefek et al., 2022). For example, benefits packages could be increased to address the disconnect between wind industry job postings and where the potential and current workforce is willing to live.

DOE-sponsored wind programs can provide exposure and training in DW, leading to greater recruitment into the sector. There is a two-times higher likelihood of students participating in DOE-sponsored programs[2] working in the wind industry than students who have not (D. Keyser & S. Tegen, 2019; Kotarbinski et al., 2020; Stefek et al., 2022). In addition, only six wind-energy-specific apprenticeships are currently registered with the DOL.[3] Expanding the offerings of apprenticeships that meet DOL standards is an easily transferable strategy for expanding the DW workforce.

The National Wind Energy Workforce Assessment similarly provides insights into wind workforce opportunities, which also applies to DW. Namely, collaborating with educational institutions to build awareness of wind industry opportunities among students, establishing internship and apprenticeship programs, connecting with students through outreach programs and competitions, and addressing and reducing barriers to entry for historically underrepresented populations (McDowell et al., 2024). For instance, the DEWWind project at PNNL is advancing new and equitable partnership-building opportunities for workforce development at the collegiate

[2] These programs include the CWC, WFS/Wind Application Centers, NAWEA, KidWind, and the National Energy Education Development project.

[3] When an apprenticeship program is registered with DOL, it means that it has met specific criteria and standards set by the DOL Office of Apprenticeship. A Registered Apprenticeship Program meets rigorous federal quality, credibility, and consistency standards and enables employers to access larger talent pools.

level.[4] DW employers can tap into these existing partnerships to access resources and support for recruiting, training, and retaining skilled workers.

3.2 Challenges

Adapting workforce development efforts from utility-scale wind to DW requires careful consideration of the differences in scale, scope, and technical requirements between the two sectors. There may be differences in economic and employment impacts on local communities given the difference in scale in large wind farms and DW energy. For example, a study of operations and maintenance positions for wind power plants found that for every 1 MW of installed capacity, a community can expect 0.11 direct full-time equivalent positions for that large-scale plant and 0.33 indirect and 0.06 induced positions to support other businesses and services (Kotarbinski et al., 2020). For smaller and more geographically dispersed DW projects, these values may be minuscule, do little to increase the desirability of DW roles, and be less immediately impactful for local communities. Adapting workforce development efforts from utility-scale wind to DW requires a nuanced approach to address the scale, scope, and technical requirements as well as the potential economic and employment impacts on local communities.

Scaling workforce efforts may require significant financial investments, staff time, and infrastructure that DW companies may struggle to afford. For instance, manufacturers and installers may require customized training materials and curricula that address specific challenges and requirements. When developing these materials, granular data on DW-specific skills and regional employment opportunities are missing. This identification can help the industry understand how to target specific populations better and build partnerships by region or skill. For example, Michaud (2020) provides a useful quantitative mapping method for transitioning workers by wage and skills from traditional to renewable or clean energy occupations. This would apply to DW if the granular skills and position data from the U.S. Bureau of Labor Statistics were available to matrix with declining occupations. McDowell et al. (2023) also provide clearer context on the workforce gap based on the difficulty in finding and hiring qualified applicants. Still, they are only focused on utility-scale and offshore wind jobs. Having more granular data to understand where DW stands would help identify more targeted workforce pathways and skills gaps. Without adequate resources, DW employers may find it challenging to effectively replicate workforce development initiatives. There could be increased potential if DW collaborated with utility-scale and offshore wind projects to align their efforts where possible, thereby expanding the workforce across different wind applications.

[4] https://www.pnnl.gov/distributed-wind/diverse-equitable-workforce-wind-energy

4.0 Interested Party Feedback

PNNL conducted a brief survey at the 2024 Distributed Wind Energy Association annual conference to gather input on roadmap development for the DW industry. The survey (see Appendix A), aimed to shape the roadmap's initial phase, received five responses from prominent DW interested parties involved in the industry for at least 2 years. Two questions delved into the respondents' background and their roles in the industry. Another question sought recommendations for DW workforce roadmap content, while a separate question addressed barriers hindering the expansion of the DW workforce. The final question inquired about necessary skills and focus areas specific to DW that may not be required for utility-scale wind. In addition, PNNL gathered insights from discussions with DW installers through other SEND tasks and the DEWWind project.[5] A summary of the feedback is highlighted in Figure 2.

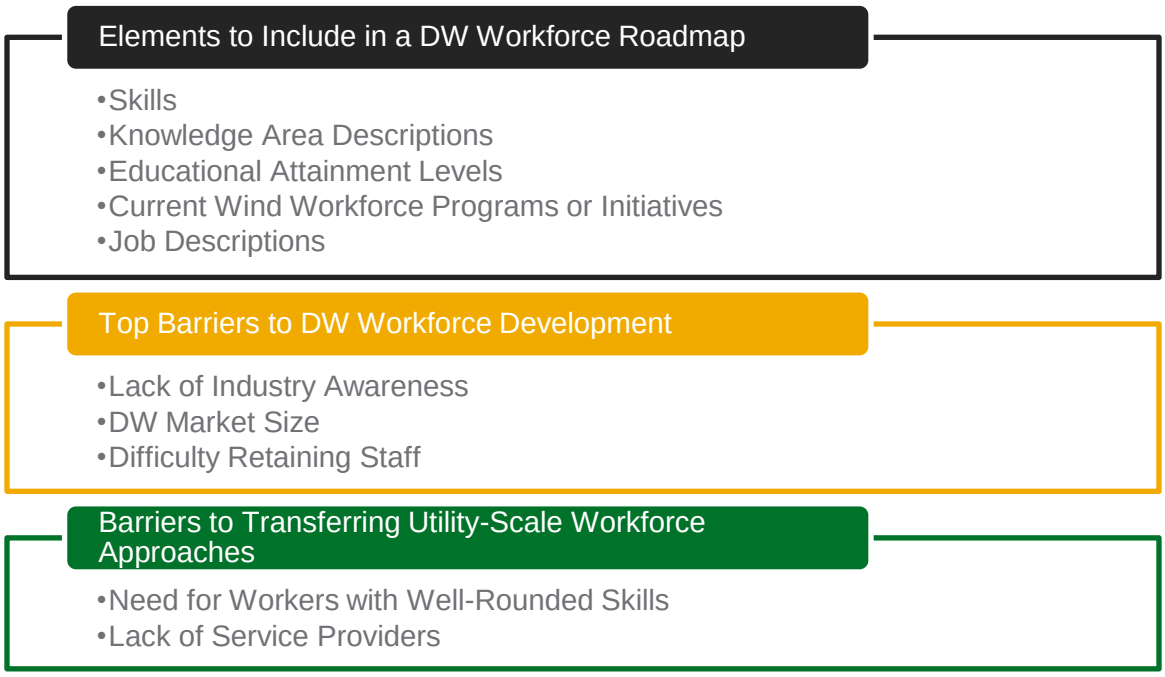

Figure 2. A summary of the questions and top responses from the interested party survey for DW workforce roadmap development.

The top five suggested roadmap elements were skills and knowledge area descriptions, educational attainment levels, current wind workforce programs or initiatives, and job descriptions. These survey results strongly underscore the importance of human capital development in sustaining and advancing a DW workforce. Skills and knowledge area

[5] Additional SEND tasks include a virtual summit to facilitate discussions specific to stakeholder segments, including workforce development; development of journey maps to understand deployment barriers; and collaboration with NREL and Repowering Schools to establish networks that address the needs of individual schools with available turbine inventory, technical assistance, and funding mechanisms. The DEWWind project has developed a replicable, equity-driven rubric to identify potential industry and academic collaborators across locational, institutional, and socioeconomic criteria to advance new partnership-building opportunities in areas favorable for DW.

descriptions indicate a need for clarity and standardization in defining the skills and knowledge required for various roles within the wind industry. Standardized position descriptions, like those used by federal agencies such as DOE, can facilitate better communication between employers, educators, and job seekers, leading to more efficient recruitment, training, and career development processes. Understanding the educational requirements for distinct roles can help institutions tailor their programs to meet industry needs, ensuring that graduates have the right skills and qualifications to succeed in the field. The suggestion for chronicling current wind workforce programs or initiatives suggests a desire to build upon existing workforce development efforts in the DW industry and determine what is working well and where there may be gaps or areas for improvement. Clear and accurate job descriptions are essential for attracting qualified candidates and ensuring alignment between employer expectations and employee responsibilities. An additional item to consider in roadmap development is job case studies to illustrate the range of employment opportunities. By investing in skills development, education, and workforce programs, interested parties can ensure a steady supply of qualified talent to support the growth and innovation of the industry.

The top three barriers to DW workforce development were lack of industry awareness, size of the market, and the difficulty of retaining staff. If industry awareness is lacking, it suggests that potential workers may not be aware of opportunities available in the sector. This could be due to insufficient marketing and outreach efforts by industry interested parties. Addressing this barrier requires proactive initiatives to raise awareness about the benefits and career opportunities within the DW industry. The small size of the DW market means fewer job opportunities and reduced investment in workforce training, potentially making it less attractive for individuals to pursue careers in the sector. To address this barrier, interested parties may need to explore strategies to expand the small wind market, such as advocating for additional policy support, promoting renewable energy incentives, and fostering innovation in DW technology. Retaining staff can be a significant challenge for any industry. Still, it may be particularly acute in DW because the impact of high turnover rates and recruitment costs can disrupt productivity. To address this barrier, employers may need to improve employee satisfaction, offer competitive wages and benefits, provide professional development and advancement opportunities, and foster a positive work environment. Additionally, industry-wide efforts to address skill shortages and promote career pathways can help retain talented workers by providing opportunities for growth and advancement within the sector. By overcoming these challenges, the DW industry can strengthen its workforce pipeline and ensure long-term sustainability and growth.

Transferring utility-scale wind workforce approaches to DW was particularly hindered by the need for workers skilled in many functions, unique to the DW industry's small scale. DW workers must often wear multiple hats and be proficient in various skills. This requires a high degree of versatility and flexibility, as employees may be required to perform various tasks, from installation and maintenance to troubleshooting and customer service. Having workers who can perform multiple functions can help maximize resource efficiency. Rather than hiring separate specialists for each task, DW companies can rely on multifunction workers to handle diverse responsibilities, thereby reducing overhead costs and optimizing operational efficiency. The downside is that this approach may hinder industry expansion and may not be an attractive characteristic for new workers. Multifunction positions may lead to worker burnout and limited career advancement. In addition, to fulfill these roles, employers may need to invest in comprehensive training programs to ensure that workers have the knowledge and expertise

required to perform their duties effectively. Overall, this sentiment reflects the sector's immediate size and unique challenges.

A survey respondent mentioned another challenge hindering industry growth was the lack of service providers, which was anticipated to “increase over the next few years when the industry wants to experience expansive growth.” This is a manifestation of the need for multifunction workers because installers are often service providers for technology they did not install and companies that went out of business. DW also has high domestic content, which means workforce needs for the industry will span multiple phases of the project lifecycle: manufacturing and assembly; installation; operations and maintenance; and testing and certification.

The DW industry is at a pivotal point. Many of the industry leaders at the forefront of the industry’s inception – some of these companies helped put up the first DW projects – are now seeing these projects reach the end of their operational lifespan. As a result, there is an emerging workforce need to handle both project decommissioning and ongoing maintenance tasks. This transition period is further complicated by many long-time industry leaders stepping down, creating a significant gap in experience and leadership. Creating clear succession plans is therefore crucial, mainly to ensure that knowledge transfer and continuity are maintained. This includes not only identifying and grooming the next generation of leaders who can oversee these transitions effectively but also developing strategies for upskilling current employees to manage the complexities of decommissioning and modernization. Addressing these challenges with strategic foresight and proactive planning will be essential in navigating this critical phase and ensuring a smooth transition.

5.0 Reflections

The desk-based research and interested-party feedback on DW workforce development revealed several challenges and opportunities. Gaps between installer recruitment and applicant availability are impacted by a lack of skill mapping to positions, a critical necessity in many energy industries. Policy plays a vital role in enabling workforce development programs. Tax credits in the IRA and the RAISE initiative grants could benefit from alignment with DOL programs for apprenticeship standardization to create a more cohesive and effective approach to workforce development. This alignment can facilitate the development of standardized apprenticeship programs that meet industry needs, provide clear career pathways, and ensure that workers gain the skills required for success in the DW industry. The current small size of the industry has many implications for potential workforce expansion. Prominent interested parties hold significant industry knowledge; however, they are not always able to replicate their skill sets with new individuals in the workforce, limiting growth and scaling, and enabling the multifunction worker model. While this model meets immediate industry needs, it is unsustainable for long-term expansion due to worker burnout, training breadth, and limitations on career advancement.

Encouraging specialization among workers and providing advanced training could challenge this model and improve current worker retention, revealing specific skillset needs and motivating hiring away from multifunction positions. The slow growth of the DW industry, evident in minimal increases in active installers since 2009 and fluctuations in deployment since 2012 (Pacific Northwest National Laboratory, 2024), contrasts sharply with the rapid expansion seen in distributed solar, where the total capacity increased by 9% in 2012 through 2019 alone (IEA, 2019). This lack of growth leads to fewer job opportunities and skill stagnation, impacting recruitment and potential policy incentives. Efforts to expand should not overlook the challenge of retaining current workers. Overall, addressing these challenges can capitalize on opportunities to prioritize skill mapping, policy support, and strategic workforce development initiatives to ensure the long-term sustainability and competitiveness of the DW industry.

Reflecting on these findings, Figure 3 summarizes recommended goals and solutions for a DW workforce roadmap. DW tools, such as the under development Distributed Wind Explorer which helps assess potential DW deployment, and the creation of career case studies to showcase existing positions and how they evolve over time can be enablers for many solutions. To advance the work under Phase 1, Phase 2 of the roadmap will need to identify priorities and define actors and actions needed to complete solutions and address the needs and barriers discussed in this report.

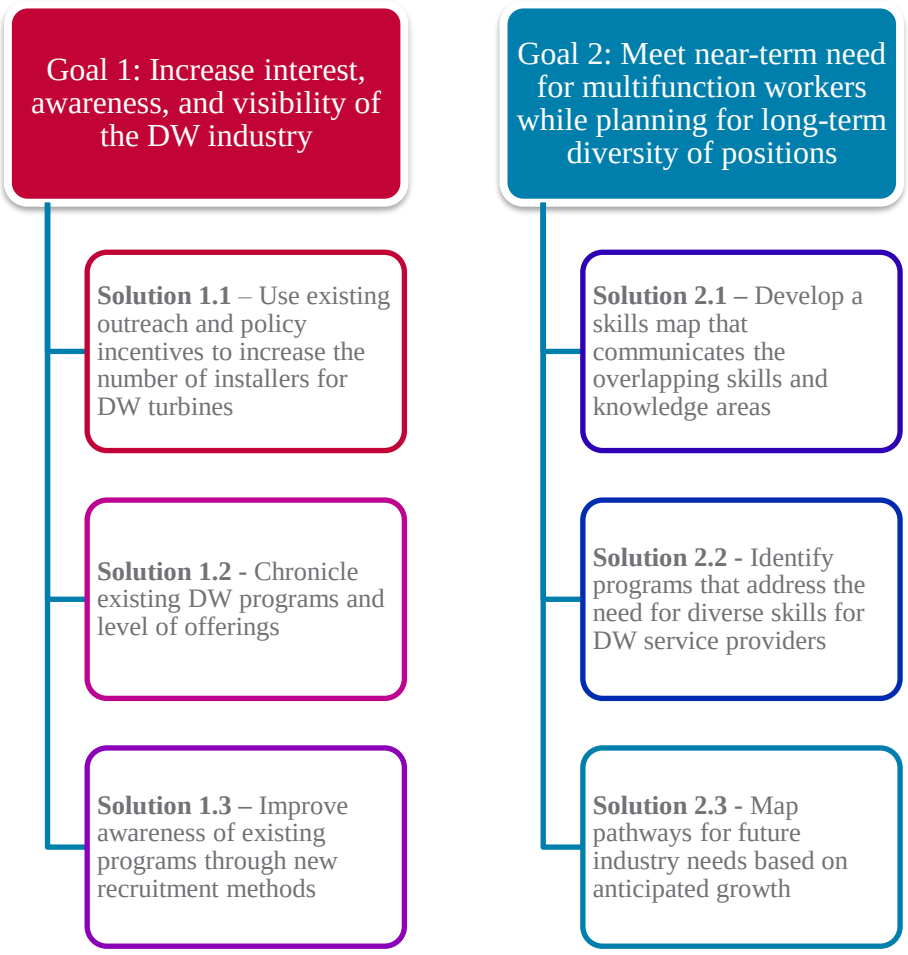

Figure 3. Summary of suggested goals and solutions to address the DW industry's needs and barriers to workforce development.

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Appendix A – Workforce Roadmap Survey

Distributed Wind Workforce Roadmap Development Input

Pacific Northwest National Laboratory (PNNL) with support from National Renewable Energy Laboratory, is conducting desk-based research for a future distributed wind workforce roadmap. This survey gathers feedback from DW interested parties that will inform the roadmap's development. Survey responses will be incorporated in Phase 1 of the roadmap which outlines workforce needs and barriers.

1. What is your connection to Distributed Wind? Select all that apply. (required)

☐Installer
☐Manufacturer
☐DW Turbine Owner/Project Host
☐Operations and Maintenance Provider
☐Utility
☐Academic Partner
☐Federal Agency
☐Workforce Development Partner
☐Financial Partner
☐Enthusiast
☐Future DW Stakeholder
☐Other
☐Prefer not to answer

2. How long have you been involved with distributed wind?

☐0-2 years
☐2-4 years
☐5-7 years
☐7-10 years
☐More than 10 years
☐ Prefer not to answer

3. What content should a distributed wind workforce roadmap include? Select all that apply. (required)

☐Descriptions of necessary skills
☐Descriptions of knowledge areas
☐Descriptions of occupations
☐Descriptions of current wind workforce programs and/or initiatives
☐Descriptions of necessary educational attainment levels
☐Jobs by region or location

☐Other

Response

☐ Prefer not to answer

4. What barriers prevent the distributed wind workforce from expanding? Select all that apply. (required)

☐Size of DW market
☐Lack of policy intervention
☐Poor academic partnerships
☐Lack of awareness about DW
☐Unclear connection and scaling of other wind workforce efforts
☐Lack of a prepared workforce
☐Difficulty retaining candidates
☐Too little interest in distributed wind positions
☐Lack of apprenticeships
☐Other

Response

☐ Prefer not to answer

5. To your knowledge, are there skills or focus areas needed in distributed wind that are not needed for utility-scale wind? (required)

☐Yes
☐Maybe
☐No
☐Unsure
☐Prefer not to answer

6. If you answered yes or maybe, what skills or focus areas are needed in distributed wind that are not needed in utility scale wind?

Response

7. Please provide additional context for your previous answers or additional thoughts on the distributed wind workforce here. (optional)

Response

8. If you are interested in follow-up on your survey responses, please provide your contact information. (optional)

(Name)	*(Email)*

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