Global Wind Workforce Outlook

2023 - 2027

GWEC
GLOBAL WIND ENERGY COUNCIL

GLOBAL WIND ORGANISATION

Table of Contents

Copyright © October 2023
This document contains forward-looking statements. These statements are based on current views, expectations, assumptions and information of the Authors (GWEC & GWO). The authors and their employees and representatives do not guarantee the accuracy of the data or conclusions of this work. They are not responsible for any adverse effects, loss or damage in any way resulting from this work.

Authors
Andrea Scassola (GWO)

Ian Buckland(GWO)

Joyce Lee (GWEC)

Feng Zhao (GWEC)

Anjali Lathigara (GWEC)

Permissions and Usage:

This work is subject to copyright. Its content may be reproduced in part for non- commercial purposes, with full attribution.

Design:
Aspire Design, India

Publication Date:
11 October 2023

Foreword

Ben Backwell, CEO,
Global Wind Energy Council

Jakob Lau Holst, CEO,
Global Wind Organisation

The last few years have exposed new dimensions and vulnerabilities of the global energy system.

Climate change is manifesting with more severity than ever, and the current global energy crisis has made it abundantly clear the world must transition to a secure and resilient renewables-based energy system.

Wind energy is at the heart of the energy transition. Under the International Renewable Energy Agency's 1.5°C Scenario, cumulative global renewable energy capacity must triple by 2030, with wind capacity scaling by nearly four times to more than 3,500GW by the end of the decade. Wind energy already provides affordable, zero-carbon electricity to power economies, revitalise local communities and drive sustainable development. Large-scale wind projects reduce reliance on imported and volatile fossil fuels, and create a diverse value chain of job opportunities, from paper concept to generating power over the course of an average 25-year asset lifetime.

The GWO/GWEC Global Wind Workforce Outlook 2023-2027 is the fourth edition of our joint work highlighting the workforce development required to meet the forecast global expansion of the industry, highlighting in particular, wind technicians who construct, install, operate and maintain wind assets.

This report, published in the context of wind supply chain challenges experienced in regions around the world amid rising costs and an inflationary environment, focuses on the enormous socioeconomic value and transformative job creation opportunities brought by wind power to countries around the world.

It also reminds us that for the industry to grow sustainably, a rapidly expanding workforce must be afforded access to training according to industry best practice, so they can work safely and return home to their families.

As a global industry, we rely heavily on cooperation between stakeholders from different countries, so it is necessary to work with a system that recognises standards wherever possible.

That combined narrative of workforce development and the need for a collaborative approach is achieved through a unique combination of inputs. GWEC Market Intelligence global onshore and offshore wind outlook, aligned with GWO's Workforce Forecasting Model, continues and refines our understanding of the task ahead:

More than 574,000 technicians will be needed to construct, install, operate and maintain the world's rapidly growing wind fleet by 2027. The report reveals:

- The wind workforce will grow faster offshore (+79%) than onshore (+12%) from 2022-2027.
- More than 400,000 people needed for C&I and O&M could receive industry standard training in the next five years.
- As the industry matures, the gap between numbers of technicians working in construction and installation versus operations and maintenance will reduce. By 2027, O&M technicians will make up 46% of the projected workforce in 2027 from 42% in 2023.
- Increases in turbine ratings will result in a lower number of people working on a per MW basis, particularly offshore.

As global industry associations, GWO and GWEC play a role in the employment process value chain, which also involves employers, investors, policymakers and regulators to name a few stakeholders.

We hope that this report will support stakeholders in the growing wind energy industry by providing visibility of the varied opportunities available to foster workforce development and for the wind industry to contribute to climate resilient growth around the world.

Chapter 1:
Executive Summary

There is widening consensus that wind and other forms of renewable energy are the solutions to the most defining challenge of our generation – climate change. This is reflected in rising government ambition and public rallying calls for wind energy capacity across the globe.

In 2023, the wind industry passed the milestone of 1TW of installed wind capacity globally, and we are on-track to install another TW within this decade. This fast-paced growth indicates an urgent need for a skilled and trained workforce ready to deploy for the forecast installations ahead, and to safely operate and maintain an expanding wind fleet in countries around the world.

As the fourth edition of this report series advocating for the job creation opportunities in the wind sector, the Global Wind Workforce Outlook 2023-2027 outlines the near-term demand for trained and certified technicians for construction, installation (C&I), operation and maintenance (O&M) of wind farms.

This year's report seeks to answer three fundamental questions:

1. How many technicians will require wind industry standard training for the construction and installation and operation and maintenance of wind assets?

2. What is the gap between the level of penetration for GWO industry-standard training that is currently available and the level that would be required to train the forecast workforce out to 2027?

3. Where are the biggest opportunities for educators and training providers to enhance the wind workforce?

The outlook builds upon GWO's Workforce Forecasting Model and leverages GWEC's Global Wind Market Intelligence as the primary inputs to determine the volume of technicians and skilled workers required for the C&I and O&M segments of the value chain across global onshore and offshore wind from 2023 to 2027.[1]

We note that this model does not include calculations of workforce needs in other segments of the project lifecycle, such as research and development, procurement, manufacturing (the most labour-intensive segment in certain markets), transport and logistics, decommissioning and repowering, etc.

The report's outlook for training needs is therefore just a fraction of the expansive job opportunities which will be generated by the growth of wind energy worldwide.

Annual wind capacity additions around the world are projected to double from 78GW in 2022 to 155 GW in 2027, according to GWEC Market Intelligence. By the end of 2027, the cumulative worldwide operational wind fleet is poised to exceed 1,500 GW, more than double the level attained prior to the COVID-19 pandemic.

As wind power expands, a well-trained wind technician workforce is needed to install new turbines and maintain the operational fleet. This gives opportunities for job creation for local and national governments that foster renewable energy as a driver for socioeconomic development, and for training providers looking to expand their activities towards developed and emerging economies.

In the coming years, it is expected that the number of technicians in the C&I segment will increase by 9% from 286,200 people (253,200 onshore, 33,000 offshore) in 2022 to 311,100 (256,000 onshore, 55,100 offshore) in 2027. Similarly, the total number of O&M technicians is expected to grow 29% from 203,400 people in 2022 to 263,100 in 2027, driven by a larger operational fleet.

Nearly 600,000 skilled workers will be required to construct, install, operate and maintain the global wind fleet by 2027 alone. Overall forecasts suggest an increase of at least 17% for required new qualified personnel every year in the C&I and O&M segments, growing

1 See Methodology section at the end of this report.

the total number of skilled workers from 489,600 people in 2022 to 574,175 in 2027. Driven by increases in MW capacity and associated attrition, as employees exit the sector, almost 43% of the 574,200 technician workforce will need to be recruited between 2023 - 2027 (see analysis on page 12). Analysis finds that workforce needs will grow more rapidly offshore, increasing 79% from 2022 to 2027 compared to 12% onshore within the same timeframe. However, while offshore wind technicians will gain share over the next five years, by 2026 87% of the technicians will still be located onshore.

In particular, this report examines the policy and workforce outlook for 10 countries where wind power is on the rise: the United States, China (excluding Taiwan), Australia, South Korea, India, Japan and Brazil, Colombia, Kenya and Egypt. These markets represent 73% (490GW) of all new onshore and offshore wind capacity additions expected worldwide over the five-year forecast period. Training needs in these 10 countries constitute 67% of the total number of C&I and O&M technicians in 2027 and 75% of the total training development potential projected over the next five years.

As the wind industry continues to innovate, more efficient and higher average rating onshore turbines will reduce the number of technicians needed on a per-MW basis. In the case of offshore wind, with the likelihood of larger projects deploying higher-rated turbines much further offshore, a higher number of O&M technicians are expected to be deployed permanently on-site to address any risks.

Further support on skills and training standardisation from industry and adoption of GWO standards will help to support personal and operational risk mitigation through deployment of certified workers. Skilling and certification will also enable greater job mobility for individuals to move across companies and regions in the wind sector.

Meeting global wind power ambitions must be backed by a strong culture of health and safety, a skilled workforce and an efficient supply chain. Government and industry-led initiatives for training and certification are a win-win, both advancing socioeconomic opportunities and enabling safety and stable growth of the wind industry. As reflected by the significant training needs ahead, the wind energy workforce will be a key actor in supporting a just and equitable energy transition away from fossil fuels, and ensuring workers and communities have a place in a modern, sustainable and renewables-based economy.

Figure 1 - Forecast Capacity Installations and Number of People Requiring C&I and O&M Training from 2023-2027

Country	Onshore Wind		Offshore Wind		Total
	Installations (MW)	Training Needs (# of technicians)	Installations (MW)	Training Needs (# of technicians)	People
Australia	7,625	6,624	0	0	6,624
Brazil	16,000	12,308	0	0	12,308
China	300,000	219,622	64,000	29,693	249,315
Colombia	2,250	694	0	0	694
Egypt	3,550	3,017	0	0	3,017
India	21,300	27,653	20	697	28,350
Japan	3,800	3,355	848	1,758	5,113
Kenya	550	574	0	0	574
South Korea	1,000	820	2,299	1,630	2,450
USA	55,000	71,742	11,858	5,751	77,493
Total Ten Countries	**411,075**	**346,409**	**79,025**	**39,529**	**385,938**
Global	**551,475**	**499,481**	**123,018**	**74,694**	**574,175**

Source: GWO, GWEC 2023

Fig 2 - Forecast Number of People Requiring C & I and O & M Training to meet Wind Energy Growth as of the End of 2027. (Additional C&I and O&M Wind Technicians Requiring Training from 2023- 2027)

Global Total
574,175

Chapter 2:
Safety Training Standards and Growing Demand for Training

As wind industry growth accelerates and its workforce becomes increasingly mobile, being able to transfer safety training certifications across companies and countries becomes a key enabler of industry scalability and international growth.

The Benefits of Standardisation

The global wind industry collaborates, through GWO, setting internationally recognised standards which address the most common risks and hazards faced by technicians in their work. This results in reduced complexity, removal of duplication and increased productivity for the wind technician workforce over the long term. Third-party certification of GWO training assures quality, and enables participants and their employers to verify when wind technicians are appropriately trained.

How are Training Standards Developed?

GWO training standards are the product of collaboration between HSE and training experts representing the world's largest wind industry employers. They pool knowledge and data on risks and hazards in the wind turbine environment, prioritising the creation of training standards that will have a meaningful impact on the safety of the widest possible cohort of wind turbine technicians. Inclusive design processes ensure training standards are fit for purpose.

The GWO Training Standards Portfolio

In 2023, the GWO standards portfolio consists of 16 standards divided into 27 modules. Some of the standards introduce enduring skills that technicians practice every day at work, while other skills that are not used on a daily basis (such as practising first aid or rescuing an injured person from the nacelle to the ground) must be refreshed regularly.

In 2022, global duty-holders have aligned descriptions for entry-level job profiles for wind technicians, and agreed on skills, knowledge and abilities that can be acquired through a training pathway towards employment known as the GWO Entry Level Framework. This combination of GWO courses for entry-level job profiles includes GWO Basic Technical Training and GWO Basic Safety Training plus a variety of additional courses specific to the task, site and employer.

The Global Community of Training Providers

Currently, standards are recognised and used in more than 50 countries, and can be accessed at more than 540 training centres certified to deliver GWO courses. The course certificates (training records) are owned by the individual wind technician, and can be verified in an online global training records database, establishing a mechanism for transparency and accountability for safety across the supply chain and all teams working on a given site.

Growing Demand for Wind Safety Training

During 2022 the most frequently trained GWO modules were Working at Heights (WAH), Manual Handling (MH), Fire Awareness (FAW) and First Aid (FA), all of which are part of the Basic Safety Training (BST) Standard and must be refreshed at intervals. The number of wind technicians worldwide with an active GWO certificate in at least one of the GWO modules almost doubled from around 79,000 in the first half of 2019 to around 156,400 in the first half of 2023, signalling a strong expansion of wind power and trained workforce needs. The number of technicians who will need GWO training is set to increase 17% from 2022 to 2027, which in turn requires scaling up training providers and educational facilities in wind markets worldwide.

Chapter 3:
Wind Workforce Forecasts and Dynamics

As global installed wind capacity is set to grow by 74% from 906GW in 2022 to 1,581GW in 2027[2], a skilled workforce is needed to install and maintain the global wind fleet. Training providers and educators have a significant opportunity to ramp up delivery of skilled personnel training.

Defining the Workforce Forecast

During the past two years, GWO has worked to develop a model that forecasts the growth in the number of wind technicians over a five-year horizon. The model's latest update is configured to use GWEC's global wind market forecasts as its primary input and focus on the total number of wind technicians involved in the C&I and O&M of the onshore and offshore wind capacity installed globally each year from 2022 to 2027. The results reflect the number of wind technicians that will work in the phases of C&I and O&M each year from 2022 to 2027. The annual numbers can also be viewed as representing the total number of persons, who will need to receive training to acquire or refresh their safety and technical skills during the outlook period.

The forecasts include pre-assembly work for offshore C&I. However, they exclude the workforce from other segments of the wind project lifecycle, such as research and development, procurement, manufacturing (traditionally the most labour-intensive segment in certain markets), transport, decommissioning and repowering. The wider workforce throughout the wind value chain is therefore larger than the workforce eligible for GWO training identified in this report.

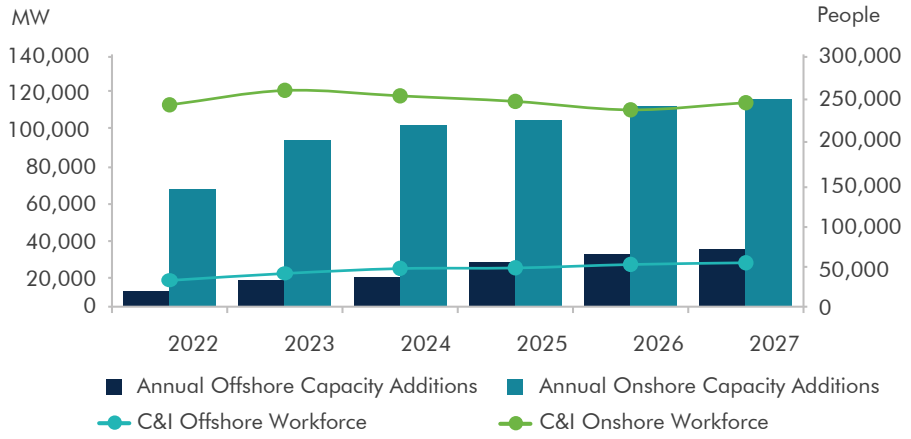
The impact of refresher courses is not considered in the workforce forecasts but represents an additional opportunity for training providers and educators.

Different Project Phases, Different Workforce Patterns

Growth dynamics in workforce demand can be radically different across C&I and O&M. Since demand for maintenance has a linear relationship with the size of the installed fleet, O&M employment has a steady growth profile and proves resilient to year-over-year fluctuations in installed volumes. By contrast, demand for C&I activity is volatile by nature, as relevant employment patterns vary alongside annual installations.

While investment in new capacity requires intense C&I activity and has a substantial impact on employment during the early years of industry development, demand for O&M work starts to grow slowly but gains traction as the installed base becomes more significant. Importantly, both C&I and O&M require a significant base of locally employed wind technicians, which requires planning for local recruitment and supply of training. The volume of wind technicians deployed locally also helps to deliver socioeconomic benefits to the communities hosting wind projects and related infrastructure and facilities, and may provide a

Figure 3 - Global Wind Capacity Additions and C&I Technician Workforce



Source: GWO, GWEC 2023

2 Global Wind Energy Outlook, Q1 2023 Market Outlook

response to the potential displacement of workers from sunset industries associated with the fossil fuels sector.

Given that the number of technicians required for the C&I of larger turbines does not deviate significantly from the headcount needed for the installation of turbines with lower power rating, annual gains in turbine rating result in a lower number of turbines and thus in a lower workforce requirement on a per-MW basis throughout the outlook period (see Methodology section at the end of this report).

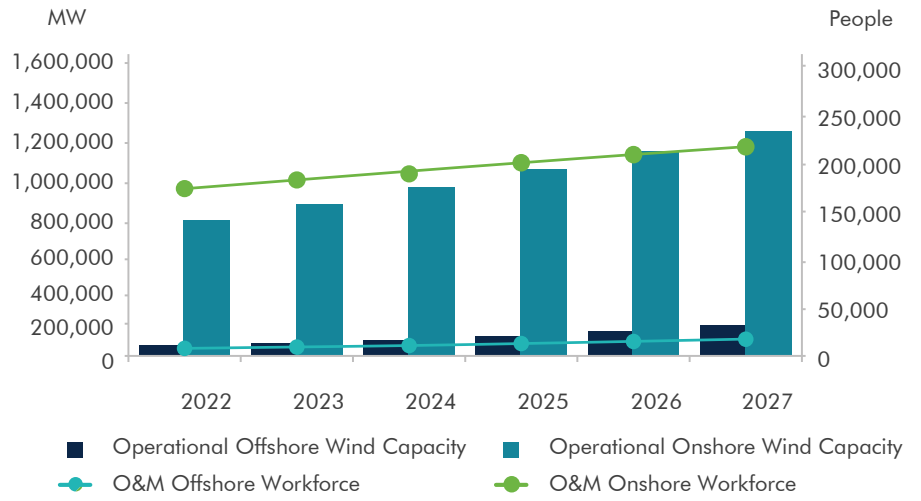
These efficiency gains will occur across sectors but will have a more material impact offshore than onshore due to the rating increase in terms of MW nameplate capacity. GWO expects the number of C&I technicians to increase, driven mostly by the addition of new turbines, growing from 286,200 people (253,200 onshore, 33,000 offshore) in 2022 to 311,100 (256,000 onshore, 55,100 offshore) in 2027.

As far as O&M is concerned, GWO expects the reduction in the number of turbines to drive more operational efficiency gains onshore. Logistics play a key role in defining offshore O&M strategies. In principle, a lower number of turbines in a wind farm should increase technicians' productivity and result in a sharp drop of people per MW. However, as offshore turbine rating increases, so does the impact of turbine failure, and operators seek to mitigate this risk by securing a permanent presence of technicians on site. Thus, as turbine rating increases, and projects become larger and are located further offshore, operators increasingly opt for offshore-based O&M strategies, which typically require a higher number of technicians per turbine. A relatively small wind farm located up to 30km from shore would allow for onshore-based O&M strategies making use of crew transfer vessels (CTVs). Larger plants, even more so if located further away from shore (i.e. >40 km), require permanent on-site availability of a substantial number of technicians, and thus are better serviced via service operation vessels (SOVs) or accommodation platforms (APs). The total capacity of the platforms or the vessels used to maintain a single wind farm works as a reliable indicator of the workforce that needs to be readily available for O&M activity (see Methodology section at the end of this report).

Data extracted across around 50 offshore wind projects show that the O&M technician workforce tends to be lower on a per-turbine basis for wind farms that adopt an onshore-based strategy than for wind farms that employ SOVs or APs. Estimates range from 0.3 to 0.6 people/turbine for smaller wind farms located less than 30km away from shore to 0.7 to 1.5 people/turbine for wind farms that are larger in size or located >40km away.

GWO expects the total number of O&M technicians to grow 29% from 203,400 people in 2022 to 263,100 in 2027, driven by a larger operational fleet. Efficiency gains - driven primarily by technology factors such as higher average turbine ratings - will be visible onshore, reducing the number of technicians needed on a per-MW basis. The number of onshore O&M technicians is expected to grow 25% from 194,600 people in 2022 to 243,500 people in 2027. Offshore, a lower number of machines will prompt asset owners to secure a substantial presence of personnel on site, partly offsetting the efficiency gains achieved through higher rating. GWO expects the number of offshore O&M technicians to grow 122% from 8,800 in 2022 to 19,600 in 2027.

Figure 4 - Global Operational Wind Capacity and O&M Technician Workforce



Source: GWO, GWEC 2023

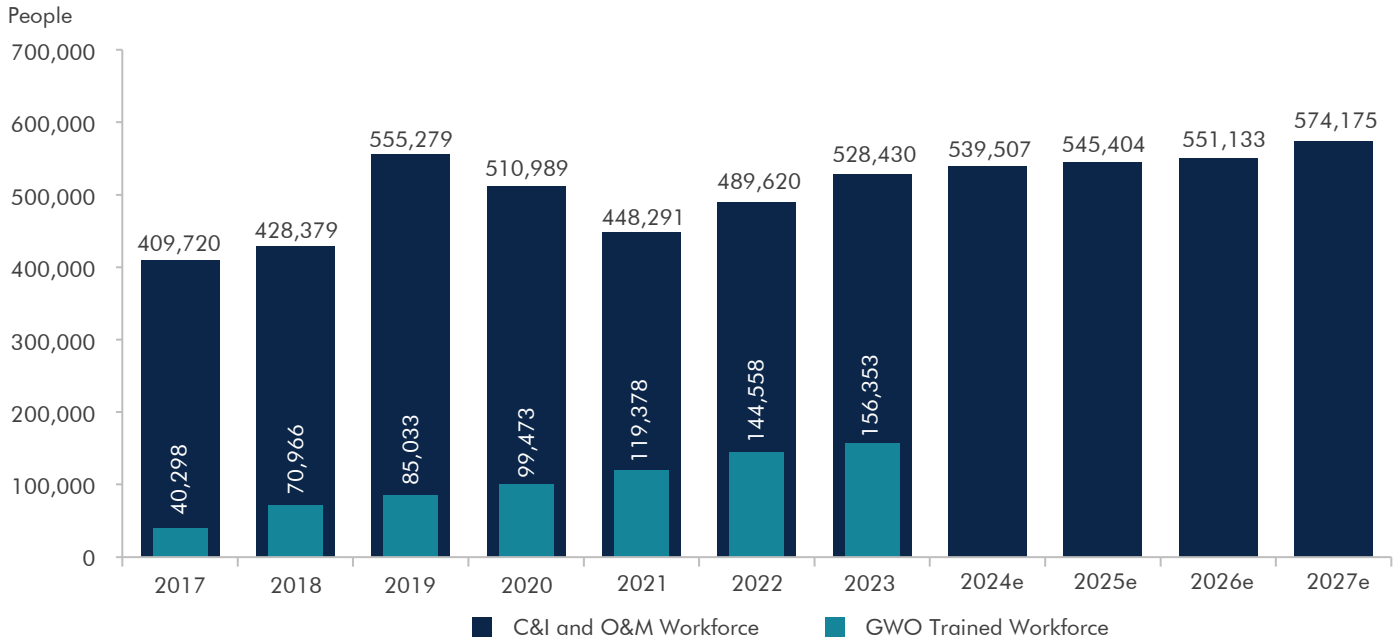
Chapter 4: Global Wind Workforce Outlook, 2022-2026

Drawing from GWEC's wind capacity forecasts and wind project records, the workforce model uses data and assumptions that help estimate the size and forecast the growth of the total number of technicians over a five-year forecast period.

The volume of expected C&I and O&M activity will require new qualified personnel every year, growing the total number of technicians in these segments from 489,600 people in 2022 to 574,175 in 2027.

This represents a call to action for the industry to collaborate with educators and governments to ensure that energy transition ambitions are aligned with workforce planning on a national and sub-national scale, and a strategy is in place to establish local education and training centres to target the recruitment and training of local workforces.

Figure 5 - The GWO Trained Workforce and the Total Number of Technicians Needed in the C&I and O&M Segments



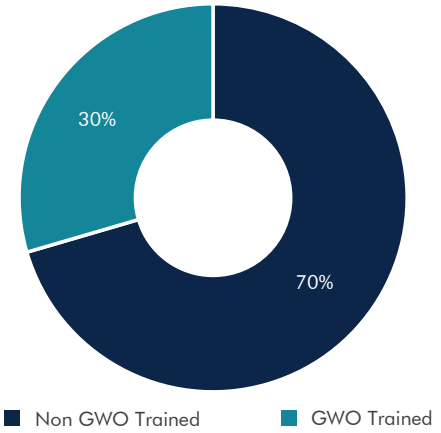
Source: GWO, GWEC 2023

As of the end of 2022, 145,000 people held at least one valid training certificate in the BST Standard. This means that GWO training covered 30% of the total number of technicians estimated globally.

This share is estimated to have remained stable as of the first half of 2023, when active BST certificate holders amounted to 156,400 against a total number of technicians in the C&I and O&M segments estimated at 528,400 people. Increasing the accessibility and use of globally recognised training will be crucial to facilitate technicians' mobility and minimize the need for retraining.

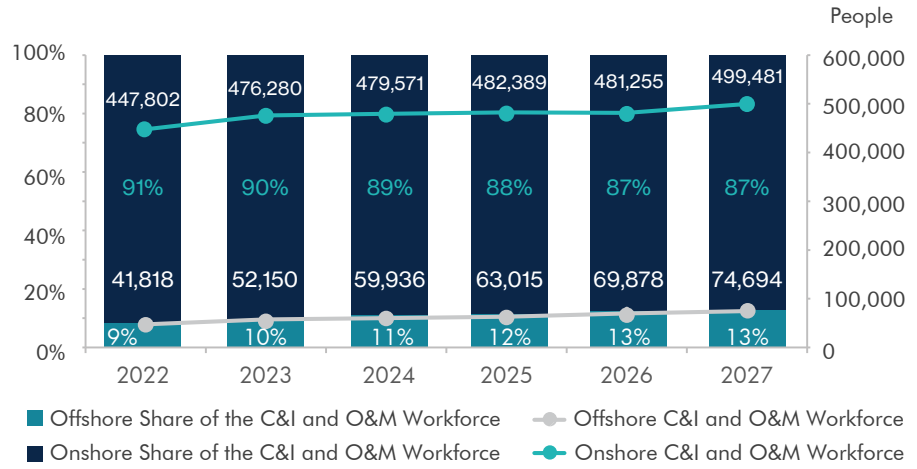
The analysis expects the total number of technicians to grow more rapidly offshore, increasing 79% from 2022 to 2027 compared to 12% onshore within the same timeframe. However, while offshore wind technicians will gain share over the next five years, by 2027 87% of the technicians will still be located onshore.

Figure 6 - Share of the Total Estimated Number of Technicians Needed for C&I and O&M in 2022



Source: GWO, GWEC 2023

Figure 7 - Annual C&I and O&M Workforce Forecasts, Onshore and Offshore

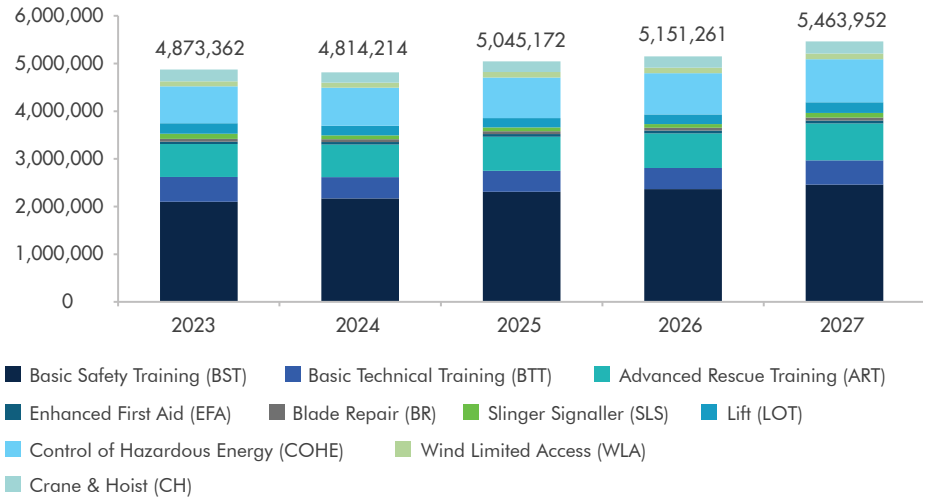


Source: GWO, GWEC 2023

Based on the annual C&I and O&M workforce forecasts for onshore and offshore, the potential demand for wind technicians training is projected to grow from 4.9 million modules in 2023 to 5.5 million modules in 2027. See the Methodology section for further information on the scope of training and application.

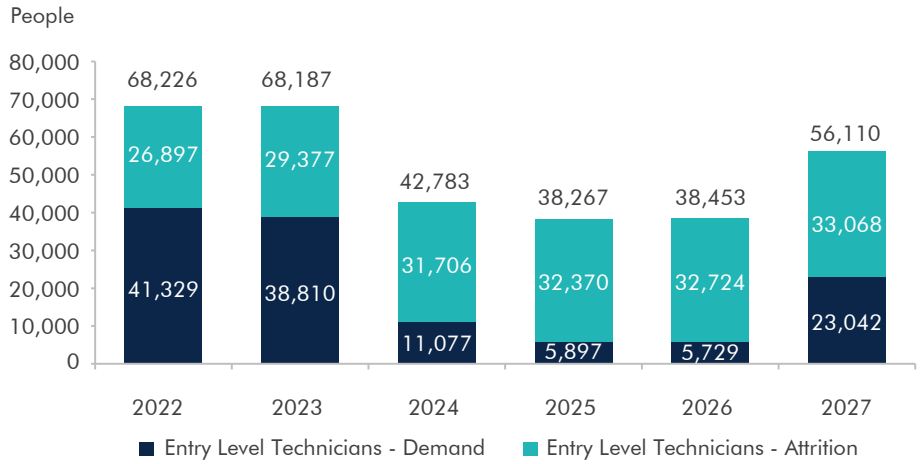
Demand for wind power will drive the need for C&I and O&M workforce for a total of 84,600 entry level technicians during the 2023-2027 period, averaging 16,900 entry-level technicians every year, globally. **Assuming an annual attrition rate of 6% within the existing population of technicians, entry level technicians are estimated to be 243,800 in from 2023 to 2027, growing at an average of 48,800 people every year, globally.**

Figure 8 - Forecast Necessary GWO Training Modules



Source: GWO, GWEC 2023

Figure 9 - Entry Level C&I and O&M Workforce Needed Each Year



Source: GWO, GWEC 2023

Chapter 5:
Country Commentaries

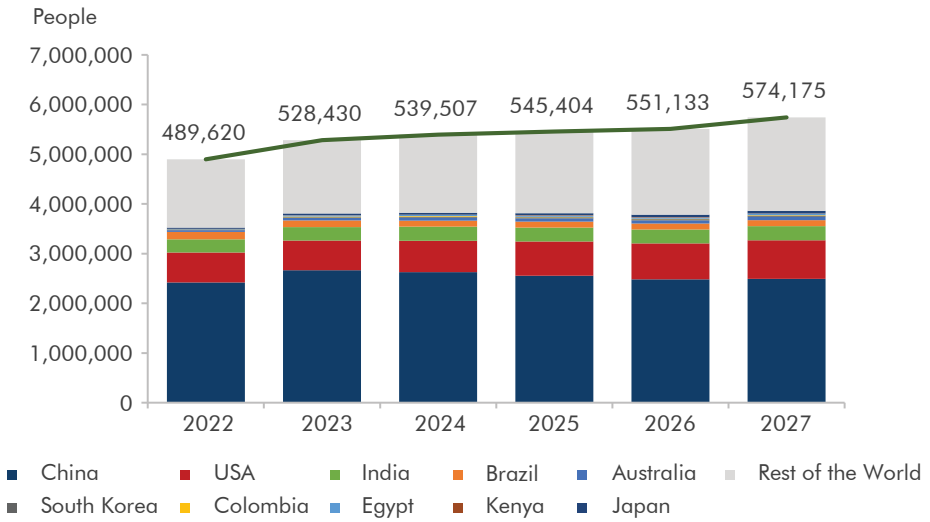
In addition to the global wind workforce forecast for training needs in the C&I and O&M segments, this report also analyses the training needs specific to ten selected countries: China, USA, India, Brazil, Japan, South Korea and emerging wind markets of Australia, Colombia, Egypt and Kenya.

These countries were selected for regional diversity and market growth: Combined, they represent 73% (490GW) of all new onshore and offshore wind capacity additions expected worldwide from 2023 to 2027.

Together, the training needs in these ten countries account for approximately 67% of the total number of C&I and O&M technicians in 2026 and 75% of the total training development potential projected over the next five years.

GWO training providers and educators can potentially extend training to an additional 429,600 people globally from 2023 to 2027.

Figure 10 - Trained C&I and O&M Technicians Needed in Selected Wind Power Countries



Source: GWO, GWEC 2023

Australia

The Federal Government of Australia is supportive of onshore and offshore wind development. It has committed to a 43% emissions reduction by 2030 and to net zero by 2050. While there are no federal wind targets, the Victoria State Government decided to provide offshore wind business case certainty to investors by setting a target of 2GW offshore wind generation by 2032, 4GW by 2035 and 9GW by 2040. The newly elected New South Wales State Government is still considering to introduce state offshore wind target for its Hunter Valley and Illawarra zones.

In 2022, Australia installed 1.4GW of new onshore wind capacity which takes total wind installed capacity to 10.5GW. The total capacity of shovel-ready onshore wind projects at the start of 2023 was close to 4GW. Based on announced project commissioning dates and GWEC Market Intelligence forecasts, annual installations will surge from 2024 with more than 3GW of onshore wind expected to be connected before 2026. Growth momentum is likely to continue beyond 2025 because first; more states have rolled out renewable tenders and zones to replace coal plants due to retire. Secondly, strong corporate PPA market driven by sustainability goals and mining and heavy industries committing for usage of captive renewables and green hydrogen. Lastly, several transmission projects, such as Project EnergyConnect, VNI West and Marinus Link, are either approved or under construction.

To encourage the Australian offshore wind sector in August 2022, the federal government announced the establishment of several offshore wind zones around the country (Gippsland, Hunter Valley, Illawarra, Portland, Northern Tasmania, Perth, and Bunbury). Similarly, Victoria set up a one-stop-shop agency called Offshore Wind Energy Victoria (OWEV) for offshore wind procurement, transmission, ports, policy, workforce development, legislation, and reform. The initial feasibility licence application for the Gippsland zone (to be awarded before the end of 2023) attracted 37 applications after consultations. Applications activity increased during 2023 as two other consultations were launched in the Hunter and Southern Ocean Regions in February 2023 and June 2023, respectively. The State of Western Australia is expected to be considered in the next tranche of consultations.

Although being relatively new to the offshore wind space, Australia is politically

committed to adopting best practice for offshore renewable energy through forward-looking regulations, competitive license process and flexible frameworks published last year. These include the Offshore Electricity Infrastructure Act 2021 (OEI Act for activities in Commonwealth waters), Offshore Electricity Infrastructure Regulations 2022, Offshore Electricity Infrastructure (Regulatory Levies) Regulations 2022 and Cost Recovery Implementation Statement (CRIS). Australia has committed to Global Offshore Wind Alliance at COP27, as part a demonstration of its own ambition and to encourage other countries to explore offshore wind opportunities.

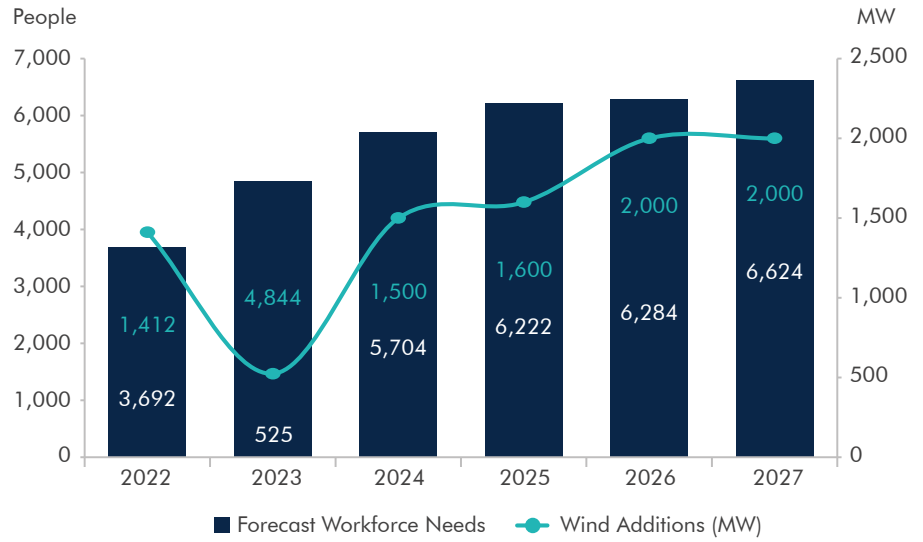
Unlocking the full offshore wind potential will require Australia to consider a number of challenges, common to other emerging markets, over the next two years to ensure timely projects commissioning. These include: grid connections, port infrastructure, access to vessels, workforce development (including skills development training) and investing in supply chain capacity development.

In addition to offshore wind, renewable hydrogen production is at the centre of country's global decarbonisation strategies. Its National Hydrogen Strategy has a vision to be at the forefront of green hydrogen production through renewables and export, the Queensland State Government has launched the Hydrogen Industry Workforce Development Roadmap 2022-2032.

Workforce Training Needs

The number of active GWO certified training centres in Australia grew significantly from two in 2018 to 13 in 2023, successfully addressing the training needs of a rapidly growing wind workforce. By the end of 2022, 2,600 people were certified in at least one valid BST module, up from 600 at the end of 2018. GWO and GWEC estimate that the total C&I and O&M workforce will number 6,600 people, up from 3,700 in 2022. GWEC expects Australia's first offshore wind farms to reach commercial operations in 2031, with no impact on the workforce during the outlook period.

Figure 11 - Onshore Wind Additions and the Forecast Workforce Needs for C&I and O&M in the Australia



Source: GWO, GWEC 2023

Brazil

A more climate-friendly Brazilian federal administration is resuming work on key issues that were abandoned in recent years, such as the protection of the Amazon and investment in climate change mitigation. Under the Paris Agreement, Brazil has committed to reduce greenhouse gas emissions by 37% from 2005 levels by 2025 and by 50% by 2030. At COP26, Brazil announced a zero illegal deforestation target by 2030 alongside a national hydrogen strategy. The latest Ten-Year Energy Expansion Plan by Brazilian energy planning agency, EPE, foresees renewable energy representing 48% of the country's energy matrix by 2031.

A recent report by ABEEólica, the Brazilian wind energy industry association, found that for every Brazilian Real (BRL) invested in wind farms, there is a BRL2.9 uplift in GDP. By the end of 2022 Brazil exceeded 25.6GW total wind capacity and witnessed another strong year of growth. This included the largest ever onshore wind installation of 4GW new capacity, primarily driven by the free market environment for electricity and a shift from regulated auctions towards resilient corporate PPAs. GWEC and ABEEólica expect annual additions of 3GW for onshore wind over the next decade, or almost 16GW in the period 2023-2027, though this may prove to be a conservative estimate.

Offshore wind and green hydrogen are expected to act as additional drivers for wind energy development in the coming years. According to EPE's 'Roadmap Eólica Offshore Brasil', Brazil has a huge offshore wind potential of roughly 700GW in waters with a depth of up to 50 metres off 8,000 kilometres of coastline. A World Bank study finds more than 1,200GW of offshore wind potential. This complements the impressive 500GW of onshore wind potential estimated by ABEEólica.

A series of regulatory outputs stimulated offshore wind market development in Brazil in 2022. Federal Decree 10,946/2022 set guidelines on the use of maritime space and the exploitation of natural resources and an Act, PL 576/2021 regulating all types of energy exploration in the ocean (and in other kinds of water bodies) introduced a one-stop-shop system through an information portal that manages offshore areas for power generation. ABEEólica also launched a study outlining the pathways for offshore wind value chain development. It is expected that offshore wind legislation will be

published by November 2023 to facilitate investment. State-owned energy giant, Petrobras has already published plans to develop offshore wind projects with a total capacity of up to 23GW. It has submitted licensing requests for 10 areas and is exploring up to 14.5GW of partnership projects with Equinor.

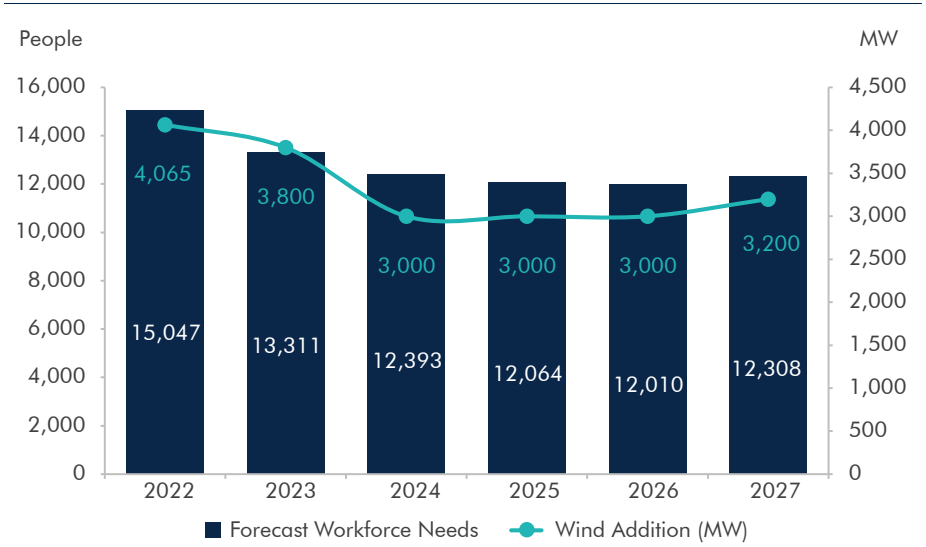
For the first offshore wind tender expected in 2023, investors have shown greater appetite with tens of project applications totalling 170GW already filed with the Brazilian Institute of the Environment and Renewable Natural Resources (IBAMA).

ABEEólica supports an industrial policy focusing on the synergies between green hydrogen and wind energy and expects to engage positively with the Brazilian government to fast-track its progress. However, the challenge for the future is to consolidate policies and establish a strong regulatory framework for offshore wind and green hydrogen in order to provide the appropriate ecosystem for industry to invest. This unique Brazilian wind growth would require a good number of wind workforce addition with offshore wind training.

Workforce Training Needs

The C&I and O&M workforce in Brazil is expected to decline in 2022 and 2023, driven by weakening onshore wind construction activity in 2023 and 2024. The figures are forecasted to start growing in 2024 towards a trained workforce of 14,400 people in 2026, as onshore installations pick up again in 2025 and companies prepare for the first offshore project scheduled for commissioning in 2028.

Figure 12 - Onshore Wind Additions and the Forecast Workforce Needs for C&I and O&M in Brazil



Source: GWO, GWEC 2023

China (Mainland)

China continues to be world's largest leading wind market in 2022 with a total of 334GW onshore wind and 32GW offshore wind installed capacity. Following on its '30-60' pledge[3] and target to increase the share of non-fossil fuels in primary energy consumption to around 25%, China made its commitment to further expanding the role of renewables in its energy mix to more than 80% of total new electricity consumption by the end of the 14th Five-Year Period (2021– 2025). China's National Energy Administration (NEA) predicted that generation from wind and solar power would double from 2020 levels by 2025. To support this commitment means around 250–300GW of wind power capacity addition from 2021-2025.

Since January 2022, China has shifted from a subsidy driven feed-in tariff (FiT) model to a 'grid parity' mechanism. This means electricity generated from wind and renewable projects will receive the same remuneration as that from coal fired power plants. While 2022 was a difficult year, with strict COVID-19 restrictions and the impact of a sudden 'reopening' of the country, the resilience of the Chinese wind industry was demonstrated by it adding 33GW of new grid connected onshore wind (mechanical installation of 45GW) and 5GW of new offshore wind capacity. This year also saw NEA approve 11GW onshore wind capacity under the 'grid parity' mechanism, which is one-fifth of the volume reported for 2021. Building on the more than 80GW of wind turbine orders already awarded in 2022, provincial Chinese governments announced a further 50GW of onshore wind capacity to be delivered under the grid-parity pipeline by January 2023.

Provincial level financial support for offshore wind at the is still available in Guangdong, Jiangsu and Shandong however this is much lower than the FiT previously offered by the central government. Progress shows that six provinces almost completed their offshore wind development plans for the 14th five-year plan period, NEA reviewed and approved 30GW of nearshore wind and 35GW of offshore wind capacity by June 2023, more capacity is expected to be approved by another four provinces, and a GW floating offshore wind farm is planned by 2027 in addition to floating wind demonstration projects.

China is one of the leaders in wind turbine technology and has the world's largest

3 Peaking carbon dioxide emissions by 2030 and achieving carbon neutrality by 2060.

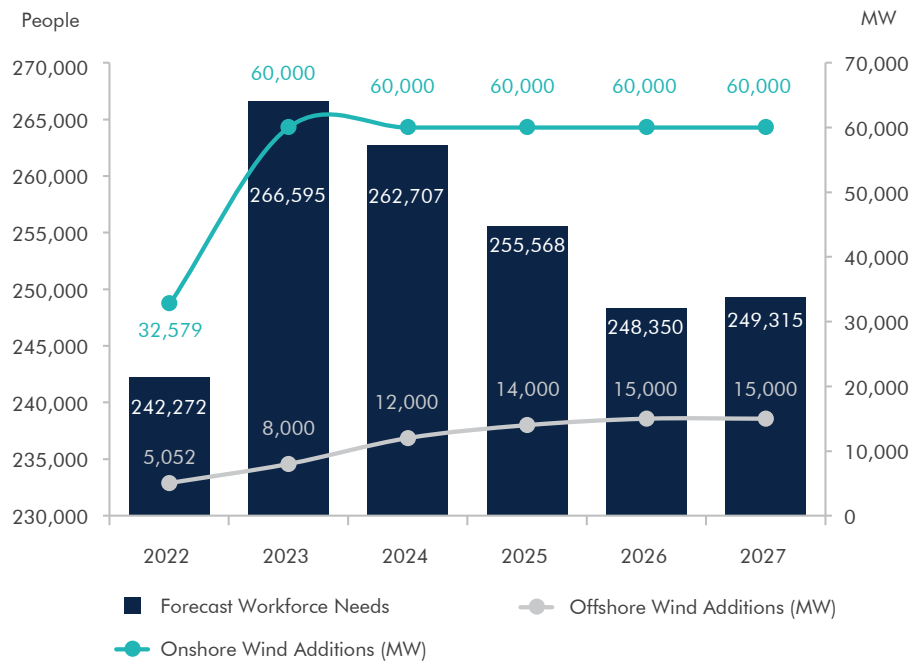
wind supply chain. It accounts for 60-70% of the global market share of wind turbine nacelles and key components production, with more than 15 wind turbine manufacturers active in China and the construction of several 10GW offshore wind bases anticipated off the eastern coast. Moreover, the Chinese wind industry released an initiative during Global Offshore Wind Summit-China 2022 (co-organised by GWEC) that calls for 100GW of offshore wind in China by 2025; 200GW by 2030 and 1,000 GW by 2050. If realised, this target would further drive demand for a trained workforce.

Considering the above factors, GWEC Market Intelligence has upgraded China's onshore wind installations forecast and now predicts 300GW of new wind capacity to be added to the grid in the next five year. This equates to annual installations of 70-80GW for the rest of this decade and 139GW of new offshore wind capacity will be built in the coming decade.

Workforce Training Needs

The number of GWO certified training centres established in China increased from six in 2018 to 22 in 2022. However, the impact of lower financial support combined with COVID-19 restrictions had a severe impact on construction activity, especially offshore, and hence on demand for training. As a result, the number of wind technicians holding a valid BST certificate decreased drastically from 3,360 at the end of 2021 to 2,600 at the end of 2022. The total number of technicians is expected to grow only marginally from 242,300 in 2022 to 249,300 people in 2027 as onshore and offshore capacity growth remains stable while turbine ratings increase.

Figure 13 - Onshore Wind Additions and the Forecast Workforce Needs for C&I and O&M in China



Source: GWO, GWEC 2023

Colombia

At COP26, Colombia reiterated the country's commitment to reducing greenhouse gas emissions by 51% by the year 2030 from 2014 levels, and to reach net zero by 2050. Its electricity mix is highly dependent on hydropower that has been negatively impacted by low rainfall periods since 2018. Security of supply has become a growing issue. It seems timely for the country's larger regions with untapped onshore and offshore wind potential be developed to meet power demand and help reach climate goals.

Post-Covid, a recovery plan, 'Commitment to the Future of Colombia' covered five wind power projects for funding . This investment is more than one-third of the total USD3.1 million assigned for electricity projects and is expected to generate around 4,300 local jobs to support Colombia's green recovery.

A sense of promise for the Colombian wind industry has been created from the aggregation of the following initiatives. First, the announcement of a new energy transition law in mid-2021 legislating power generation from non-conventional renewable energy sources (NCRS). Secondly, progress on the development of the La Guajira wind farm and lastly, the award of 1.2GW wind capacity (includes 350MW offshore wind) in March 2023 under Mining and Energy Planning Unit UPME's RE power procurement tendering process. With 30MW new onshore wind installation in 2022, GWEC's Wind Market Outlook forecasts that around 2.2GW onshore wind could be added from 2023-2027.

In May 2023, the government launched a final offshore wind development roadmap, which identifies the potential of more than 50GW and targets between 3GW and 9GW of installed capacity in a high-case scenario between 2030 and 2050 off the country's Atlantic coast. Colombia is also a member country of Global Offshore Wind Alliance (GOWA)[4].

Colombia's Ministry of Mines and Energy announced that rules for a first competitive offshore wind tender round in the Atlantic area would be enacted in the second half of 2023, taking an early lead as a first mover in Latin America and the Caribbean. A pipeline of 11 projects

4 GOWA is founded by the government of Denmark, IRENA and GWEC in September 2022 to drive the uptake of offshore wind through political mobilisation and the creation of a global community of practice with an initial aim to contribute to achieving a total global offshore wind capacity of at least 380GW by 2030, and 2,000GW by 2050, with 35GW being deployed on average each year through the 2020s and a minimum of 70GW annually from 2030.

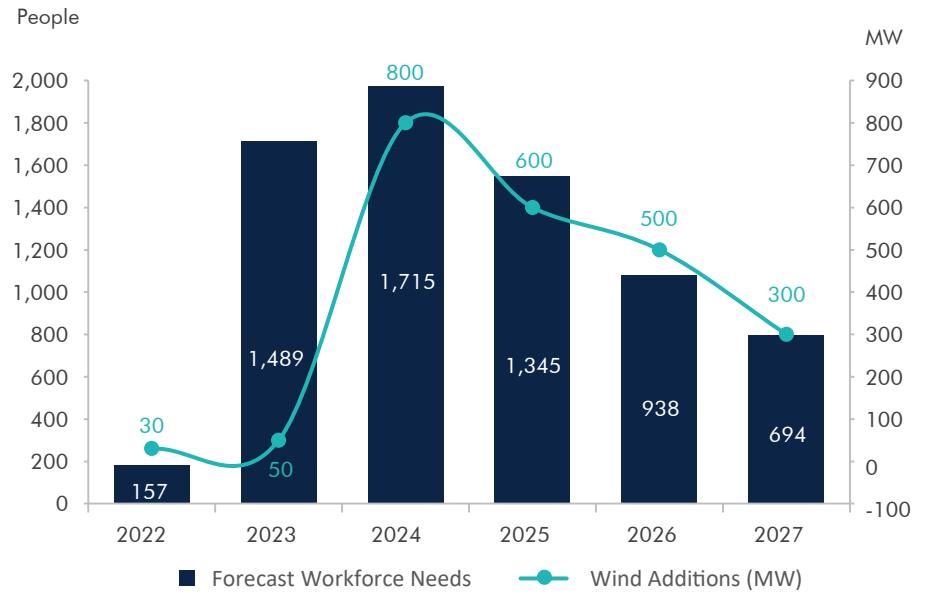
of total 5GW capacity has already been registered by developers with the energy planning body UPME. The government has regulated the procedure for the site allocation through Resolution 40284 of 2022. Further regulatory activity is expected in the short and medium term to streamline the permitting process.

Colombia's mix of onshore, offshore wind and other mature renewable energy technologies will allow for a diversified and reliable renewable energy mix. However, to scale up wind deployment, the Colombian Government must identify solutions that increase social acceptance, expand grid infrastructure, improve port readiness, drive workforce development and establish supply chain availability.

Workforce Training Needs

By the end of 2022, only ten people had received training through the single training facility established in Colombia since 2021. Training started to accelerate during 2023 after a new training centre was established in December 2022. The total workforce needed to build and maintain wind capacity in Colombia will grow from 160 people in 2022 to 700 in 2027. Construction of new wind assets slated for commercial operations from 2024 and 2027 will drive demand for wind workforce in Colombia, with a peak in demand in 2024 falling throughout the rest of the outlook.

Figure 14 - Onshore Wind Additions and the Forecast Workforce Needs for C&I and O&M in Colombia



Source: GWO, GWEC 2023

Egypt

Egypt became one of the pioneering countries for wind energy in Africa and the Middle East in 1988 when the government's New & Renewable Energy Authority built a pilot wind energy project in Hurghada. Following two decades of modest wind and renewable energy targets, today Egypt is poised to regain its status as a leading wind energy market through its number of GW-scale projects announcements on the sidelines of acting as host to COP27.

Egypt aims to have the 42% renewable energy by 2035 with support of Green Corridor Initiative. This features projects such as two 10GW onshore wind farms planned by Masdar and ACWA Power. There are other multi GW-scale projects in early stages of development and if the projects are constructed, they will propel the country's wind energy industry into the upper echelon of emerging markets worldwide.

Egypt's current installed wind capacity sits at 1.7GW following grid connection of Lekela Power's 252MW West Bakr wind farm. This will rise by 1.6GW once the AMEA Power led, 500MW Amunet project, Engie led 500MW Gulf of Suez 2 and ACWA Power's 1.1GW wind farm, Africa's largest, are completed.

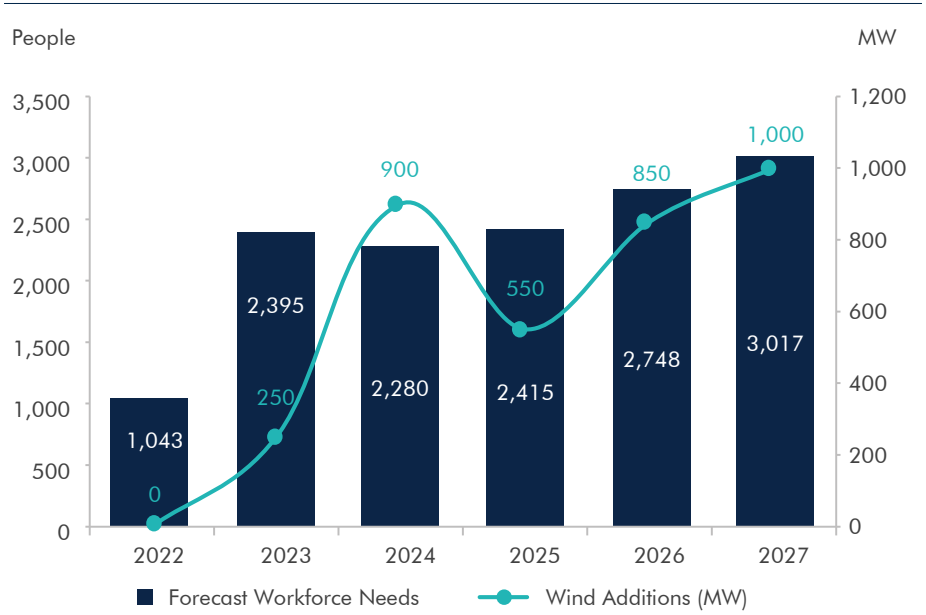
GWEC forecasts 4.3GW onshore wind capacity will be added by 2026, if the pipeline go as expected. From 2027, the several projects covered by Memorandum of Understandings (MoUs) between industry and the Egyptian Government could add an estimated 1GW per year, culminating in more than 8GW of installed wind capacity by 2030. GWEC is currently leading the establishment of Egypt's first wind energy association to support the ambitious growth that is planned.

To diversify its energy mix, Egypt, endowed with the Mediterranean and Red Sea coasts, has embarked on ambitious plans to explore offshore wind. Its government has also signed countless MoUs with several local and global companies for initiating studies related to green hydrogen projects. It also signed an MOU with the European Commission in November 2022 establishing a long-term strategic partnership to collaborate broadly on future EU imports of renewable hydrogen and its derivatives. This growth certainly sets a great opportunity for wind deployment jobs creation within Egypt.

Workforce Training Needs

Since 2021, when GWO training was first made available in Egypt, two training centres have trained 246 people. Resumed wind construction activity will increase workforce demand and bring new training opportunities. As newly installed wind capacity in Egypt grows from 0MW in 2023 to 1GW in 2027, the wind workforce needed to build it and maintain is expected to triple from 1,000 to 3,000 people during the same period.

Figure 15 - Onshore Wind Additions and the Forecast Workforce Needs for C&I and O&M in Egypt



Source: GWO, GWEC 2023

India

India has long been the fourth leading wind market in the world. With more than 44GW of onshore wind installed capacity as of August 2023, it plays a crucial role in determining the pace of the energy transition in wider Asia. It has already achieved its 40% non-fossil fuels target well before the 2030 deadline.

With growing energy needs, the country has raised its climate commitments. This includes; installing 500GW renewables capacity by 2030 (which includes 140GW wind), reducing the emissions intensity of its GDP by 45% by 2030, and reaching net zero by 2070. Ambitiously, India aspires to be a developed economy by 2047 with an aim of growing manufacturing GDP 15-fold between 2021 and 2047.

India commissioned 1.84GW of new wind power capacity in 2022, continuing the trend for recovering installation rates and resolving challenges around project cancellations caused by high inflation, post-COVID gaps in grid availability and timeline extensions in commissioning dates. GWEC forecasts the country's onshore wind market will continue to recover and install total 21GW of onshore wind capacity in next five years.

Harnessing the maximum wind potential is important for India to serve round-the-clock, peak power demand and ensure grid stability. To accelerate wind growth, India's onshore wind market recently shifted from an e-reverse auction mechanism to new enablers. Among these are first; a target for 10GW annual onshore wind auctions from 2023-2027 through a single-stage, two-envelope bid system. Second, wind-specific Renewables Purchase Obligation (RPO) implementation from 2023 to 2030. Third, a waiver of Inter-State Transmission System (ISTS) charges up to June 2025 for onshore wind and up to 2032 for offshore wind (with graded charges between 2033 to 2037). Fourth, transmission planning to integrate 58 GW wind capacity by 2030 (includes 10 GW offshore in Tamil Nadu and Gujarat) as well as other state and central policy incentives for commercial, industrial and green open access wind power procurement.

The government has also announced an auction trajectory for 37GW offshore wind capacity from 2023-2030. After several stakeholder consultations on the draft offshore wind seabed tender for Tamil Nadu, the Ministry of New and Renewable Energy published (in August 2023) the Strategy for Establishment of

Offshore Wind Energy Projects (Revision 1, depicting a 37GW auction trajectory under three Models A, B, and C). This was followed by two calls for proposals to conduct offshore wind studies/ surveys. First, one for the country's Exclusive Economic Zone (EEZ) and second for proposed zones in Tamil Nadu (as per Strategy) with an aim to hold the first seabed lease tender for Tamil Nadu by 2023. Viability Gap Funding (VGP) for the initial few GWs of offshore wind is expected from the Indian Government for the Gujarat sites.

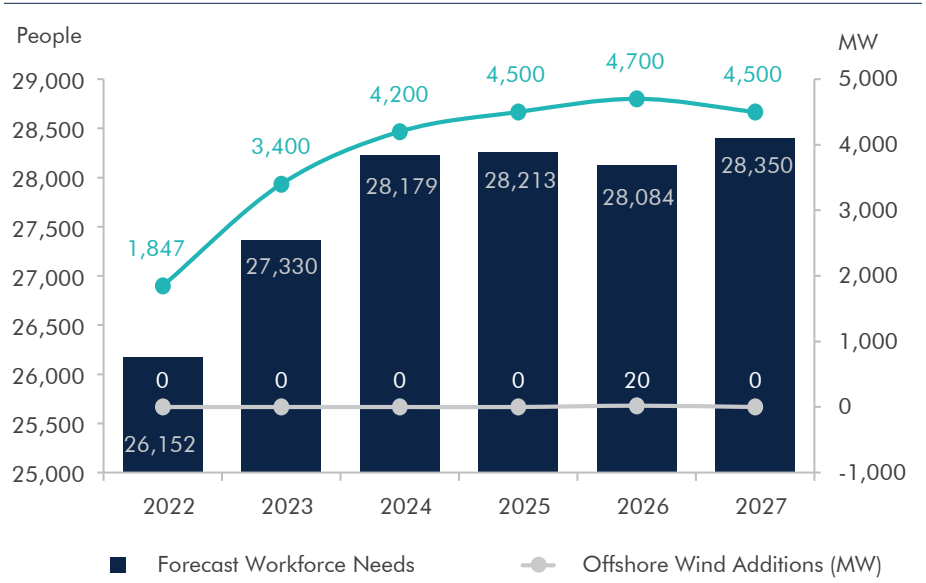
As the second largest, Asia Pacific hub for turbine assembly and key components production, India is strategically seen as well placed for wind manufacturing, global exports and an 'China plus one' approach. Government support for domestic manufacturing includes encouraging manufacturing of various offshore wind installation vessels where a subsidy will be provided under the 'Shipbuilding Financial Assistance Policy' under the label of 'Specialised Vessels'.

To increase the annual wind installation rate a persistent set of onshore wind related issues need to be resolved. These issues include right of way, PPA sanctity and delayed payments, land allocation, increased turbine prices due to commodity price inflation, expensive finances and higher debt rates. Faster progress through 'state central social community' coordination and robust policy, regulations and standards will be needed to achieve the 30GW offshore wind target by 2030. To help train a quality wind workforce training providers, such as the nodal agency, National Institute of Wind Energy, operates the Vayumitra Skill Development Program in nine windy Indian states with onshore installations. The availability of a skilled offshore wind workforce is at a nascent stage.

Workforce Training Needs

The number of GWO trained people in India has grown steadily from 2,000 in 2018 to 8,200 in 2022. As the wind market recovered from the 1.1GW dip in 2020, the C&I and O&M workforce in India is estimated to have grown from 23,500 in 2020 to 26,200 in 2020 and is expected to expand further to 28,400 in 2027 fuelled by increasing capacity additions. With the first commercial scale offshore wind farm expected to be commissioned in 2028, offshore wind will start contributing to wind power growth in India at the end of the outlook period. This will have a marginal but positive impact on workforce volumes (700 people) by the end of 2027.

Figure 16 - Onshore/Offshore Wind Additions and the Forecast Workforce Needs for C&I and O&M in India



Source: GWO, GWEC 2023

Japan

Japan has the sixth-longest coastline in the world with massive uncaptured offshore wind potential especially floating wind, however, its offshore wind targets are 10GW by 2030 and 30-45GW by 2040, so that wind energy meets only 5% of the energy mix by 2030. The country has pledged to reach net zero by 2050 with an interim goal of reducing greenhouse gas emissions by 46% compared to 2013 levels by 2030.

Total wind installed capacity for Japan stands at 4.6GW for onshore wind and 136MW for offshore wind, by the end of 2022. This includes 143MW onshore wind and 84MW offshore wind capacity out of 140MW Akita Noshiro Port offshore wind farm. Despite Akita Noshiro Port wind farm turbines being installed by December 2022, it only became fully operational in early 2023. Considering the wind market dynamics in Japan, GWEC forecasts 3.8GW onshore wind and 0.9GW offshore wind to be added in the next five years, leaving a big gap to its target of 10GW offshore wind installation by 2030. GWEC analysis shows that to achieve its 2040 offshore wind targets, annual tender allocation has to rise from an average of 1GW to more than 4GW from 2026.

Following the 2021 Round 1 Fixed Bottom Offshore Wind Tender, Japan launched Round 2 of public tenders for offshore wind development in territorial waters (four promotion zones of more than 1.8GW capacity) under the 'Promotion of Use of Marine Areas for Development of Marine Renewable Energy Generation Facilities Act'. Revisions in the Round 2 tender guidelines included a cap on maximum capacity to be allotted to a company; the replacement of the FiT with a new feed-in premium; various evaluation methods for project feasibility and speed factor for timely delivery. An unknown number of bids were submitted for this tender by June 2023. Bids are expected to be awarded as soon as December 2023 or March 2024.

Looking at Japan's current tender process and industry feedback on the process, bid allocation along with site identification, permitting and consenting processes need to be robust and streamlined for market acceleration. There may also be offtaker risk as the FiP requires bidders to arrange their own PPAs; FiP price is another criteria to be addressed.

The 5MW Goto floating project, in place since 2019, gives Japan an ideal position to strengthen its regional footprint as the

only East Asian (and one of the world's top five country) for total floating wind installations. The Japanese government is proactively exploring the possibility of developing offshore wind within its Exclusive Economic Zone (EEZ) and to unlock the industrialisation opportunity offered by floating offshore wind by instituting laws and regulations for offshore wind deployment as per its adopted, 4th Basic Plan on Ocean Policy.

Progress to further increase the floating wind momentum has come from both the Japanese government (METI) and industry. This includes, first the Basic Plan for the Green Transformation Policy (a 10-year decarbonisation roadmap) which covers grid and infrastructure facilitation for floating offshore wind uptake; secondly a JPY85 billion (USD58 million) subsidy for two large-scale floating demonstration project tenders by March 2024. Lastly the Public-Private Dialogue Council formed a Floating Offshore Wind Industry Strategy Working Group in June 2023 with the goal of introducing a separate floating offshore wind target and developing an industrialisation plan to deliver the target by the end of 2023. GWEC advocates for setting ambitious floating targets supported by a clear and robust framework as fundamental to the long-term success of Japan's offshore wind industrialisation strategy.

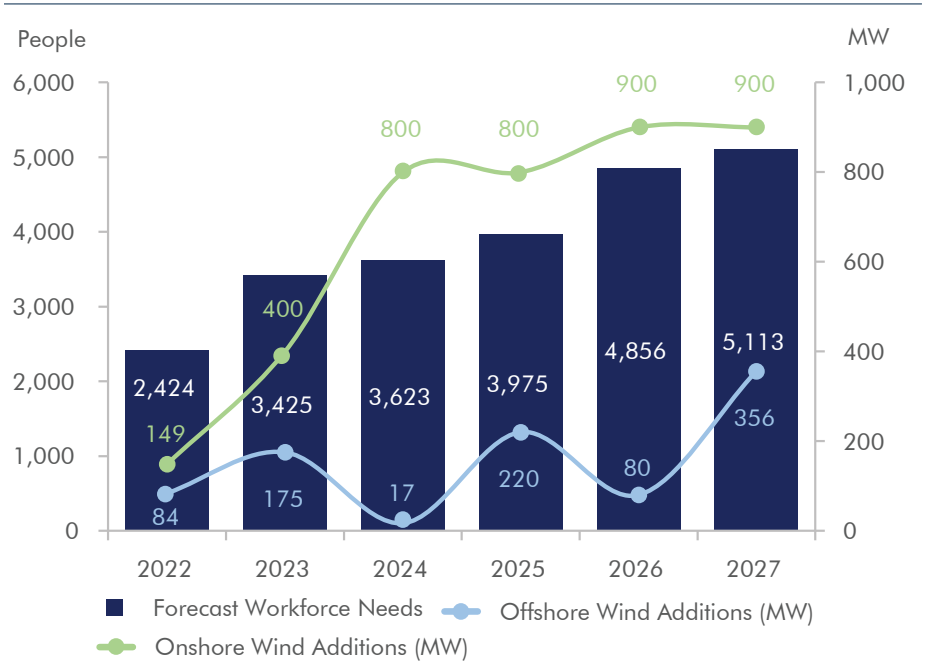
Notably, for training offshore wind workforce in Japan, the Japanese shipping classification society, ClassNK signed a memorandum of understanding with Maersk Training A/S in October 2022 to train offshore wind farm operators. Maersk Training is also collaborating with GiraffeWork, to open a centre called 'GiraffeWork powered by Maersk Training' for offshore wind courses. This is expected to open in Kawasaki in 2024.

With a strong requirement for local content and a long history of heavy industry manufacturing capability and expertise in wind, Japan further aims to establish a manufacturing base for offshore wind through its 'Program for Promoting Investment in Japan to Strengthen Supply Chains' initiative. The country is also exploring the production and export of hydrogen and the establishment of international supply chains, with a particular focus on the transport sector. Japan together with Australia and South Korea has agreements in place to begin establishing an international hydrogen supply chain.

Workforce Training Needs

The GWO trained workforce in Japan increased from 60 people in 2018 to 1,600 in 2022. The supply of standard wind industry training in Japan has grown from one training centre active in 2018 to five in 2023, thus expanding the portfolio of training standards. The number of C&I and O&M technicians in Japan is expected to more than double from 2,400 in 2022 to 5,100 in 2027. This growth will be fuelled by the rapidly emerging offshore wind market. GWO estimates that by 2027 the C&I and O&M trained workforce could be expanded by 3,900 people in addition to the 1,600 already active, as of the end of 2021.

Figure 17 - Onshore / Offshore Wind Additions and the Forecast Workforce Needs for C&I and O&M in Japan



Source: GWO, GWEC 2023

Kenya

Kenya set a 100% renewable power target by 2030 at COP26 and committed to fuelling the green industries of the future by 2040 at the launch of the 'Accelerated Partnership for Renewables in Africa' in Nairobi. In late 2023. With these goals, the country is striding towards increasing its energy access levels and becoming a renewable energy leader on the continent.

According to the Energy and Petroleum Regulatory Authority (EPRA), 73% of Kenya experiences 6 m/s wind speeds or higher at 100m height. Of this, 28,228 sq. km experiences wind speeds of between 7.5 – 8.5 m/s and 2825 sq. km experiences wind speeds of between 8.5 – 9.5 m/s. Kenya has installed 440MW onshore wind capacity by 2022 with FiT policy support since 2008. The Lake Turkana Wind Power project of 310MW capacity is the biggest wind power plant in sub-Saharan Africa and its largest public-private investment. GWEC forecasts 550MW additional onshore wind capacity in the next five years.

As well as Lake Turkana, onshore wind potential is available in parts of Marsabit, Samburu, Laikipia, Meru, Nyeri and Nyandarua and Kajiado counties. The majority of the projects currently under development are located in Kajiado county. Several proposals to develop offshore wind farm in Malindi last year were rejected by the Kenyan Government due to insufficient demand to utilise the proposed capacity.

Recent Kenyan Government facilitation of wind development includes releasing the 2021-2030 LCPDP (a 10-year Least Cost Power Development Plan) to address the requirements arising from the recommendations made by 'Taskforce to review Power Purchase Agreements' and the enactment of the 2019 Energy Act. A few of the highlights articulated in this plan include; recovery of the power sector from COVID-19, enhancement of renewable energy technology integration, focus on emerging technologies, and investment in primary data such as wind and solar insolation mapping necessary for attracting quality developers.

To make the wind and solar deployment more competitive and support the country's nascent renewable energy sources, in 2021 the Ministry of Energy of Kenya issued the FiT Policy 2021 on Renewable Energy Resource Generated Electricity (Small-Hydro, Biomass and Biogas) and the Renewable Energy Auctions Policy 2021.

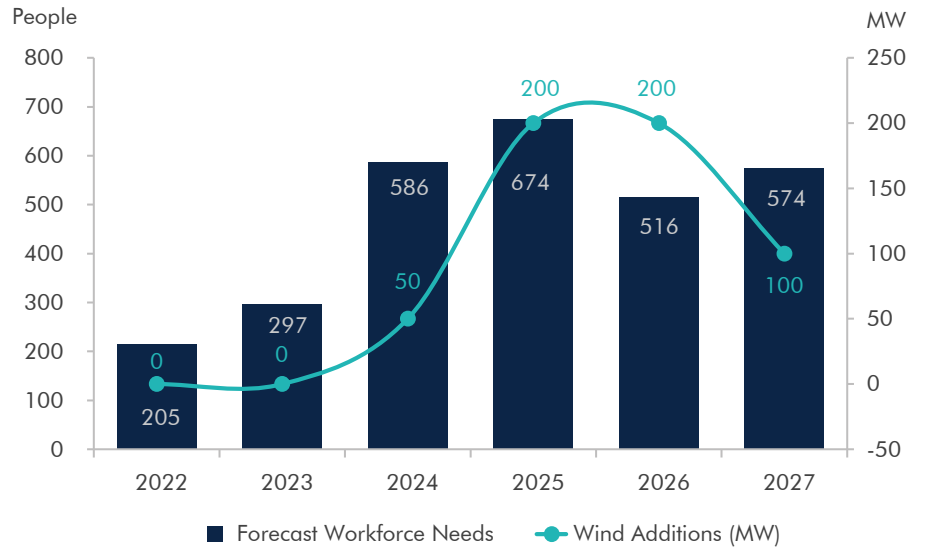
The Auctions Policy allows EPRA to run a competitive process before awarding a generation licence under the Energy Act, 2019. The 2021 FiT Policy, a revision of the 2012 FiT Policy (in a bid to align with the Energy Act, 2019) mandates that all renewable energy projects larger than 20MW will be procured under the Auctions Policy rather than the FiT Policy.

Permitting issues in Kenya, such as acquiring land, can be laborious; as permitting processing is under-resourced, such as the National Lands Commission in LamuCounty. There is a need to harness wind and other renewable energy potential available in the country to meet the climate targets timely. With the benefits of proper power demand/supply management, long-term electricity mix planning, suitable policy and regulatory frameworks, social awareness campaigns and grid evacuation infrastructure in place Kenya can lead in the long-term climate goal mitigation and job creation story in sub-Saharan Africa.

Workforce Training Needs

No GWO certified training centres have been established in Kenya to date. However, the expected tripling of the number of people needed to build and maintain wind assets in Kenya from 2022 to 2027 poses new opportunities for training the country's growing wind workforce.

Figure 18 - Onshore Wind Additions and the Forecast Workforce Needs for C&I and O&M in Kenya



Source: GWO, GWEC 2023

South Korea

South Korea is one of the world's most promising potential market for offshore wind. With an aim to achieve carbon neutrality by 2050, Korea has set a 14.2GW offshore wind target by 2030 under its 10th Basic Plan, released in December 2022. The country's existing manufacturing competitiveness has also been a positive incentive for establishing a resilient offshore wind supply chain, as evidenced by recent significant investments from Vestas (USD 300 million) and CIP (USD 350 million) in 2023.

The 10th Basic Plan, includes wind energy increasing from 2% to 34% within a 30% renewables target by 2036. This suggests 34GW wind installed capacity by 2036. However, GWEC Market Intelligence forecasts 1GW onshore wind and 2.3GW offshore wind to be added in next five years. The new onshore and offshore wind installed capacity in 2022 stand at 96MW and 0MW, respectively, out of total installed 1.7GW onshore wind and 142MW offshore wind.

In terms of floating offshore wind, by the end of 2030, South Korea is likely to replace Japan in the top-five country grouping. The country's staggering floating offshore wind power potential capacity of 277GW and 6.7GW of floating offshore wind projects (under permitting process) gives South Korea one of the biggest floating offshore wind pipelines in the world.

South Korea's total offshore wind capacity (those with electric business licenses (EBL) grants) reached an impressive 20.8GW as of December 2022. However, these projects faced bottlenecks from a lengthy bureaucratic/permitting process (under an open-door approach), lack of policy support and regulatory clarity. For example, the 'one-stop-shop' offshore wind bill which was due to introduce a dual-track system has (as of July 2023) been pending for more than two years.

To fully realize South Korea's offshore wind potential and accelerate deployment, the South Korean government has pushed for a variety of reforms. First, the introduction of a government-led site selection and auctions to ease the costly and lengthy EBL-based project permitting process which involves 29 licenses from different ministries. Second, focusing on capacity building and awareness raising initiatives to streamline the licensing process. Third, assessing and communicating socio-economic effects through wider

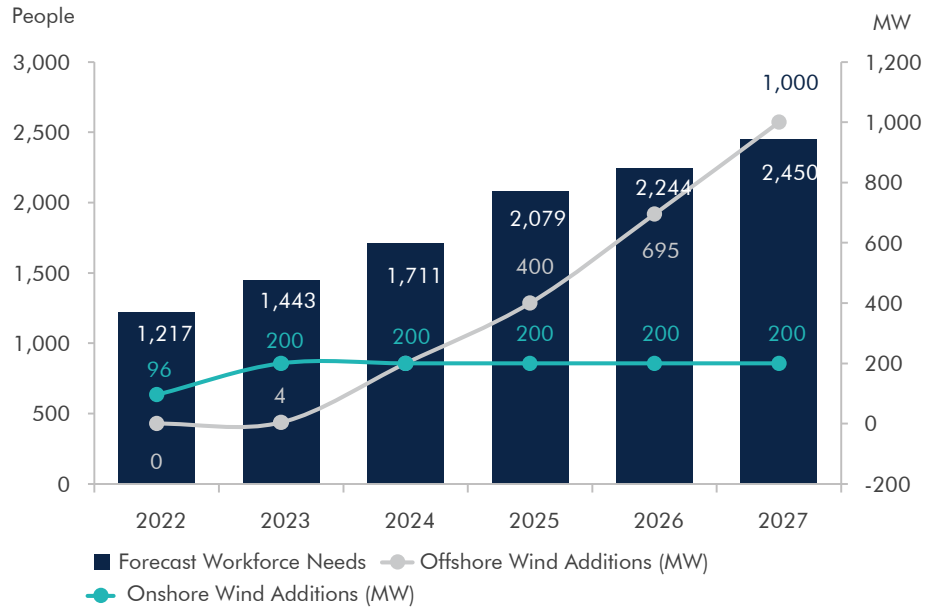
stakeholders' engagement to resolve fishermen conflicts. Last, effective policy support, actively developing its port and infrastructure with robust supply chain. A long-term wind target beyond 2030 would also provide a boost to the sector.

With these onshore and offshore developments, demand for qualified service and maintenance personnel for wind farms is growing in the country. The move to address this way began back in July 2013, when BZEE of Germany signed a cooperation agreement with the vocational training college, Korea Polytechnic III based in Chuncheon City.

Workforce Training Needs

With only 454 people with a valid BST certificate as of the end of 2022, training providers and educators could train an additional 2,000 people in the next five years. Onshore wind capacity additions will average 200MW annually from 2023 to 2027. As a result, the workforce needed to install and maintain the onshore wind fleet will remain stable at around 800 people during the same period. With 2.3GW coming online from 2023 to 2027, offshore wind will drive workforce additions, with a surge in the total number of technicians needed to install and maintain assets growing from 400 in 2023 to 1,600 in 2027. The total number of C&I and O&M technicians in South Korea is expected to reach 2,500 people in 2027 driven by the buildout of new offshore wind assets.

Figure 19 - Onshore / Offshore Wind Additions and the Forecast Workforce Needs for C&I and O&M in South Korea



Source: GWO, GWEC 2023

USA

As one of the world's leading wind markets, the USA had a total installed capacity of 144GW of onshore wind and 42MW of offshore wind, by the end of 2022. This was the lowest year since 2018 in terms of new installation with only 8.6GW of new onshore wind and zero offshore wind capacity commissioned. Despite the one-year Production Tax Credit extension for onshore wind projects to be commissioned by end of 2022 (announced in 2021), more than 10GW of onshore wind capacity faced delays due to supply chain constraints, grid interconnection issues, and developers awaiting full clarity on the Inflation Reduction Act (IRA) rules.

The US onshore wind market has historically been tax credit driven. With the IRA, signed into law by the Biden administration in August 2022, GWEC expects the USA market to accelerate sharply now as it is fully understood by investors. The impressive IRA package prioritises offshore wind planning and permitting reform legislation, manufacturing, and clean job creation in four ways. First, tax incentives for wind projects up to 2032; secondly $100 million for offshore wind transmission planning; thirdly domestic manufacturing tax credit for offshore wind components and an extension of the investment tax credit for vessel construction, and finally; offshore wind development in the southern Atlantic coast and the eastern Gulf of Mexico.

Collectively, 13GW of offshore wind capacity was allocated through the New York Bight, Carolina Long Bay, and California lease (floating) sales in 2022. The first utility-scale offshore wind project is expected to be partially connected in 2023. GWEC Market Intelligence Q1 2023 outlook forecasts 54GW of onshore wind and 15GW of offshore wind capacity to be added in the next five years. The five-year growth would make the USA the third largest offshore wind market (after China and the UK) in terms of new additions. This is dependent on the timely supply chain being established to address the growth from the east coast of the USA.

More offshore wind capacity could be added in 2028–2032 primarily driven by technology neutral tax credits and a federal target of 30GW by 2030 (to be largely met using bottom fixed technology). There is also a 15GW floating offshore wind target by 2035 and a vision to deliver 110GW by 2050. This final targeted volume includes policy commitments (including floating wind)

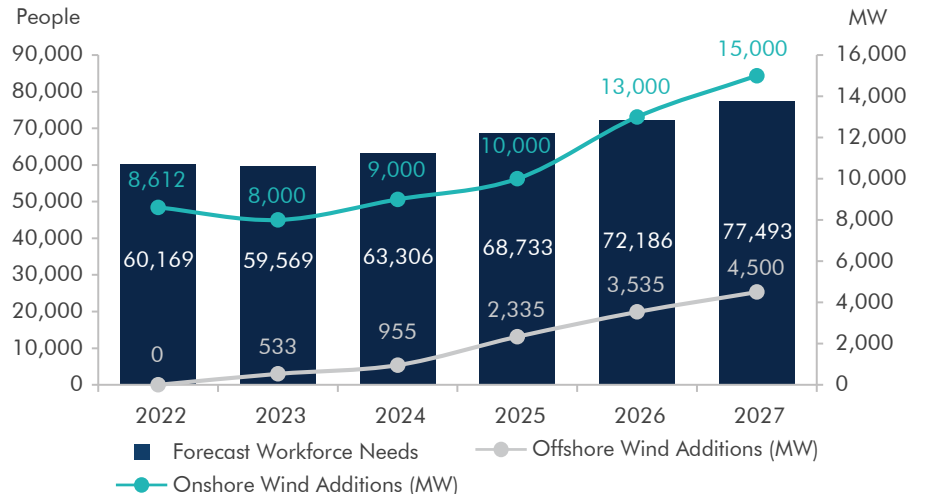
from seven eastern states for 42.7GW by 2040. Additionally, with offshore wind project pipelines at over 50GW with 32 leases in active development, the Bureau of Ocean Energy Management (BOEM) intends to conduct lease auctions in the Gulf of Mexico (2023), central Atlantic coast (2023), Oregon (2023) and the Gulf of Maine (2024) as part of the Path Forward initiative. BOEM will also review at least 16 construction and operations plans by 2025 worth more than 27GW.

To fully capitalise on wind growth and leverage IRA benefits, the USA will need to resolve a number of challenges. These include grid access issues (which often stem from coordination and planning challenges between regional transmission organisations and independent system operators); investments in port upgrades across the country; and trained and qualified workers to manufacture, construct, operate, and maintain wind turbines for the growing onshore and offshore wind sectors. Notably, the USA has an 'Offshore Wind Workforce Education and Training Database' to increase offshore wind training opportunities and 'Wind Energy Technologies Office' to address the wind industry's workforce needs through various targeted investments.

Workforce Training Needs

The workforce trained in GWO standards in the USA increased from 1,800 in 2018 to an expected figure of 11,900 at the end of 2027 while the network of local training providers is expected to grow from six training centres to 39 during the same period. The total C&I and O&M technicians is estimated at 77,500 people by 2027, that is training providers and educators will train an additional 65,600 workforce during the next five years.

Figure 20 - Onshore / Offshore Wind Additions and the Forecast Workforce Needs for C&I and O&M in the USA



Source: GWO, GWEC 2023

Chapter 6: Methodology: The GWO Wind Workforce Forecasting Model

At the end of 2022, the GWO-trained workforce (the number of individuals with a valid GWO BST certificate) numbered 145,000 who received training at centres in 52 countries. Nonetheless, the workforce in scope for GWO training is much larger and is growing rapidly alongside wind installations.

Since 2020, GWO and GWEC have worked together to produce the Global Wind Workforce Outlook. This report is based on a model developed by GWO that estimates the volume of people that GWO training providers and educators will need to train to capture the development potential offered by wind industry growth over the next five years. This chapter unveils an updated methodology to calculate the global construction and installation (C&I) and operation and maintenance (O&M) workforce. GWO that estimates the volume of people that GWO training providers and educators will need to train to capture the development potential offered by wind industry growth over the next five years. This chapter unveils an updated methodology to calculate the global construction and installation (C&I) and operation and maintenance (O&M) workforce.

Workforce

GWO's workforce forecasting model builds projections for the number of technicians needed to support global wind market growth. Four different formulas are utilised to estimate wind workforce growth. Each formula is calculated separately to account for differences in the available input data and to reflect the dynamics inherent in each segment (ie onshore or offshore) and development phase (ie C&I or O&M).

The model combines data from GWEC on installed capacity, capacity forecasts and average turbine ratings with the following elements included in the forecasts: number of projects, number of turbines and, in the case of offshore projects, distance from shore and O&M logistics setup. These data are combined with inputs on the typical workforce needed to carry out C&I and O&M on onshore and offshore wind projects each year

Construction and Installation (Onshore & Offshore)

GWO's model considers available data on project construction to estimate a typical people/turbine ratio for plant commissioning. Then, it combines historical and forecast wind capacity additions with annual gains in turbine rating to estimate the number of wind turbines installed each year. By multiplying the number of turbines installed each year with the people/turbine ratio the model calculates the number of technicians needed to construct and install wind assets throughout the outlook period.

Using data on project construction validated by GWO members, we estimated that the C&I of an offshore wind farm typically requires 18 people/turbine. Large scale onshore projects with a high number of turbines typically enable developers to utilise fewer people on a per turbine basis, while the people/turbine ratio tends to be higher for the buildout of smaller wind farms. The workforce needed to build and install an onshore wind farm can vary greatly, ranging from three people/turbine to 20 people/turbine. Given that most projects developed are below 10 turbines, we estimated that the construction and installation of a typical onshore wind farm will require 12 people/turbine.

Given that the model aims aims to understand the workforce trainable by GWO training providers, the forecast of the total addressable workforce for onshore C&I includes 70% of the turbines forecasted for the year ahead and 30% of the turbines forecasted for the year under study. For example, if 10 turbines were to be added in 2022 and another 20 in 2023, the workforce calculation for 2022 would consider the workforce needed for 30% of the 20 turbines of 2022 and 70% of the 10 turbines of 2023. The expectation is that a major part (70%) of the C&I workforce will need training one year ahead of the commissioning of the onshore project, while the remaining part (30%) will be trained during the year in which the project is commissioned. A similar logic applies for offshore C&I, but with 30% of the turbines forecasted for the year ahead and 70% of the turbines forecasted two years ahead.

Operation and Maintenance (Onshore)

Using GWEC's total installed capacity data and data inputs on the rating of operational wind turbines, we estimated the number of turbines operating in each country. We then used annual turbine additions to project the volume of the cumulative installed turbine fleet out to 2027. Using data on project O&M validated by GWO members and weighted by plant size, we estimated that the O&M of an onshore wind farm typically requires 0.45 people per turbine. This figure, multiplied by the total number of turbines in operation each year, resulted in the forecast of the total number of technicians needed each year for onshore O&M.

Operations and Maintenance (Offshore)

Project level visibility allows the calculation of the forecast for offshore operation and maintenance based on the projected number of turbines and offshore substations. Research on planned projects enables accurate assumptions on the rating and number of turbines that correspond to the capacity expected to be in operation each year throughout the outlook period. The people/turbine coefficient is calculated based on the total expected number of technicians required to be readily available at each site divided by the total number of turbines. The indicator that informs this number is the capacity of the vessels expected to be utilized based on the O&M strategy selected or most likely to be selected by the operator based on project characteristics. This coefficient is a cumulative figure that reflects the installed fleet and thus changes in time based on the characteristics of all the projects that are operational in each given year. This people/turbine coefficient is then multiplied by the total number of operational turbines to complete the forecast for offshore O&M.

GWO Modules

The second part of the model calculates the potential volume of modules applicable to the number of technicians in scope for GWO training. There are 27 GWO modules in addition to 13 refresher modules (excluding the BSTR-P training standard). Each of those modules corresponds to courses that GWO training providers and educators can be certified to deliver to their course participants. Understanding the development potential of GWO courses can help training providers and educators accelerate their training activity and support workforce globally.

The 27 modules have been classified as:

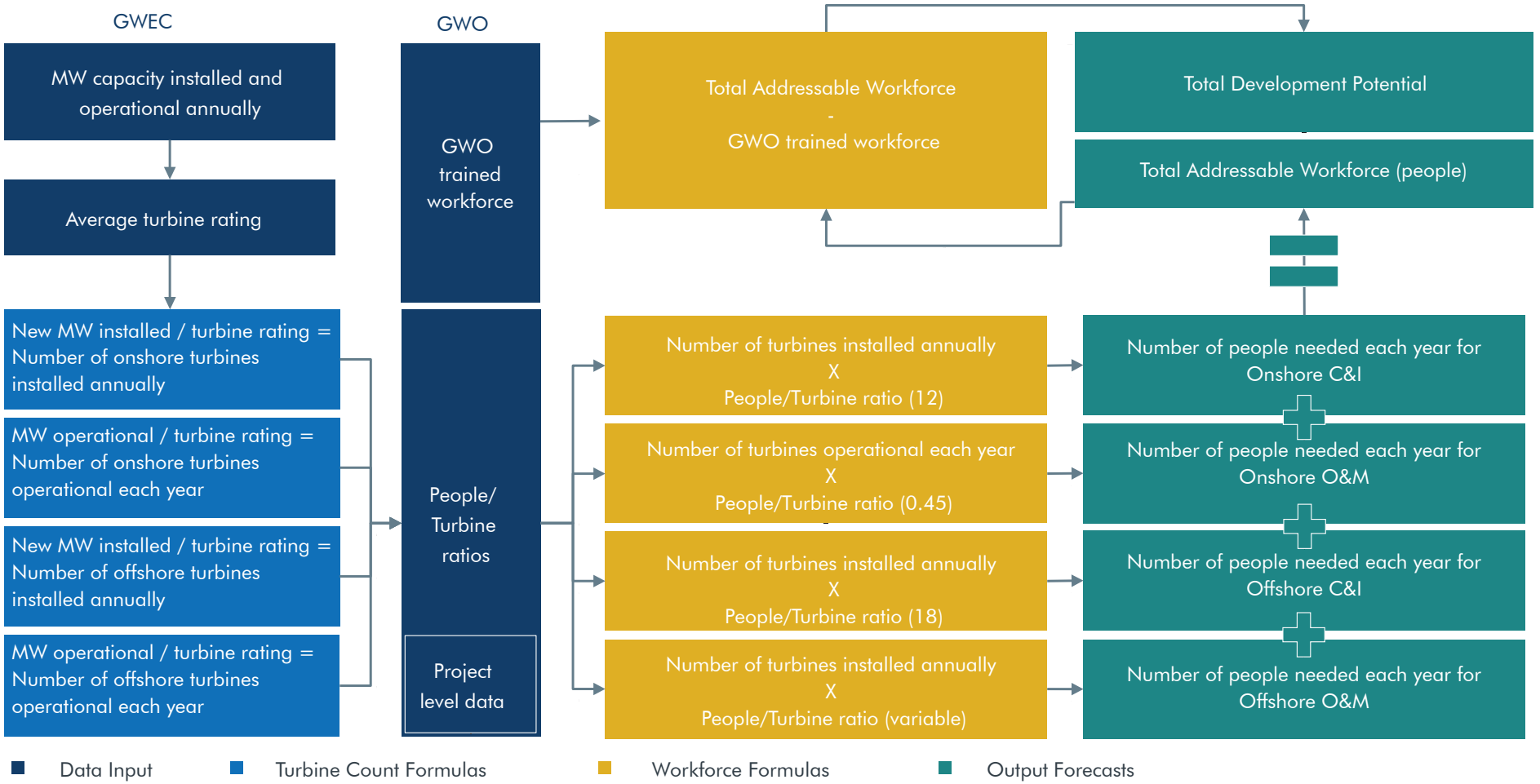
- modules with or without an expiration date
- modules for the onshore O&M workforce,
- modules for the offshore O&M workforce,
- modules for onshore C&I workforce and
- modules for the offshore C&I workforce.

Although there is no restriction over who can complete GWO courses and obtain certificates, no matter their job and industry, the categorisation in groups allows GWO to estimate a total potential training volume that is consistent with the segmentation used to make the workforce forecasts.

The baseline for calculating the total potential for GWO modules is the total number and breakdown of technicians in scope for GWO training in 2021 and 2022. These figures provide the basis to calculate the refreshers for each year of the outlook period. The modules applicable to each segment (including the refreshers) are applied to each of the outlooks' years. The resulting projections conclude that there is a total potential of up to almost six million modules (including refreshers) in 2027.

Note: See next page, Figure 21 - Summary of the Workforce Forecasting Model

Figure 21 - Summary of the Workforce Forecasting Model



Source: GWO, GWEC 2023

Figure 22 - GWO Standards & Their Applicability to Onshore and Offshore Wind

GWO module	Onshore, C&I	Onshore, O&M	Offshore, C&I	Offshore, O&M	Refresher
Advanced Rescue Training - Hub	x	x	x	x	Yes
Advanced Rescue Training - Nacelle	x	x	x	x	Yes
Advanced Rescue Training (Singleton) -Hub	x	x	x	x	Yes
Advanced Rescue Training (Singleton) -Nacelle	x	x	x	x	Yes
Basic Safety Training - First Aid	x	x	x	x	Yes
Basic Safety Training - Fire Awareness	x	x	x	x	Yes
Basic Safety Training - Manual Handling	x	x	x	x	Yes
Basic Safety Training - Sea Survival			x	x	Yes
Basic Safety Training - Working at Heights	x	x	x	x	Yes
Basic Technical Training - Bolt Tightening	x	x	x	x	No
Basic Technical Training - Electrical		x		x	No
Basic Technical Training - Hydraulics		x		x	No
Basic Technical Training - Installation	x		x		No
Basic Technical Training - Mechanical	x	x	x	x	No
Blade Repair	x	x	x	x	No
Control of Hazardous Energies - Basic Safety	x	x	x	x	Yes
Control of Hazardous Energies - Electrical Safety	x	x	x	x	Yes
Control of Hazardous Energies - Pressure Fluid Safety	x	x	x	x	Yes
Crane and Hoist - Basic User	x	x	x	x	No
Crane and Hoist - Inspection and Maintenance		x		x	No
Enhanced First Aid	x	x	x	x	Yes
Lift Commission and Inspection	x	x	x	x	No
Lift Commission, Inspection, Installation and Maintenance	x	x	x	x	No
Lift User	x	x	x	x	No
Slinger Signaller	x	x	x	x	No
Wind Limited Access - Offshore Limited Access					No
Wind Limited Access - Onshore Limited Access					No

Source: GWO, GWEC 2023

Limitations

The assumptions embedded in the Workforce Forecasting Model have limitations that influence the final outcomes. Firstly, the workforce considered in the model accounts only for GWO trainable professionals within the O&M and C&I phases of onshore and offshore wind project development. Thus, the workforce active in other phases of project development is not considered in the Global Wind Workforce Outlook.

Secondly, given the evolving dynamics of the wind power market, both wind installation forecasts and turbine rating assumptions are inherently prone to upwards and downwards reviews, and may result in a different outcome from that forecast in this report. Consequently, the inputs and assumptions built in the workforce formulas will be impacted by future forecast updates.

During 2023, GWEC and GWO reviewed upwards their long-term assumptions on average turbine rating. This change brought a decline in the estimated number of turbines installed each year, resulting in lower workforce figures at the backend of the Global Wind Workforce Outlook. However, this decline was not significant, as it was offset by an upgrade in the MW forecasted to come online during the outlook period.

GWO is confident that continuously improving the Workforce Forecasting Model will help the industry to better understand the volume of the C&I and O&M workforce and stimulate further discussions and research on this topic. The model will be refined on an ongoing basis to build in more granular, country and industry specific project data, thus progressively reducing the degree of uncertainty in the results.

Definitions

Terms	Definition
ABEEólica	Associação Brasileira de Energia Eólica - Brazilian Wind Energy Association
BST	Basic Safety Training Standard (GWO Standard)
BOEM	US Bureau of Ocean Energy Management
CAPEX	Capital expenditure
CoHE	Control of Hazardous Energies (GWO Standard)
C&I	Construction and Installation
COD	Commercial operation date
CTV	Crew transfer vessel
EPE	Energy Research Office (Brazil)
FiT	Feed-in Tariff
GW	Gigawatts
GWEC	Global Wind Energy Council
GWO	Global Wind Organisation
HSE	Health, Safety and Environment
IBAMA	Instituto Brasileiro do Meio Ambiente e dos Recursos Naturais Renováveis
MW	Megawatts
OEM	Original Equipment Manufacturer
O&M	Operations & Maintenance
PPA	Power Purchase Agreement
REC	Renewable Energy Certificate

Global Wind Energy Council
Rue de Commerce 31
1000 Brussels
Belgium
+32 22 13 18 97

info@gwec.net
www.gwec.net

Global Wind Organisation
Langebrogade 3H
Copenhagen 1411

info@globalwindsafety.org
www.globalwindsafety.org