

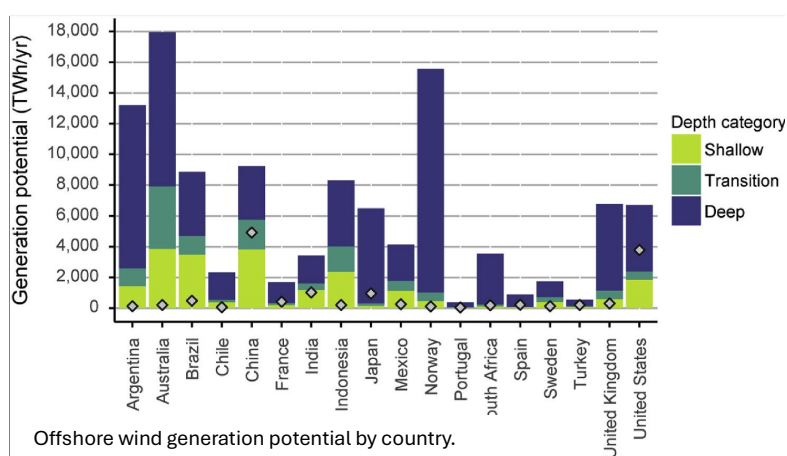
OFFSHORE WIND - FUTURE-READY WORKFORCE

The world will need 532,000 new wind future-ready workforce by 2028 to meet the increasing demand for onshore and offshore wind. According to a 2022 report by the International Renewable Energy Agency, power generation from renewable sources such as wind, solar and hydropower plays an essential role in the global energy transition in line with net-zero emission pathways.

A skilled workforce is essential for building a secure and sustainable energy future to mitigate global challenges including climate change, pandemics, conflict, political uncertainty, and energy insecurity. Energy security and workforce development are intertwined. Workforce development initiatives, including training and education, are vital to address the skills gap and prepare the future-ready workforce.

Wind is expected to become the second largest source of global renewable electricity generation behind solar, surpassing that generated by hydropower. Offshore wind allows for vast expansion beyond coastal areas, making it a globally viable renewable energy source with a much larger reach compared to traditional onshore wind farms. Technology maturity expands the places where one can build offshore wind, transforming a regional industry into a global industry.

The implications of competitive, commercial scale offshore wind are massive, with resource potential that far exceeds the global energy demand. With load factors averaging between 40% and 60%, it has tremendous potential to contribute to decarbonization and alleviate energy needs.



The offshore wind industry is growing fast, with potential for thousands of gigawatts of capacity globally, despite facing macroeconomic and political pressures; long regulatory and permitting process; supply chain constraints; inadequate infrastructure; complex

energy procurement; deficient transmission and grid connections. This rapid expansion has led to increased demand for a skilled and diverse workforce to support construction, installation, operations, and maintenance of the wind farms, which stimulates the overall economic activity of a region. To meet this demand, it is important to build competencies and train the next generation of specialists in various fields. This requires a long-term strategy and proactive approach that starts early, engaging and educating primary school-aged children to ensure a purpose-driven steady pipeline of talent, capable of supporting the complex and diverse roles needed in the offshore wind industry.

Our purpose here is to explore offshore wind workforce challenges, strategies for mitigation, and ways to maximize the opportunities presented by this rapidly growing sector.

JOB CREATION

The offshore wind industry's nascent stage, coupled with the varying pace of regional development, underscores the importance of global collaboration and knowledge transfer to foster rapid progress. This collaboration drives the establishment of a robust domestic supply chain, creating jobs across multiple sectors, including direct, indirect, and induced employment, thereby contributing to regional economic growth. While most jobs are generated during the production and implementation phases of projects, other long-term sustainable jobs are also needed during the lifetime of the windfarm.

The development of an offshore wind farm has four main phases: DEVEX, CAPEX, OPEX and DECEX.

DEVEX (Development and Permitting) encompasses the preliminary stages of project development, research, and development (R&D), planning, financing, and licensing. All of these require skilled professionals in engineering, environmental studies, financing, regulatory aspects, and project management.

- **Site Selection:** Choosing the most suitable location for the wind farm, considering factors like wind resources, seabed conditions, and environmental impacts.
- **Feasibility Studies:** Assessing the technical, economic, and environmental viability of the project.
- **Permitting:** Obtaining necessary licenses and approvals from relevant authorities.

CAPEX (Capital Expenditure) involves the financial investments required for construction and establishment of the wind farm creating jobs in manufacturing, construction, logistics, and specialized maritime services.

- **Design and Engineering:** Design focuses on the conceptualization and planning of the wind farm system, engineering involves the practical implementation and

optimization of that system resulting in the creation of detailed plans and specifications.

- **Construction:** Building the wind farm components, installing the turbines, laying cables, and constructing onshore substations.

OPEX (Operational Expenditure) focuses on the ongoing costs of running and maintaining the wind farm. It demands a long-term workforce specializing in technical support, monitoring, and repair services.

- **Operation:** Monitoring the performance of the wind farm, ensuring its efficient operation.
- **Maintenance:** Performing routine and preventative maintenance on the turbines and other equipment to ensure their longevity and reliability.

DECEX (Decommissioning) involves the removal or repurpose of the wind farm infrastructure at the end of its lifespan requiring workforce specialized in environmental management and construction.

- **Removal:** disassembling and removing the turbines, foundations, and other components.
- **Repurposing:** exploring options for reusing or recycling materials from the wind farm.

Establishing supply chains should happen concurrently to these phases fostering job creation in manufacturing, transportation, and related tasks. It also should help with the formation of industrial clusters around offshore wind projects stimulating local economies and attracting investment.

To meet the growing demand for offshore wind energy, the industry must address multiple workforce challenges and debunk barriers by investing in education, training, and workforce development programs. Significant challenges include limited workforce; potential workers' lack of necessary skills and qualifications for offshore work, a need for specialized training and education; and inconsistent training standards. Other challenges involve misalignment between worker availability and facility start-ups; attracting and retaining workers, especially in remote locations; competition for skilled workers from other sectors and the need to be up to date on digital/AI tools and cybersecurity.

Workforce shortage can hinder the industry's ability to quickly scale up operations and meet growing demand. Acquiring offshore qualifications and skill takes time. Inconsistent training standards across the offshore wind industry, particularly in areas like fixed offshore wind farm installation aids, lead to challenges in certification and create unnecessary costs and

risks. The lack of uniform practices and standards also results in non-uniform approaches across the industry.

ROBUST WIND WORKFORCE

To build workforce competencies and train the next generation of specialists in various fields, the process should begin by engaging and educating primary school-age children and end with formalized employment agreements between manufacturing facilities, trade organizations and the labor unions. Cultivating a robust offshore wind workforce requires global knowledge transfer (sharing projects' best practices and lessons learned), regional collaborative initiatives, aligning safety training, and creating diverse, inclusive programs that target communities impacted by energy transition, leveraging existing infrastructure and expertise.

It is important to create regional collaborations and industry-academia-government partnerships to align training efforts and ensure a skilled workforce. In many regions, central and local governments have leveraged initiatives that foster partnerships for offshore wind implementation to support equitable job growth and ensure a well-trained workforce. They have also engaged local colleges and unions in developing and implementing training programs to ensure they are relevant to industry needs and accessible to a wide range of individuals.

Key aspects for offshore wind training and skill development involve specialized courses covering safety, technical skills, and project-specific knowledge, as well as broader educational programs. Essential training includes basic safety certifications like GWO Basic Safety Training, which includes modules on working at heights, first aid, fire safety, and sea survival. More advanced training may focus on areas like mechanical, electrical, and hydraulic skills, as well as specialized skills for installation, operations, and maintenance.

Prioritizing and standardizing safety training for offshore wind workers ensure safe operations and minimize risks. This involves developing industry-wide standards, aligning training programs with these standards, and providing comprehensive safety certifications. Leveraging the expertise of workers in related sectors (maritime, oil and gas, shipbuilding) to support the growing offshore wind industry can help address the demand for skilled labor. By recognizing transferable skills and providing targeted training, the transition can be smoother, allowing experienced workers to contribute to the sector.

IMPORTANT PATHWAYS

Establishing apprenticeship and internship programs that provide hands-on experience and equip students with the technical skills needed for offshore wind jobs are important

pathways for young generations to gain the technical skills needed to successfully enter the wind industry. Incentives like tuition reduction, scholarships, and financial support for travel, housing, and childcare can significantly increase participation in training programs, especially for students from disadvantaged backgrounds. Additionally, funding apprenticeships for high school students can create a skilled workforce and a pathway to further education and employment.

While DEI application has faced challenges due to multiple factors, the core principles of building diverse, inclusive, and equitable workplaces remain key for creating an environment where everyone feels respected, valued, and can contribute. A diverse, inclusive, and equitable workforce ensures long-term success in the offshore wind energy industry, as it enhances innovation, adaptability, and resilience. To attract and retain a diverse workforce from communities most impacted by offshore wind development, proactive strategies should focus on creating equitable access to jobs and economic benefits. They also should prioritize diversity, and inclusion initiatives, and actively raising awareness of the available opportunities through targeted outreach and education programs.

Offshore wind development presents a significant opportunity to revitalize and uplift economically and educationally disadvantaged communities by creating jobs, boosting local economies, and strengthening infrastructure. In tandem with this economic revitalization, implementing supplier diversity programs that extend through all levels of the supply chain ensures fair and equitable participation from these communities.

Technological advancements in offshore wind, such as automation and robotics, enhance efficiency and create new job roles. Ports and staging areas are essential for offshore wind projects, offering opportunities for local employment and economic development. Industries like maritime, offshore oil and gas, and shipbuilding are experiencing growth and diversification, creating a broader range of employment opportunities applicable also to offshore wind.

KEY ACTIONS

To build a future-ready offshore wind workforce, key actions include raising awareness of job opportunities, motivating younger generations, fostering collaboration among stakeholders, and embracing innovative technologies. This encompasses targeting recruitment through modern platforms, building partnerships with educational institutions and local organizations, creating accessible pathways for diverse groups to enter the field, and implementing standardized safety certifications and training programs. It also requires investing in education and training, including programs to help individuals transition from

other industries, and promoting diversity and inclusion while prioritizing local hiring and economic development in coastal communities.

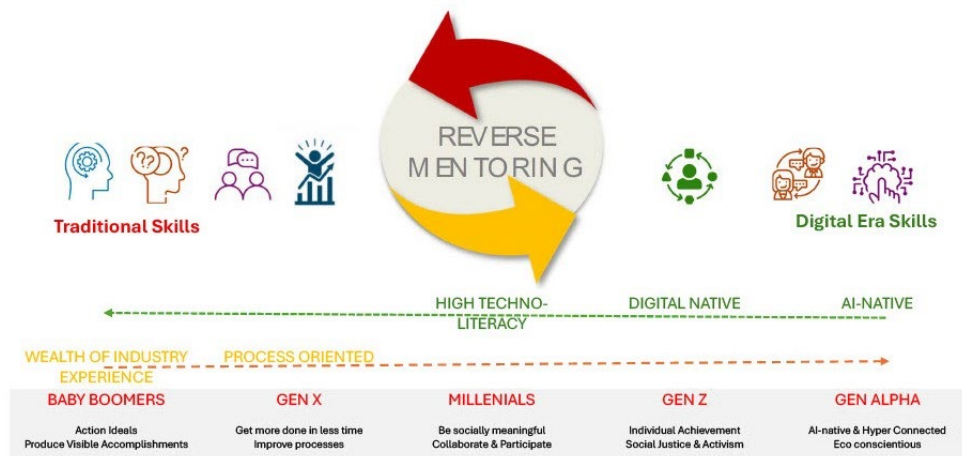
Offshore wind is a manufacturing intensive industry. Manufacturing is evolving to integrate robotics, artificial intelligence (AI) and augmented reality/virtual reality (AR/VR). AI technologies enhance the safety and efficiency of offshore activities by lowering operational costs, creating new job roles, and attracting a young generation of professionals who should leverage AI as a tool rather than viewing it as a threat.

To fuel the growth of the offshore wind industry, substantial investments in infrastructure (ports, transmission, manufacturing yards), domestic manufacturing, and shipbuilding are vital. These investments will support the construction, installation, and ongoing operation of offshore wind projects, while also developing the domestic supply chain and workforce.

LIFE-LONG LEARNING

To stay where you are, you need to focus on your technical acumen, curiosity, communication skills and motivation. **To advance** you need to cultivate the ability to continuously adapt, engage with others in that process, and most importantly retain your core sense of identity and values. **To be ahead** you need to develop your digital capabilities. For students, it is not just about acquiring knowledge, but about how to learn. For the rest of us, we should remember that intellectual complacency is not our friend and that learning – not just new things but new ways of thinking – is a life-long endeavor.

Deep generational dialogue is necessary to guarantee any industry continuity. The application of reverse mentoring, also known as upward mentoring, is a valuable approach where junior employees mentor senior colleagues, in areas where the junior employee possesses expertise, such as digital/AI technology or diversity and inclusion, while junior employees learn from the experience and guidance of senior colleagues.



Along with core knowledge, a future-ready workforce needs a blend of digitalization skills, soft skills (communication, critical thinking), and the ability to effectively collaborate with AI to enhance efficiency, safety, and cybersecurity. The revolutionizing effect of AI applications like predictive maintenance, adaptive modeling, and neural networks analyzing renewable energy data demands a focus on ethical AI implementation, particularly in data governance and model interpretability, alongside a workforce proficient in AI. This requires a blend of theoretical knowledge, practical experience, and continuous learning, all underpinned by a strong mathematical foundation. Increased reliance on digital systems makes businesses and critical infrastructure vulnerable to cyberattacks, data breaches, and other security threats requiring a robust cybersecurity strategy and a "cyber-ready" workforce trained in identifying, preventing, and responding to these threats.

TRANSFERABLE SKILLS

Offshore wind engineering draws upon a wide range of disciplines, including naval architecture, structural, mechanical, electrical, civil, marine, geotechnical, environmental engineering, and project management. Transferable skills from similar industries are highly valuable in the growing offshore wind sector. Engineers familiar with subsea systems, power generation, or platform integrity can bring their expertise directly into this field. For those skilled in hands-on maintenance and troubleshooting, roles as technicians are a natural fit.

According to research by Offshore Energies UK, approximately 90% of oil and gas industry workers possess skills transferable to offshore wind roles.

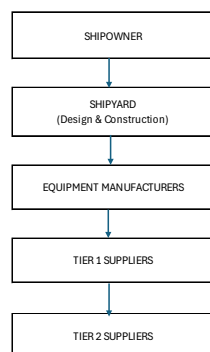
- **Project Management:** offshore wind projects are complex, requiring strong project management skills to coordinate various tasks, timelines, and resources.
- **Health, Safety, and Environmental (HSE) Knowledge:** working in an offshore environment requires a strong understanding of HSE regulations and practices.
- **Technical Expertise:** experience with offshore operations, mechanical systems, and electrical infrastructure is valuable.
- **Problem-Solving and Adaptability:** unforeseen challenges can arise in offshore environments, requiring quick thinking and critical thinking skills.
- **Leadership and Management:** leading teams in a challenging environment requires strong leadership and management skills.
- **Communication Skills:** effective communication is vital for coordinating with various stakeholders, both internal and external.
- **Offshore-Relevant Behavioral Skills:** experience working in remote or challenging environments, like offshore, can be a significant asset.

- **High Voltage Electrical Skills:** many offshore wind jobs require expertise in high voltage electrical systems.
- **Logistics and Supply Chain Management:** ensuring the timely delivery of materials and equipment to offshore sites requires strong logistics and supply chain management skills.
- **Regulatory Understanding and Compliance:** navigating the complex regulatory landscape of the offshore wind industry requires a thorough understanding of regulations and compliance procedures.
- **Analytical and Technical Skills:** skills in analyzing data, understanding technical specifications, and applying them in a renewable energy context are highly valuable.
- **Cultural Awareness:** experience working in diverse cultures, especially in Asia, can be an asset in the global offshore wind industry.
- **Mechanical Skills:** experience with mechanical systems and equipment is essential for maintaining and repairing wind turbines.
- **Physical Stamina and Strength:** working in an offshore environment can be physically demanding, requiring an elevated level of physical stamina and strength.
- **Troubleshooting Skills:** the ability to diagnose and resolve technical issues quickly and efficiently is decisive.
- **Comfort with Heights and Confined Spaces:** many offshore wind jobs require working at heights and in confined spaces, so comfort with these environments is essential.
- **Digital Acumen:** the ability to effectively utilize digital technologies like digital twins, AI, and advanced analytics to optimize performance, reduce costs, and enhance safety.

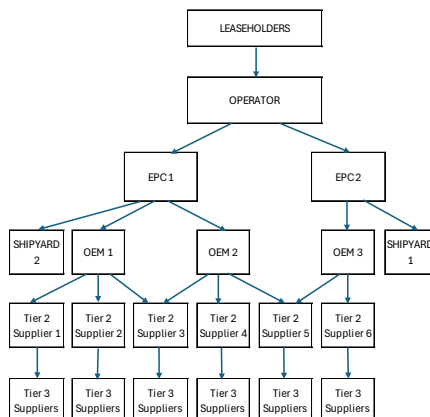
Non-transferable skills are those specific to the unique challenges and technologies of this sector, such as experience with offshore wind components, installation, and operation. While most of the elements are based on oil and gas components they differ in their composition and operation.

To understand transferable skills, it is important to understand the key differences. The maritime/shipbuilding, offshore oil and gas (O&G), and offshore wind industries differ significantly in their core activities, production methods, and focus. Maritime/Shipbuilding primarily involves the design, construction, and operation of ships at sea, seldom in serial production (sister vessels). Offshore O&G focuses on fossil fuel extraction, typically involving one-off asset design and construction, with some potential for similar unit replication. Offshore wind, on the other hand, centers on renewable energy generation, requiring one-time asset design followed by mass serial production of many units for financial viability. The contracting models and project development processes in each of these industries are significantly different, reflecting their unique needs and complexities as shown in the graphic below a simplified version for construction.

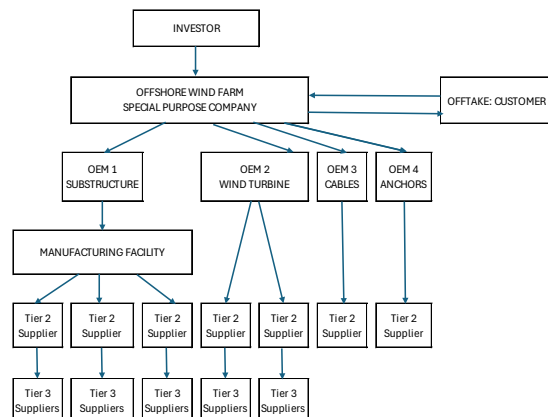
SHIP CONSTRUCTION



O&G ASSET CONSTRUCTION



OFFSHORE WIND FARM CONSTRUCTION



SUCCESSFUL EFFORTS

Naval architects and marine engineers play a key role in offshore wind by designing and engineering bottom fixed and floating structures that support wind turbines in the ocean ensuring their ability to withstand harsh marine environments. Other specific roles are wind turbine engineers (design, build, and oversee the construction of wind farms), electrical engineers (design and install electrical systems for turbines and grids), mechanical engineers (turbine components design and manufacture), civil engineers (infrastructure design and construction). Also included are installation crews (platers, welders, quality controllers, and coating specialists), maintenance crews (wind technicians, plant managers), service and operations vessels crews.

In Europe, a well-regarded option is the European Wind Energy Master (EWEM), a joint master's program involving multiple universities, including Delft University of Technology, Technical University of Denmark, Norwegian University of Science and Technology, and Carl von Ossietzky University of Oldenburg. Poland's Gdynia Maritime University offers an Executive MBA in offshore wind while the Gdansk University of Technology offers post-graduate studies. The European Wind Academy, DNV, OffTEC, and OEG Renewables offer offshore wind basic safety training and specialized technical training. OffshoreWind4Kids is a non-profit organization that focuses on engaging and empowering kids with hands-on programs to discover the science and technology behind clean energy solutions.

In the U.S., there are graduate programs at Tufts University, University of Massachusetts Amherst, the University of Rhode Island, Stony Brook University, and the University of New Orleans. Other organizations that offer training and education at various levels are the Oceanic Network, American OW Academy, NYSERDA and NREL. The Oceanic Network's Industry Education team provides training and education to help U.S. companies enter the offshore wind supply chain. They have trained nearly 4,000 participants in the last three

years and offer coaching and mentoring programs to assist businesses individually in navigating and entering the industry.

The American Offshore Wind Academy (AOWA) is an industry-led institution focused on delivering specialized technical and professional training to upskill the workforce and support sector growth across more than fifty specialties. Through a combination of virtual courses, in-person workshops, and expert-led recorded lessons, AOWA equips individuals, organizations, and government entities with essential expertise to succeed in the offshore wind sector. NYSERDA (New York State Energy Research and Development Authority) has created interactive lessons designed to educate middle- and high-school students about the basics of offshore wind. NREL's Wind Webinar Series provides a good overview of floating and fixed-bottom wind technologies.

In Japan, a number of schools have research organizations specializing in offshore wind power that are developing the technology and training professional engineers. These include Kyushu University, the University of Tokyo, Osaka University, Yokohama National University, Tokyo University of Marine Science and Technology, Nagasaki University, Akita University, Chiba University, and the University of Kitakyushu. In addition, there are eleven training centers that issue GWO certificates to operators, including the Nippon Foundation Center for Human Resource Development in Offshore Wind. Industry-academia partnerships include the Research and Education Center for Offshore Wind, Kyushu University, the Industry-Academia Consortium for Higher Education Program on Offshore Wind, and the Industry-Academia Consortium for Higher Education Program on Offshore Wind (ECOWIND), an industry-government collaboration.

Brazil has taken proactive steps to prepare its workforce for the offshore wind sector by leveraging the expertise of institutions historically rooted in offshore oil and gas. Two of the country's premier engineering universities, the Federal University of Rio de Janeiro (UFRJ) and the University of São Paulo (USP), have launched initiatives to retrain professionals from the offshore energy sector and adapt their graduate and extension programs to offshore wind competencies. A notable success is the creation of the GERO Group (Grupo de Estudos em Regulação do Offshore) at UFRJ, which promotes interdisciplinary research and training focused on regulatory frameworks and sustainable offshore development. Additionally, the Instituto Brasileiro de Petróleo e Offshore has expanded its mission to include offshore wind, creating a vital platform for professional training and industry engagement. The Brazilian Society of Naval Engineering also plays a key role in this transition by organizing conferences, technical committees, and publications that support knowledge exchange and capacity building in offshore renewables.

Developing a future-ready workforce for the offshore wind industry requires a multifaceted approach focusing on outreach, education, training, recruitment, retention, and upskilling.

This necessitates collaboration among industry stakeholders, government agencies, and educational institutions. By focusing on these key areas and implementing bold initiatives, the offshore wind industry can develop a strong, engaged and diverse workforce that is ready to meet the challenges and opportunities of the future.

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