Global Wind Workforce Outlook

2021-2025

GLOBAL WIND ORGANISATION

GWEC GLOBAL WIND ENERGY COUNCIL

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Definitions

Terms	Definition
Basic Safety Training	GWO training standard consisting of five training modules and regarded as the minimum necessary to enter or work on an offshore wind project
GRIP	Global Renewable Infrastructure Projects database, developed by The Renewables Consulting Group and containing data on offshore wind projects worldwide, from concept stage through to operations and maintenance
GW	Gigawatts
GWEC	Global Wind Energy Council
GWEC Data	An annual forecast of projected onshore wind installations in 94 countries for the period 2021 to 2025
GWO	Global Wind Organisation
GWO Data	A dataset extracted from the WINDA Database listing all GWO Sea Survival and Sea Survival Refresher training courses undertaken at all European training centres from its launch in October 2016 to January 2020
GWO Trained Workforce	People with a valid GWO training certificate
MW	Megawatts
O&M	Operations and Maintenance – phase of the offshore wind project lifecycle following commissioning
RCG	The Renewables Consulting Group Ltd
Reference Period	The calendar years 2019-2020 for which representative baseline of training activity could be established and correlated with installation and O&M activity
Sea Survival	A component module of the GWO Basic Safety Training course, usually a pre-requisite for working offshore on projects developed by GWO member organisations, and a proxy for calculating the size of the workforce qualified to work offshore
Sea Survival Refresher	A refresher course for the Sea Survival course, required every two years to ensure ongoing competence
Target Countries	The 10 countries of interest detailed in this report and for which country-specific training needs forecasts are presented
WINDA	GWO database for recording all GWO training undertaken and the details of all training recipients
WINDA ID	Unique identifier assigned to each GWO training recipient, as recorded in WINDA
WTG(s)	Wind turbine generator(s)

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Foreword

Ben Backwell, CEO,
Global Wind Energy
Council

" With increased ambition for wind energy, the potential for jobs, clean power, green investment, cleaner air and more sustainable development can reach greater heights."

As the global community fixes its gaze on a world beyond the COVID-19 pandemic, there is no better signpost to economic recovery than clean energy.

Not only can wind energy provide the affordable, clean and zero-carbon electricity to repower economies, but it can deliver tremendous socioeconomic benefits and jobs to rebuild local communities. Large-scale wind projects have the capacity to generate a diverse value chain of sustainable jobs, from procurement all the way through to decommissioning or repowering.

This report focuses on job creation in the construction and O&M segments of the industry – reflecting a small but vital fraction of the positive economic effects brought by wind energy. The fraction covered in this report alone encompasses nearly 500,000 jobs required over the next five years to install and maintain forecast wind projects.

Following last year's landmark report produced by GWO and GWEC and authored by RCG, which provided an assessment for offshore wind job growth in six key countries, this report expands the research and analysis to cover job creation and training needs in the onshore and offshore wind sectors of 10 countries. From Brazil to China to Morocco, these 10 countries cover nearly every region of the world, encompassing the largest current onshore wind markets globally like the US and China, high growth countries for wind energy like Vietnam and India and emerging economies like South Africa and Mexico.

What these 10 countries share is common need and opportunity. There is the need to expand existing workforces to build, operate and maintain mega-size renewable energy projects safely, knowledgeably and efficiently. GWO and GWEC jointly foresee the requirement to scale up global training capacity to ensure the industry continues to deliver on-time and with high performance. Standards and proper training are essential to protecting health and safety as a core principle of industry growth, allowing wind energy to attract new talent and safeguard its reputation as a sector of choice.

Then there is the opportunity to accelerate green recovery by encouraging policymakers to raise their ambitions for wind energy growth, bringing even greater value creation. Under current policies, GWEC Market Intelligence is forecasting 470 GW of new onshore and offshore installations worldwide from 2021 to 2025 – equivalent to about two-thirds of today's global capacity. This will bring total wind installations beyond the 1,200 GW mark by the middle of the decade.

This means higher wind capacity targets in the medium and long term, as well as reforms to resolve the bureaucratic bottlenecks that make project permitting too costly and slow.

We are no longer able see the energy transition as something that will happen in the future. Scenarios from both IRENA and the IEA are calling for current annual wind energy installations to scale up by 3-4 times to meet the 1.5-degree scenarios compliant with our Paris Agreement targets. Without an urgent step change in renewable energy ambition, we will miss the opportunity to limit long-term global warming and achieve our carbon neutrality objectives by 2050.

The time must be now, ahead of the momentous COP26 summit this year, to unlock the full potential of wind energy to transform our global energy system. Nearly half a million jobs will be needed to deliver our forecasts in this report, and millions more could harness the energy systems of tomorrow. GWEC looks forward to working with policymakers, the wider wind industry and colleagues in other technology sectors to realise this future.

Foreword

Jakob Lau Holst, CEO,
Global Wind Organisation

GLOBAL WIND ORGANISATION

" Every day, hundreds of thousands of people work on our turbines, facing unique hazards and risks to build and maintain the world's renewable energy infrastructure."

Working together with Global Wind Energy Council and research partners Renewables Consulting Group, in this co-authored report, we shine a light on one of the lesser-discussed topics of the climate change debate – our people. The workforce making it all happen.

The GWO Trained Workforce Forecasting Model provides credible business intelligence for investors, companies, policy makers, and anyone involved in the wind industry supply chain

Every day, hundreds of thousands of people work on our turbines, facing unique hazards and risks to build and maintain the world's renewable energy infrastructure. We have a duty to keep them safe so they can return home to their families at the end of the day. GWO safety training standards are one of the most efficient ways to secure this objective on a global basis and in producing this report, we explain in detail what we need to do to get there.

As the forecast model of this report shows, almost 500,000 additional people will require GWO training or similar if we are to meet the world's forecast installation quota of on and offshore wind, while also keeping the workforce safe.

The world's leading wind energy employers – OEMS, Owner Operators and Developers – increasingly require GWO as a standard for safety and technical training up and down the supply chain. When it is available, they will use it.

In other words, increasing the availability of GWO safety training in all those markets where supply is currently lacking is our single greatest opportunity to bring increased safety to more people.

This report considers the need for a GWO trained workforce in both established wind markets where thousands of technicians are already working on turbines like the U.S.A and China, while also using the same Forecast Model to guide the creation of a network from the ground up.

The Model calculates precisely how many people will require GWO safety and technical training to deliver forecast wind power installations globally, regionally and at a country-level. It combines GWO's own historic training data with GWEC and RCG's forecasts, plus a wide variety of variables to generate a reliable result.

I hope this report will serve as an input to all those decisionmakers considering investments in workforce safety. To the industry's existing community of training providers, I hope this will serve as an inspiration for your expansion into new markets. And for training partners who are new to GWO, we stand ready to support you.

Chapter 1: **Executive Summary**

Executive Summary

In 2019, Global Wind Organisation partnered with the Global Wind Energy Council to highlight the importance of safety, training and job creation to power wind energy deployment and the global energy transition.

The first output of this collaboration, Powering the Future: Global Offshore Wind Workforce Outlook 2020-2024 was published in April 2020 and provided a quantitative analysis of how many people would require industry standard GWO training in six target markets. The report sought to answer the question: "How much industry standard safety and technical training is required, on a per MW basis, to work on site building the pipeline of offshore wind in the target markets, and how can we address any workforce supply chain bottlenecks?"

The report concluded that a GWO-trained workforce of 77,000 people will be required to build and operate the projected installations in the six target markets by 2024.

As the expansion of the global wind industry accelerates, opportunities for job-creation are of growing interest across the supply chain, particularly to regional and national governments who increasingly view green energy. as a driver for economic growth and social development as well as a route to decarbonisation of electricity networks

This second report builds on *Powering the Future*, providing GWO-trained workforce forecasts for a range of 10 emerging and growth markets (the 'target countries') and expands the scope to include onshore wind.

The analysis continues to use GWO training data as a measure of workforce requirements and thus refers to a specific set of roles involved with construction and installation, operations and maintenance. Whereas *Powering the Future* derived a relatively simple 'persons per MW' value to calculate future needs, The Global Wind Workforce Outlook is based upon the outputs of a bespoke workforce forecasting model which assesses the impact of a range of interdependent influences on workforce needs, providing greater certainty in the results. This will assist in supply chain development, helping to ensure industry standard GWO training is properly targeted where it is needed most.

The model uses counts of GWO training delivered during the 2019-20 reference period as a baseline to forecast GWO-trained workforce requirements out to 2025. The link between the workforce size and the volume of installations – and operational wind farms – is retained and refined to account for factors such as the increase in average turbine size and the movement of workers between countries built into the model. As such, this report represents an evolution from using a simple linear relationship (applying the 'persons per MW' multiplication factor) to a considerably more sophisticated calculation that takes into account several complex factors that influence the size and growth of the global workforce.

Forecast installations for onshore are current as of GWEC's Q1 2021 outlook which reflect the impact of COVID-19 and announcements made since the 2020 forecasts on which *Powering the Future* was based. Offshore installations forecasts are derived from live data in RCG's GRIP database of known projects at all stages of development. Annual onshore installation forecasts were provided by GWEC. Other intelligence was sourced from industry sources and targeted feedback from GWO member organisations and training providers.

This forecast does not include the workforce needs for other segments of the wind project lifecycle, including in procurement, manufacturing (the most labour-intensive segment), transport and decommissioning or repowering. The wider workforce needs to deliver the forecast onshore and offshore wind energy fleet through 2025 are therefore larger than the training needs for construction, installation, operations and maintenance identified in this report.

The key conclusions from the modelling work, as detailed in the remainder of this report, are:

- More than 480,000 people will require GWO training to construct, install, operate and maintain the world's onshore and offshore wind energy fleet due to be installed through 2025. Of these, 340,000 will be needed in just the 10 target countries detailed in this report
- There is a significant untapped opportunity for the training and industrial education supply chain across all markets. Current GWO training market capacity is expected to support the training needs of 150,000 workers by the end of 2021 and 200,000 by the end of 2022. With at least 280,000 more workers requiring GWO training by 2025, organisations in scope to deliver it are encouraged to develop certified GWO programmes now in order to meet demand.

- Large continental markets with established workforces like China and the United States will benefit from a combination of job creation opportunities through continued expansion and improved productivity via the use of industry-recognised training standards

- Emerging wind markets can develop their safety and technical training networks from the ground up to ensure alignment with global safety systems.

Global Summary

Table 1: Forecast capacity installations and number of people requiring new training (2021-25)

Region	Onshore		Offshore	
	Installations (MW)	Training needs (# of people)	Installations (MW)	Training needs (# of people)
Europe, Middle East, Africa	92,500	60.057	34,300	44,412
Asia-Pacific (except China)	39,200	31,227	12,200	32,659
Americas (except USA)	26,800	15,660	-	-
China	194, 500	149,256	34,500	70,099
USA	46,000	51,624	9,100	25,381
Total (global)	399,000	307,924	90,100	172,281

Total (global onshore and offshore)	**480,205**

Onshore Wind   Offshore Wind

Figure 1: Forcast capacity installations and number of people requiring new training in target countries (2021-25)

Target Countries Summary

In addition to the global forecast for training needs, this report also examined the training needs of 10 countries: Brazil, India, Vietnam, Japan, USA, China, South Africa, Mexico, Saudi Arabia and Morocco. These countries were selected for regional diversity, as well as spanning the largest onshore wind markets globally (USA and China), high-growth markets for onshore and offshore wind (Brazil, India, Vietnam and Japan) and emerging wind markets (South Africa, Mexico, Saudi Arabia and Morocco).

Together, the training needs in these 10 countries comprise 70% of the global wind energy workers requiring training for construction, installation, operations and maintenance activities over the next 5 years.

The requirements for GWO-trained personnel in the target countries are influenced by several interdependent factors. While Powering the Future used a simple linear equation to estimate workforce growth, this report is based upon the outputs of a forecasting model allowing more accurate forecasts as described in the 'at a glance' box below.

Table 2: Forecast capacity installations and number of people requiring new training in training countries (2021-25)

Country	Onshore		Offshore	
	Installations (MW)	Training needs (# of people)	Installations (MW)	Training needs (# of peaple)
Brazil	9,700	3,737	-	-
India	20,200	12,973	-	-
Vietnam	2,800	5,364	1,407	3,011
Japan	4,400	2,950	2,878	8,230
USA	46,000	51,624	9,100	25,529
China	194,500	149,257	34,500	70,099
South Arica	5,648	2,434	-	-
Mexico	3,075	831	-	-
Saudi Arabia	2,116	2,399	-	-
Morocco	1,426	1,223	-	-
Total	289,865	233,892	47,885	106,869

Total (global onshore and offshore) **340,761**

Onshore Wind Offshore Wind

GWO Workforce Training Forecasting Model: At a Glance	
Purpose	To forecast the number of workers that will require GWO training to support projected onshore and offshore wind installations .
Scope	Global - all countries and territories. Onshore and offshore wind.
Primary Data	GWO WINDA training data (anonymised). GWEC installations data and capacity forecasts (onshore). RCG GRIP installations data, capacity forecasts (offshore).
Reference Period	2019-20
Key Logic	Training installed capacity and construction activity data for the reference period is used to develop 'baseline' persons per MW ratios for construction activity. Baseline ratios are also drawn (persons per turbine) for added O&M capacity and an estimate of the existing O&M workforce size. These values are used to forecast future training needs based on forecast capacity installations. For each year of the forecast period, the model: • Calculates the existing in-country workforce size. • Calculates workforce demand based on installation forecasts and operational capacity. • Redistributes 'excess' workers (where workforce size > demand) to countries with a shortfall (demand > workforce size). • Applies adjustment factors to reflect observed and predicted influences of workforce availability. Shortfalls after worker redistribution represent the GWO training needs.
Assumptions	• There is limited exchange of workers between onshore and offshore sectors. • The 2020 baseline is representative of a typical year and not significantly affected by the COVID-19 pandemic. • 80% of installations in Europe in the reference period were delivered by GWO trained workers. • The baseline captures the dynamic nature of the workforce – including retirements, career changes, new entrants and permanent/temporary workers. • Forecast training needs are met, and all newly trained personnel are considered part of the following year's workforce. • GWO Sea Survival training module certificates are the most suitable measure of the trained offshore (and therefore onshore for those without this certificate) workforce. • Workers initially work in the country in which they complete their GWO training. • Historic and forecast capacity installation effort is evenly spread across the relevant year, unless more accurate phasing data is available. • Average offshore turbine size will increase in an approximately linear manner. No such pattern will be observed onshore.
Adjustment factors	• Annual increase in average turbine size (offshore). • Abandonment of the industry when workforce demand drops. • Annual turnover of O&M personnel. • Limitation on worker movement from and to specific countries or regions. • Market penetration of GWO training standards.
User Control / Inputs	Two options: • Automatic: User selects country of interest, and the model generates a training needs forecast based on built-in capacity forecasts. • Manual: User may enter their own capacity forecast and forecast period (including for countries where there is no built-in data) to generate bespoke forecasts. Functionality allows users to change most adjustment factors to test scenarios and undertake sensitivity analysis.
Outputs	Per-year country-specific forecasts of GWO training requirements over the selected forecast period (tabulated and graphed).

Chapter 2:
Modelling Results and Forecasts

Table 3: Forecast workforce training requirements to 2025 in the target countries

Country	2021	2022	2023	2024	2025	Total
Brazil	3,537	<50	<50	<50	<50	**3,737**
India	7,777	2,593	1,583	451	569	**12,973**
Vietnam	4.426	<50	<50	499	339	**8,275**
	2,515	73	<50	<50	323	
Japan	2,048	88	88	616	110	**11,810**
	126	610	1,771	<50	6,389	
USA	38,397	770	660	10,697	1,100	**77,153**
	<50	4,905	3,334	10,851	6,389	
China	88,608	23,975	12,931	11,784	12,059	**219,546**
	61,364	6,869	683	399	784	
South Africa	1,315	88	88	1,767	176	**3,434**
Mexico	588	88	55	50	<50	**831**
Saudi Arabia	<50	988	<50	<50	1,261	**2,399**
Morocco	218	824	<50	<50	81	**1,223**
Total	**211,019**	**41,971**	**21,443**	**37,364**	**28,964**	**340,761**

Onshore Wind (dark blue rows) Offshore Wind (light blue rows)

Why GWO Training Standards?

The wind industry is experiencing exponential growth. While everyone agrees installation targets must be met to tackle climate change, rapid development must be aligned with careful management of the known risks and hazards faced by the technicians and engineers who help achieve our renewable energy goals.

GWO standards are the result of the industry's collective knowledge and continued learning about these risks and hazards. They provide a globally recognised system of safety and technical training courses that furnish our workforce with the necessary skills, knowledge, and attitude to conduct their work safely.

Without a system of safety standards that address wind energy's unique risk profile, employers may be forced to improvise or adapt training from other industries, or simply import their own programmes at considerable expense. With proper oversight and safety leadership by developers, OEMs and supply chain, this approach will often provide a satisfactory level of training. But once a project is completed and the workforce move onto their next roles, subsequent employers will have nothing more than a collection of resumes to judge. Most will be forced to re-train their workforce from the ground up, just to be sure their employees have the necessary skills in basic safety that cause injuries most often on a wind turbine.

GWO Standards are a credible solution to this problem because they can be validated and thus their increased availability is a priority for the wind industry's major employers.The forecasts in the tables above represent the number of people requiring GWO industry standard safety and technical training in each target market in each year of the forecast period. . Since the model accounts for a range of factors influencing the workforce size – and therefore its dynamic nature – the results reflect the volume of training required and the opportunity for training providers to deliver GWO standard courses that will keep pace with the installation and O&M activity over the forecast period.

Training needs forecasts

The modelling undertaken in this report allows us to forecast the GWO training requirements for each year up to 2025. These annual forecasts are presented in the data tables above by number of people requiring new training for a

GWO standards provide a globally recognised system of safety and technical training courses that furnish our workforce with the necessary skills, knowledge, and attitude to conduct their work safely.

specific set of wind project roles in construction and installation, operations and maintenance

The forecasts are based on full penetration of GWO standards; they assume a scenario in which the standards are accepted and adopted in all countries and on all wind projects at both construction and O&M stages. The forecasts reflect the number of 'new' workers that will need to be trained – assuming the same GWO market penetration as currently seen in Europe. Furthermore, the forecasts do not include the potential training demand should developers, particularly in those countries with limited GWO uptake, choose to adopt and migrate their workers to GWO standards. For large, established onshore markets such as the USA, these opportunities could be considerable.

The growth in onshore and offshore wind in all the target countries represent a significant opportunity for GWO and its global network of training providers. The volume of expected activity in the next five years is expected to require a significant ramp up in skilled personnel in each target market and provides justification for the expansion of the GWO network and the establishment of local training centres to support local supply chains and the development of skilled local workforces. It is also clear that the wind industry is in a prime position to make a significant contribution to social and economic development in each of the targets. countries, helping to deliver widespread benefits through the energy transition.

As noted in Chapter 4, the model assumes that the relatively free movement of workers between countries will continue over the forecast period (except to/from China, and to a certain extent the USA). Should the target countries pursue a strategy prioritising local content and employment – and therefore restrict the inward movement of international workers to meet the workforce demand – the in-country training needs could be even greater.

The forecasts do not include requirements for refresher training; any refresher training (for example, for the Basic Safety Training modules) requirements are in addition to these forecasts. Although some of the 'new' workers will leave the industry, retire or otherwise leave the workforce (which is reflected in the modelled forecasts), many will remain and will require periodic refresher training which represents a further opportunity for GWO and its training providers.

Finally, this forecast does not include the workforce needs for other segments of the wind project lifecycle, including in procurement, manufacturing (the most labour-intensive segment), transport and decommissioning or repowering. The wider workforce needs to deliver the forecast onshore and offshore wind energy fleet through 2025 are therefore larger than the training needs for construction, installation, operations and maintenance identified in this report.

Installation forecasts

The forecasts above are based on the following installation forecasts. The GWO Trained Workforce Forecasting Model uses capacity forecasts for all countries (where available).

Figure 3: Onshore Installations Forecasts (2021-25) - Growth Markets

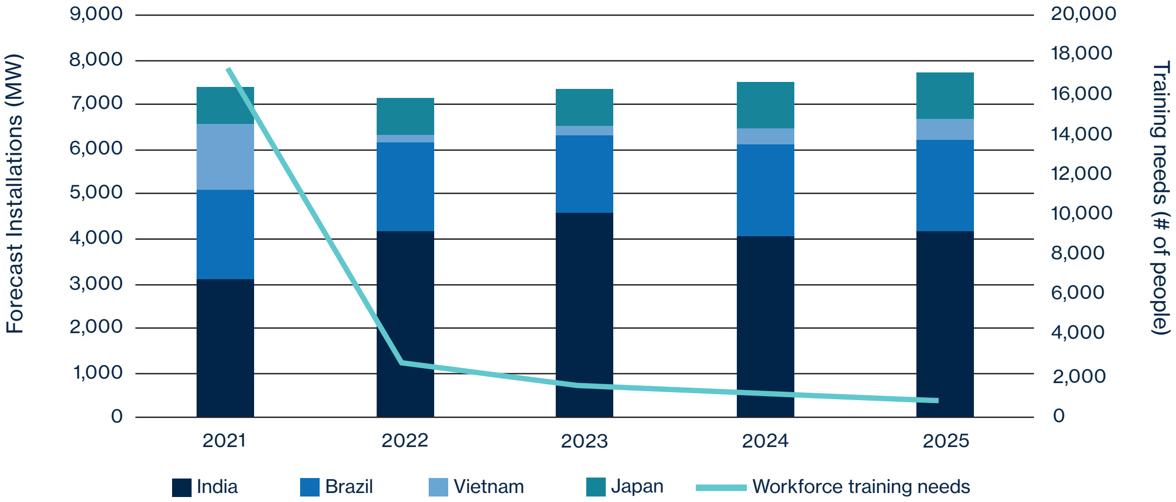


Figure 4: Onshore Installations Forecasts (2021-25) - Emerging Economies

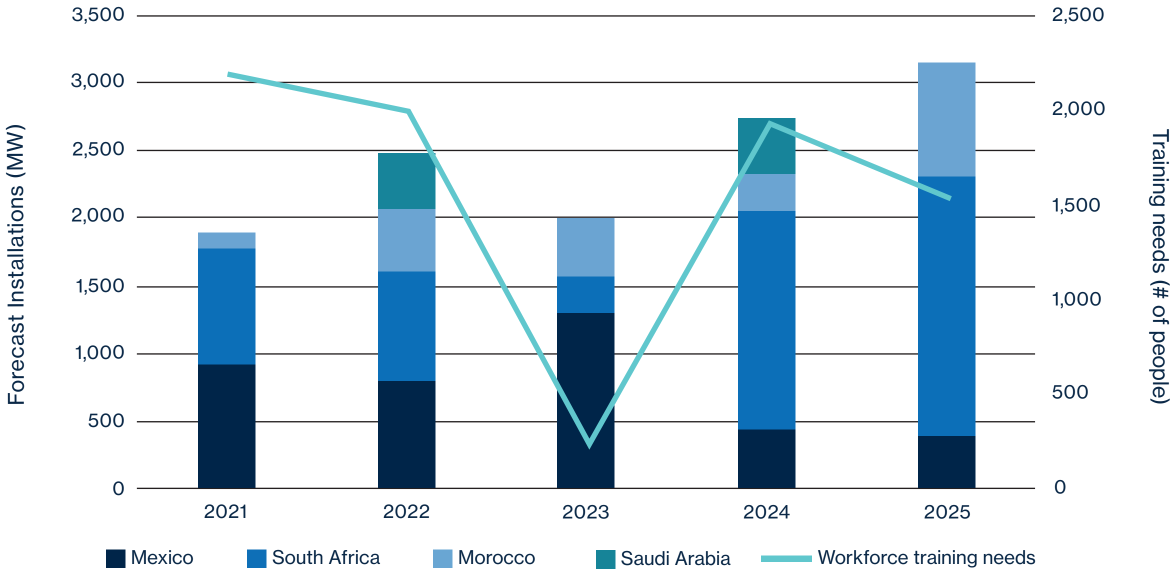


Figure 5: Onshore Installations Forecasts (2021-25) - Continental Markets

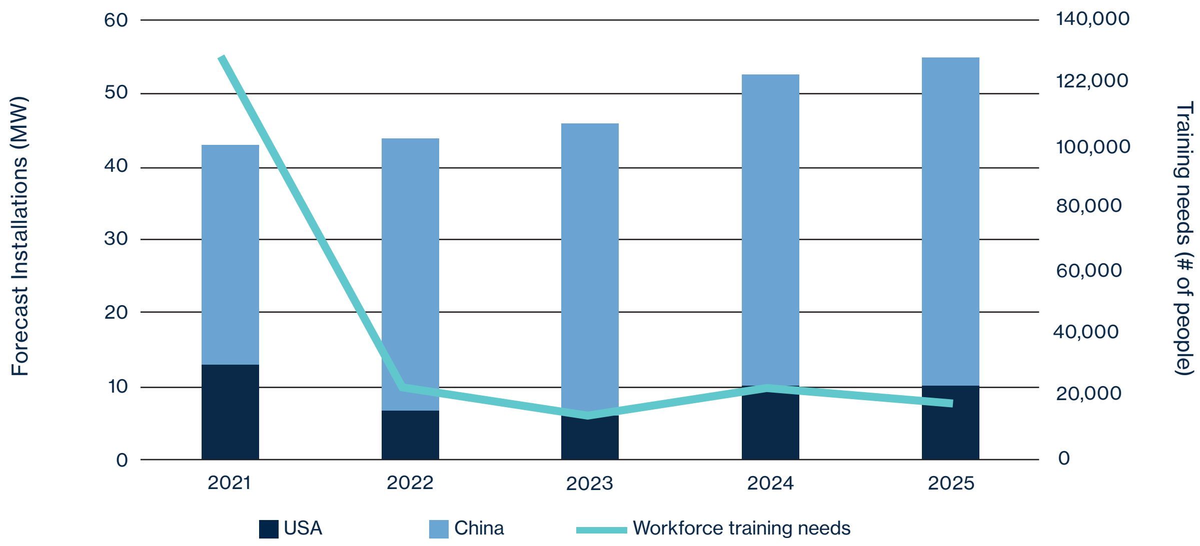
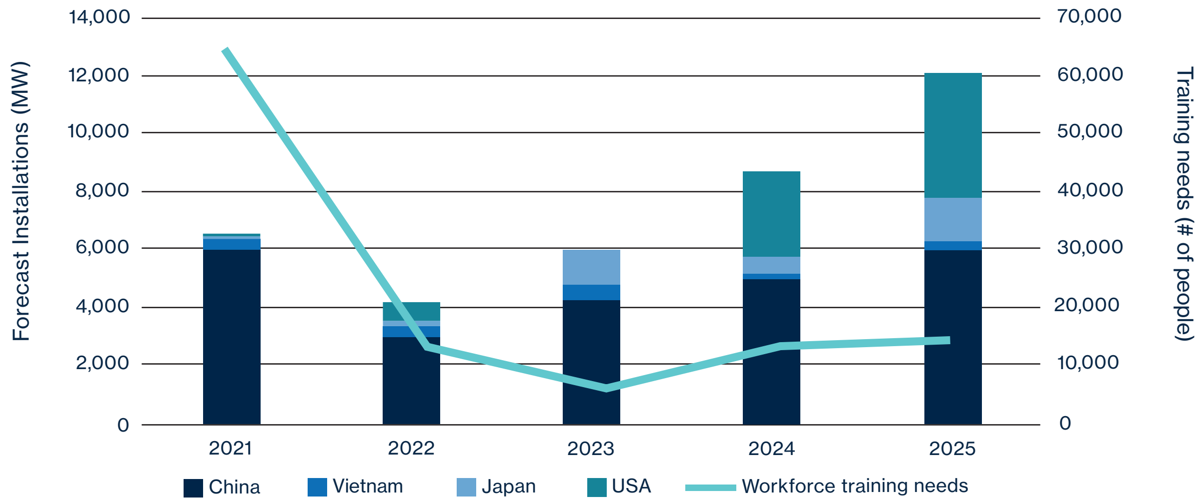


Figure 6: Offshore Installations Forecasts (2021-25)



Chapter 3:
Country Commentaries

In addition to the global forecast for training needs, this report also examined the training needs of 10 countries: Brazil, India, Vietnam, Japan, USA, China, South Africa, Mexico, Saudi Arabia and Morocco. These countries were selected for regional diversity, as well as spanning the largest onshore wind markets globally (USA and China), high-growth markets for onshore and offshore wind (Brazil, India, Vietnam and Japan) and emerging wind markets (South Africa, Mexico, Saudi Arabia and Morocco).

Together, the training needs in these 10 countries comprise 70% of the global wind energy workers requiring training for construction, installation, operations and maintenance activities over the next 5 years.

The following section outlines the wind market growth outlook for these 10 countries.

Brazil

Brazil remains one of the high-growth countries for onshore wind globally. Despite the impacts of the COVID-19 pandemic, Brazil ranked in the top 5 wind energy markets in 2020 with 3 GW of new installations. Wind is already the second-largest source of electricity in the country after hydropower. Over the next five years to 2025, Brazil is set to install an additional 9.7 GW of onshore wind, and its first offshore wind demonstration project could start spinning in the first half of this decade.

A wind leader in Latin America, Brazil has demonstrated the significant socioeconomic benefits and capital investments associated with the industry. In the windy northeast region, a robust domestic supply chain has developed for wind turbines and towers. The Government of Ceará has also signed an MoU with Mingyang Smart Energy for an offshore wind factory in the state and a pilot project off the coast of Pecém. While offshore wind is not set to take off during the period of interest for this report, more than 1,200 GW of offshore wind technical resource potential (and a project pipeline of over 32 GW) make Brazil an offshore wind market to watch. Offshore wind is expected to enter into the Brazilian market from 2027 (Ten-Year Energy Expansion Plan – PDE 2029), although Brazil currently has no specific offshore wind target, no clear leasing framework (or financial support mechanism) for offshore wind projects. New legislation concerning offshore wind is currently

being drafted which may address some of these issues.

The free market has emerged as a primary hub for onshore wind energy contracts, outpacing the capacity secured through auctions in the regulated market. Power sector modernisation, increasing corporate commitments to renewables and BNDES financing models, such as the “PLD de Suporte” initiative, have supported the growing free market pipeline.

The stakes are high for the top carbon-emitter in Latin America to accelerate deployment of wind energy. Brazil’s Paris Agreement goals aim for a 45% share of renewable energy in the energy matrix by 2030, including 23% derived from wind, solar and biomass power, and the government has announced an “indicative goal” for carbon neutrality by 2060.

GWO training in Brazil

Brazil is the fastest growing country in the Americas, with regards to both certification of new training centres and the volume of workers being trained. In 2020, the market grew by 101% and 13 training providers have educated a GWO trained workforce of over 5500 people.

As the table in Figure 3 shows, this represents one of the success stories of GWO standards establishing themselves in emerging wind markets. At current growth rates, Brasilian training providers may have enough capacity to meet demand according to current installation forecasts.

Vietnam

Vietnam is poised for more than 5.7 GW of onshore and offshore wind growth over the next five years. While it shares strong fundamentals with its Southeast Asia neighbours, including rapidly rising power demand and industrialisation, Vietnam’s excellent wind resource potential gives it an edge in the region.

Wind power currently comprises around 1% of Vietnam’s electricity production but is set to take off under the forthcoming master energy strategy, Power Development Plan 8 (PDP8) for 2021-2030 with a vision to 2045. Along with a high growth scenario for onshore and nearshore wind exceeding 16 GW total installed capacity by 2030, the draft PDP8 includes targets for true offshore wind for the first time, with a high growth scenario of at least 3 GW of offshore wind by 2030. There are over 60 GW worth of offshore wind

projects under development / consideration in Vietnam following applications for PDP 8, but the first true offshore wind projects are not expected to come online before the middle of the decade. It remains unclear whether an extension of the current FiT will be granted to projects commissioned beyond November 2021. Clarity on the FiT extension will be needed to enable the most developed projects to reach a financial investment decision.

Altogether, total wind installations are set to exceed solar PV capacity by 2045 under the draft PDP8 - reflecting the strengthening commitment from the government to growth of the wind industry. Other growth drivers include Resolution 55, which aims to open up opportunities for private-sector participation in the energy sector, and Document No. 828/BCT-DLL detailing implementation of long-term energy planning including wind targets and interconnection strategies.

To deliver this scale of growth, Vietnam will need to expand and modernise its heavily burdened transmission network, where grid congestion and the threat of curtailment are primary concerns for renewable energy developers. Improving PPA bankability will also be key, particularly as policymakers have expressed aims to transition from a Feed-in Tariff scheme to competitive bidding. Sufficient lead time and consultation with industry and investors will be needed for a smooth and transparent transition to auctions in the future.

GWO training in Vietnam

At time of writing, only one GWO training provider was at an advanced stage in certifying a training centre close to Ho Chi Minh City. Developers and OEMs requiring GWO training standards for their workforce training have often helped encourage a pipeline of certified training in other nascent markets however, barriers must be overcome if Vietnam is to align with global practice and meet its potential GWO trained workforce size.

India

While growth of wind installations has slowed in India, it remains one of the top markets globally for onshore wind, with 38.6 GW of capacity. Over the next five years, more than 20 GW of additional capacity is forecast to be installed, including the first 100 MW of offshore wind by the middle of the decade.

The government is targeting a 40% renewable energy share in the power mix by 2030, including 140 GW of onshore and offshore wind capacity. This would require the country's current operational wind inventory to swell by 3.5 times. But in 2020, India only installed around 1.2 GW of wind energy, due to significant challenges around grid availability, land allocation and power sale agreement signings.

The degree to which these issues are resolved will determine how close India can get to its wind targets this decade. A stretch target of 63 GW cumulative capacity by 2025 is within reach but would require the active pipeline to be commissioned on schedule and greater installations coming from the commercial and industrial sector. Regular hybrid tenders of wind/solar/storage and continued auctions for pure-play wind will also be needed to sustain wind growth, especially after the Interstate Transmission System charge waivers expire in 2023.

India's scalability and strong track record of manufacturing capacity has made it one of the critical export hubs for wind components and services in the Asia-Pacific region. Its domestic supply chain is extensive, making India one of the world's largest manufacturers of wind gearboxes, and the largest wind turbine production base in the region after China

Continued investments in India's wind supply chain from leading international OEMs will make wind energy a key sector under the current administration's "Make in India" manufacturing programme and Atmanirbhar Bharat initiative for self-reliance.

GWO training in India

By the end of 2020, more than 4500 people had a valid GWO training in India, thanks to the certification of 13 training centres. With a further 12,000+ trained people required by the end of 2025, the country is in an advantageous position to accommodate global standards but will need to triple availability of GWO certified courses and the centres themselves if it can keep up with demand.

Japan

Under its commitment to become a net zero economy by 2050, Japan has set high climate ambitions, bolstered by its recently updated Nationally Determined Contribution (NDC) under the Paris Agreement to reduce emissions by 46%

by 2030. The industrial powerhouse's transition from coal dependency will rely on wind power to provide increasingly large shares of clean energy to the power mix - particularly floating wind projects which will scale up towards the end of the decade.

Until then, around 6.4 GW of new wind installations are forecast in Japan through 2025, including more than 2 GW of offshore wind to be commissioned from 2022 onward. This adds to the roughly 4.5 GW of wind installations already installed in the country

The government has already recognised the economic opportunities attached to the shift to clean energy. Japan's Green Growth Strategy calls for investment in 14 key fields, from offshore wind to a strategic hydrogen roadmap. The Offshore Wind Industry Vision unveiled by the Ministry of Economy, Trade and Industry at the end of 2020 carried the banner target of 45 GW cumulative capacity by 2040. The vision outlined a clear plan to allocate 1 GW of offshore wind capacity annually through 2030, ramp up supply chain development and achieve a cost reduction pathway of JPY 8-9/kWh LCOE by 2035.

Centralised auctions for offshore wind have already begun rolling out in 2020. There are now over 30 GW worth of offshore wind projects under development / consideration in Japan following a highly active 18 months of activity. The environmental review process is time consuming and has, on average, taken 4-5 years. Officials are trying to push for a streamlined process; however, this is currently in progress. A number of projects are awaiting their EIA approval. Policymakers will need to learn from the challenges of onshore wind deployment, including overly complex permitting processes, availability of land for renewable projects, well-designed grid upgrades and the need to create efficiencies in data-sharing. A robust and competitive bilateral market could also accelerate renewables deployment among the country's large base of industrial power consumers. The next Basic Energy Plan, due in mid-2021, will reinforce the actions needed for Japan to achieve its vision.

GWO Training in Japan

The two training centres currently certified in Japan increased their activity four-fold in 2020, and the country now has almost 800 people trained according to GWO standards. In common with

other advanced industrial nations, where GWO has yet to fully establish (see USA, China) the absence of a global standard for safety and technical training has not necessarily prohibited growth, but the market can benefit from the twin objectives of increased productivity and reduced duplication by adopting one.

USA

With more than 122,000 GW of installed onshore wind at the end of 2020, the US is set to retain its global pole position as a wind energy leader, second only to China in cumulative installations. The country is also set to enter a new era of offshore wind deployment, with 42 MW installed to date across the Block Island and Coastal Virginia projects. The next five years through 2025 will see around 46 GW of new onshore wind capacity come online, in addition to just under 9 GW of commercial-scale offshore wind that already has a route to market secured scheduled to come online from 2023 onward. The total offshore wind project pipeline currently sits at ~44 GW, and with offtake auctions / solicitations already planned in New Jersey, Rhode Island, Massachusetts, Connecticut and Maryland over the coming months and years we expect the market to continue to make big strides forward.

The Biden Administration's stance on climate action has given the US wind industry strong tailwinds, underscored by the recent commitment to reduce greenhouse gas emissions by 50-52% by 2030 from 2005 levels. A centrepiece of the government's climate plans is the target to deploy 30 GW of offshore wind by 2030 - which aims to create around 77,000 direct and indirect jobs and forms a long-awaited recognition of the sector's national significance.

While the expiration of the Production Tax Credit for wind energy expiry after 2021 is expected to dampen deployment from 2022 onward, a series of presidential directives under Executive Order 14008 pave the way for wind growth. These promote wind by targeting a carbon-free electricity sector by 2035; prompting federal reviews of siting and permitting processes for renewable energy on public land; and directing federal agencies to eliminate fossil fuel subsidies and shift to investment in clean energy and infrastructure, among other measures.

Wind is already incredibly cost-competitive across the US grids, and system operators are now pursuing synergies with hybrid projects and storage technologies. Policy which can further level the playing field and ease market integration and interconnection rules can see wind energy take off over the next five years, bringing significant socioeconomic benefits to bear.

GWO Training in USA

Certified GWO training centres doubled in number and volume of courses completed in 2020, driven by an increased appetite amongst leading OEMs and owner operators who recognise the benefit of standards. With a target to reach 20,000 people in the GWO trained workforce by the end of 2022, the industry has set its sights on doubling capacity on an annual basis. However, current penetration remains modest, with 5425 people in the GWO trained workforce across the U.S.A and Canada at the turn of 2021. The Forecast Model's calculation of 38,308 required in 2021 alone demonstrates the challenge and the opportunity for businesses.

China

Among the world's largest economies and top emitters of greenhouse gases, China is demonstrating that wind energy can be a key pillar of system-wide decarbonisation and socioeconomic benefits. Over the next five years, China is on-track to install nearly 195 GW of onshore wind capacity and an additional 24 GW of offshore wind. This is in addition to its 278 GW of current onshore wind capacity - more than one-third of global installations, as at the end of 2020 - and its 10 GW of offshore wind operating across Jiangsu, Fujian, Guangdong and other provinces.

A Feed-in Tariff for offshore wind projects reaching grid connection will expire after 2021, prompting a rush to market amounting to around 6 GW in installations. After a small dip in 2022, deployment is set to return to the 6 GW level for offshore wind by 2025.

Onshore wind faces the pressures of grid parity from 2021 onward, with offshore wind soon to follow. Mechanisms which can level the playing field for cost-competitive energy sources like wind, such as phaseout of fossil fuel

subsidies and emissions restrictions under the newly established emissions trading scheme - a national carbon market of a monumental scale - can support the acceleration of wind deployment.

Already a major manufacturing hub for the wind industry, China's well-developed supply chain extends from towers to turbines to blades to brake systems. As a result, its wind energy labour force now amounts to more than half a million workers, a number which is only set to grow exponentially under the country's course to reach net zero by 2060. Further supporting China's reset course are provincial five-year development plans for renewable energy and timetables to reach peak emissions, as well as State Council guidance on low-carbon development.

GWO Training in China

The growth and availability of GWO training in China is being driven strongly by OEMs, with Vestas, Siemens Gamesa, GE Renewable Energy, Goldwind and Shanghai Electric all operating certified training centres. With owner operator CGN Windpower also opening a centre in 2020, the top-down approach to developing certified facilities is a characteristic that is likely to continue as other large employers join the system. However, in order to meet its truly vast workforce training requirements, the supply of standardised training may not be possible through the work of these companies alone. Goldwind opened its second centre in 2021 and has single-handedly trained almost 2000 people to GWO standards in less than two years. Only with several dozen training centres of this kind of scale will the Chinese market match its ambition.

South Africa

South Africa has long been Sub-Saharan Africa's largest and most developed wind energy market. Despite a period of political uncertainty over the last half decade which stalled progress, there is currently 5,648 MW of onshore wind forecast from 2021-2025, according to GWEC estimates. Moreover, the country's recent 'net-zero' commitments will continue to drive growth.

In 2020, the government approved the Low Emission Development Strategy (LEDS), which commits to various interventions which ultimately move towards a goal of net zero carbon emissions by 2050. National utility Eskom, the

in principle to net zero emissions by 2050 and to increasing its renewable capacity.

The increase in renewable energy capacity is prioritised in South Africa's key planning documents, including the National Development Plan which commits to 30 GW of renewable energy by 2030. It is supported by the Integrated Resource Plan (IRP) 2019 which prioritises renewable energy, energy efficiency and public transport, and specifically targets 20.4 GW of renewable energy (14.4 GW of wind and 6 GW of solar PV) by 2030.

The key consideration for South Africa's net zero trajectory is the reduction of demand for coal resources, which has provided an economic anchor for provinces like Mpumalanga. The IRP 2019 stipulates that, to ensure a socially just transition, an engagement process must mitigate against adverse impacts of plant retirement on people and local economies.

Although IRP 2019 extends to 2030, it is assumed that wind power will constitute an even larger share of new generation capacity beyond this decade. To meet the net zero target by 2050, energy planning policy will need to be implemented consistently. This goal will require action and coordination from private and public sectors to be successfully realised. Necessary actions from government include easing the regulatory environment, implementation of approved policies and creating a conducive environment for private sector investment.

GWO Training in South Africa

A challenging 2020 in which the pandemic forced several training providers to shut their doors meant a small drop in activity from South Africa's five certified training providers. Nevertheless, a GWO trained workforce of more than 1600 people by the end of 2020, and more than 500 people trained or retrained in the first four months of 2021 indicates this market may match the Forecast Model's predictions this year in which just over 1300 people will be required to meet predicted installations.

Mexico

During the last decade, Mexico demonstrated renewable energy leadership by setting an ambitious target of 35% renewable energy in the power mix by 2024, enshrined in the 2015 Energy Transition Law, and conducting a successful clean energy auction programme. The auctions from 2016-2018 resulted in US$9.7 billion in new investments and more than 8GW of new wind and solar capacity secured at extremely low prices.

According to GWEC estimates, there is 3,075 MW onshore wind forecast from 2021-2025, but recent measures undertaken by Mexico's current administration have stalled growth in this leading wind market in Latin America. Developers and investors in wind and solar energy have faced deeply unfavourable market conditions over the last two years, resulting in a dramatic "bust" of clean energy investment and installations since 2019.

In response, legal challenges to government have been initiated by the private renewables sector. Further hurdles for clean energy development and generation will result in stagnation of investment in Mexico's renewable energy sector. This situation has put jobs at risk, not only in the wind and solar industry which counts at least 17,000 workers in Mexico, but also in the wider value chain of industrial and commercial sectors which are committed to sustainable energy.

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However, in a positive turn for Mexico's renewables industry, a Mexican court ordered a definitive suspension of the government's contentious new electricity law in a ruling published in March 2021. The definitive suspension comes a week after a judge ordered a temporary freeze to the legislation passed by Congress this month, citing competition concerns.

GWO Training in Mexico

Mexico was a pioneer in Latin America, with three training centres certified in 2016 and a further seven joining over the next four years. Volumes of GWO training peaked in 2018 and have remained at broadly the same level, maintaining a GWO trained workforce in Mexico of some 3734 people at the end of 2020. With the country's forecast installations appearing to stall, current capacity may be adequate to meet demand.

Saudi Arabia

The Kingdom of Saudi Arabia (KSA) is in the midst of a historic shift. Over the last decade, KSA launched an ambitious, multifaceted plan to transition from reliance on hydrocarbons. Vision 2030, launched in 2016, is the blueprint for this ambitious national development programme, based

on KSA's investment power to create a more diverse and sustainable economy. The sheer scale and scope of KSA's vision has attracted global attention, leaving observers to wonder what can be realised within proposed timelines. A key part of Vision 2030 is the King Salman Renewable Energy Initiative.

The National Renewable Energy Programme (NREP) most recent target is 58.7 GW of renewables by 2030, of which 16 GW is wind. The interim target is 27.3 GW by 2023 of which 7 GW is wind. Saudi National Grid Company's CEO recently stated that KSA expects to attract more than $20 billion in renewables investments by 2030.

The Renewable Energy Project Development Office (REPDO) will make 30% of KSA's capacity additions via IPP auctions. REPDO's first wind auction in 2018 awarded the 400 MW Dumat al-Jandal wind project to Masdar (UAE) and EDF-EN (France). The $500 million project – the most cost-efficient wind energy project in the world and largest Middle East wind farm – is a big step for the sector. The project's tariff of $19.9/MWh attracted considerable attention, and turbine erection is underway, with commercial operations expected Q1 2022. REPDO announced plans for an 850MW wind farm in Yanbu, as part of NREP's fourth round, and plans to build 35 more wind farms by 2030.

As wind energy in KSA finds its feet, new growth opportunities for the technology are on the horizon. A new $5 billion green hydrogen project in Neom, the 100% renewables "smart city" in Tabuk Province, is a case in point. This will be the world's largest green hydrogen project powered by 4 GW of wind and solar. It involves a partnership between ACWA Power, the Kingdom's largest IPP, and Air Products and Chemicals. A proposal for a 500 MW floating offshore wind farm is also in development.

GWO Training in Saudi Arabia

No training providers have certified in the region to date and with a GWO trained workforce requirement of 2400 people by 2025, the opportunity for providers will be to deliver an industry standard product in an as yet untapped market. Similar sized workforces have been trained in countries such as Taiwan over just two calendar years, at a handful of certified training centres so the potential for large institutions to educate people in large numbers may be preferred.

However, the country's geography may play a part, with siting a key factor in the long-term viability of any investment decision.

Morocco

Morocco is the undisputed wind energy leader in North Africa, and one of the most advanced renewable energy markets on the African continent. Demand for electricity in Morocco has grown rapidly (6-7%) annually in recent years and estimates suggest that the country's installed generation capacity will need to triple to meet rising demand.

The 2009 National Energy Strategy set out an ambition for 42% of the total installed power capacity to come from renewable energy in 2020. This was expected to require the commissioning of new plants to bring the total capacity to 2,000 MW of solar, 2,000 MW of wind and 2,000 MW of hydro by 2020.

In 2015, Morocco announced a further planned increase in the renewables capacity to reach 52% of the total by 2030 (20% solar, 20% wind and 12% hydro). To meet the 2030 target, the country aims to add around 10 GW of renewable energy capacities between 2018 and 2030, which includes 4,200 MW of wind.

Looking further, GWEC forecasts 1,426 MW onshore wind from 2021-2025, and there is still significant growth potential, both onshore and offshore. According to a 2019 World Bank Group study, Morocco has 200 GW of offshore wind technical potential across 22 GW of fixed-bottom and 178 GW of floating capacity. Regional synergies, in terms of interconnectors and supply chain efficiencies with Europe, are also being developed and reinforce the strong growth forecast for wind energy in the country.

At present, Morocco's wind industry is at work delivering the 1,426 MW project pipeline, which continues to position wind energy as a significant source of local employment. These projects are being developed as public-private partnerships under build-own-operate-transfer models, supported by key government institutions - the National Offices of Electricity and Drinking Water (ONEE) and the Moroccan Agency for Sustainable Energy (MASEN).

GWO training in Morocco

The Forecast Model indicates Morocco's need for a GWO trained workforce is higher in the short term, with most of its planned installation taking place during 2022 and 2023. Morocco may be able to rely on established connections with training supply in southern Europe, particularly in Spain where over 60 training centres are established. However, OEMs have expressed a clear desire to see training made available locally as a means of developing a sustainable supply chain there.

Chapter 4:
The GWO Workforce Training Forecasting Model

Basis and Introduction

The GWO-trained workforce represents a pool of people, trained according to industry standards set by the world's largest employers in the wind energy industry. At the turn of 2021, this workforce numbered just over 100,000 people, trained in 42 countries.

To support the projected growth of the global onshore and offshore wind industries, a supply of well-trained people is required, GWO commissioned this model to bridge the gap in knowledge between current and projected availability of training.

The model uses data on GWO training delivered during a fixed reference period[3] (Calendar years 2019 and 2020) and combines it with data on the installed capacity (including capacity added and the flux in construction activity) over the same period. This relationship is applied to forecast capacity installations to calculate the associated workforce requirements. The model generates country-specific workforce forecasts based on built-in capacity forecasts, where available, although the model functionality allows the user to enter their own forecasts and timeframes to explore alternative scenarios.

The model is built around the assumption that historic training data provides a robust baseline from which to forecast future training requirements, subject to adjustments applied in the model. Onshore and offshore forecasts are calculated separately to account for differences in the available input data and the adjustment factors that need to be applied. The model currently assumes limited transfer of personnel between the onshore and offshore sectors.

The primary purpose of the forecasting model is to understand the volume of training that the network of GWO training providers will need to deliver to ensure the global wind industry is resourced with trained and competent personnel. The output forecasts are therefore of 'GWO trained personnel'. GWO training is not intended for all job roles, particularly in the construction phase, and is primarily aimed at personnel working on or in wind turbine generators. For the offshore industry, the GWO Sea Survival module is intended for personnel transferring onto offshore structures. It should be noted, therefore, that there is a component of the overall wind workforce who do not typically undertake GWO training – examples include vessel crews and foundation and cable installation teams. The same caveat applies to the onshore workforce.

As a result, the forecasts generated by the model and presented in this report reflect the number of workers GWO training providers can expect to train and therefore only part – albeit a significant part - of the overall workforce. Other industry reports have sought to calculate the total job creation potential of the wind industry and that work is not repeated here. Furthermore, the generated forecasts indicate the potential demand for GWO training. Realising this potential will depend on the recognition and adoption of GWO training in each market and the availability of training providers to meet demand. The model does not yet account for refresher training, so the forecasts essentially represent 'new' workers joining the industry.

The model is intended for use by GWO member organisations who are the legal duty holders for workforce safety on site at windfarms around the world. They rely on an increasingly large network of GWO certified training providers to deliver industry standard safety and technical training. The training providers themselves require business intelligence to help match supply and demand. To ensure continued accuracy, the model will be regularly updated with new baseline data and refined as additional information on the assumptions made becomes available. A summary of the model is provided in Figure 1 below. Outputs from the model are presented and discussed later in this report.

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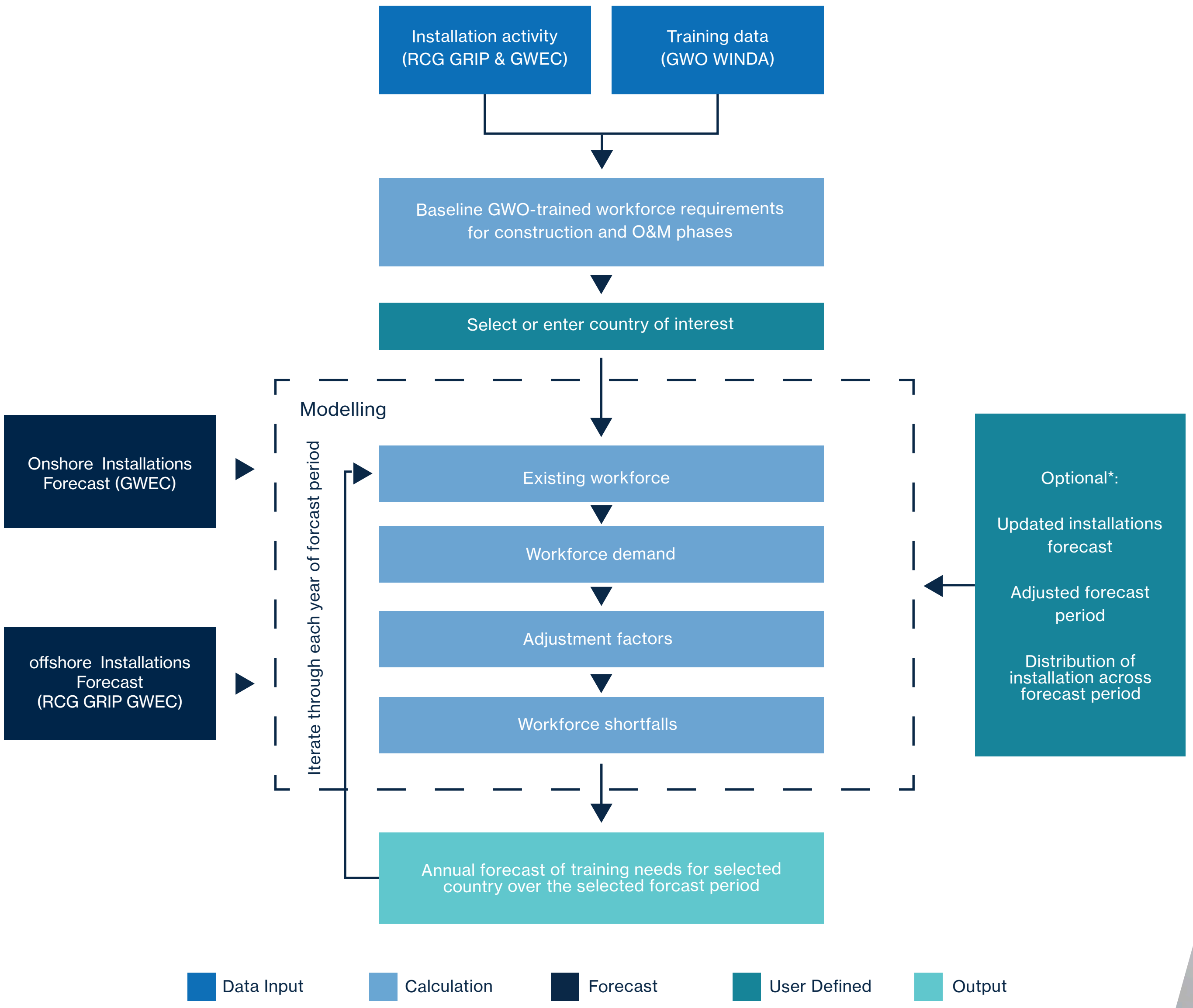
3 *2019 and 2020 are the only full calendar years for which WINDA data allows us to calculate the complete workforce size. Delegates with valid training in 2018 may have completed their last refresher course in 2016, before the introduction of the database. They would not therefore be captured in the workforce calculation, resulting in an underestimate.*

Figure 7: Summary of the workforce forecasting model



** The model includes built-in forecasts and project data which is used in the calculation unless the user enters their own data to test alternative scenarios. The default forecast period is to 2025 for onshore and to 2030 for offshore. Changing the forecast period presents an updated total workforce training requirement for the chosen period*

Data Inputs

The following data is used as the model inputs. In each case, data is for the European wind market where GWO training is well-established and where the relationship between trained personnel and installed capacity is most reliable. The data was supported by the perspectives of GWO and a sample of GWO training providers.

GWO training data

The model uses the GWO Sea Survival module (part of the GWO Basic Safety Training) as a proxy for the number of persons trained to work offshore and, since there is no equivalent proxy for onshore, assumes that persons without a valid Sea Survival certificate – and therefore not eligible to work offshore - constitute the onshore workforce. Although people holding a Sea Survival certificate could in theory switch to work onshore, the sectors are distinct and the exchange of personnel between them is assumed to be limited.

While the data is anonymised and does not give us specific details on each delegate, it naturally reflects the continuous flux in the workforce resulting from departures (retirement, career change or moves to roles where GWO training is not required) and new entrants. Workforce retention, turnover, speculative training and other influences on the workforce size and therefore captured in the dataset. By calculating the workforce size monthly over a two-year reference period, these factors are incorporated in the model calculations by default. While the data used is from Europe only, it is assumed that such patterns will be replicated in the forecast markets.

RCG GRIP offshore installations data

The RCG GRIP database contains data on over 1000 offshore wind projects at all stages of the project lifecycle and in all major offshore wind markets. Where known, the data includes major milestones – such as start and end dates for the construction phase. GRIP data was used to identify projects under construction at any point during the reference period, allowing us to estimate a monthly 'capacity flux' – the rise and fall in construction activity (measured in MW) across the reference period.

The GRIP data also enables us to estimate the proportion of the workforce engaged in O&M activities with reference to the capacity and number of turbines for all operational offshore projects in Europe. GRIP also includes capacity and turbine information for proposed projects, where publicly available.

GWEC onshore installations data

GWEC data on annual onshore installations during the reference period was similarly interrogated to estimate monthly construction activity. Since this dataset comprises only annual installed capacity data, the added capacity was assumed to have been evenly spread across the reference period, providing a two-year average installations rate, rather than a more dynamic 'capacity flux' estimate as available for onshore.

GWEC data on total installed capacity was used to estimate the O&M workforce with reference to typical turbine sizes and project capacities.

Establishing the Baseline

The model includes built-in baselines which correlate the capacity added over time against the size of the workforce, using the data inputs described above.

Training data for the reference period was extracted from the GWO WINDA database. Coding was developed to calculate the total workforce size and to allow the number of people with a valid certificate for a specific GWO module to be calculated on any given date. In simple terms, the code interrogates each unique WINDA delegate ID and looks at the certificate award and expiry dates for the module in question (including refreshers) to determine the validity of the qualification on a specified date.

Counts of the total workforce size and of the number of people with a valid Sea Survival certificate allow us to calculate the size of both the onshore and offshore workforces monthly throughout the reference period.

For the offshore part of the model, RCG GRIP data (project milestones and number of turbines) is used to estimate the number of personnel employed in operations and maintenance (O&M) roles using fixed ratios of persons per project and per turbine. This value is subtracted from the offshore workforce total to derive an estimate of the construction workforce.

The 'GWO-trained workforce equation' plots the construction workforce against the capacity installed each month. This yields a linear relationship and consequently a fixed ‘persons per MW’ ratio. This value is a measure of the number of GWO trained personnel (or, more accurately, the number of unique WINDA IDs) required to construct each MW of added offshore capacity.

The ratio aligns closely with that derived for Powering the Future and reinforces the conclusions of that report. However, the calculation behind it is more robust and more appropriate to modelling workforce requirements now and into the future. Note that the workforce equation can and should be updated periodically to incorporate updated GWO training data and ensure the model captures any emerging and evolving workforce trends.

For the onshore part of the model, GWEC capacity data is similarly used to estimate the number of O&M personnel. However, since project-specific data is limited, the model uses an estimated average project capacity and turbine size to derive the O&M workforce estimate . This value is subtracted from the onshore workforce total to derive an estimate of the onshore construction workforce.

The ‘workforce equation’ for onshore simply calculates the ratio of the annual capacity added against the average construction workforce size during the reference period to derive an equivalent ‘persons per MW’ ratio. Should monthly installation data become available, the onshore baseline can be refined in a future version of the model.

In both cases, the model reincorporates the O&M personnel later in the calculation, as described under Model Functionality below.

Model Functionality

For forecasting future global training requirements, the model reverses the workforce equation to calculate the annual construction phase workforce demand for each country where a capacity forecast is available . This calculation is the same for both onshore and offshore workforces:

Forecast installations (MW) x Workforce ratio (persons/MW) = Training needs forecast (persons)

One of the key factors influencing the actual training requirement in each country is the movement of workers. While most major wind markets are seeking to establish local supply chains and workforces, there is often some reliance on overseas expertise and labor, particularly in the early stages of wind deployment. For small countries, the number of projects may never reach critical mass for establishing a truly local industry, except at O&M stage. The offshore industry continues to see a frequent exchange of competent workers between projects, countries and continental regions.

To account for the movement of workers between countries, the model introduces the concept of ‘free workers’, calculated as the difference between the total workforce size in a specific year and the workforce demand (the number of persons required to install the forecast capacity) in that year. It is assumed that all trained workers at the end of 2020 were employed. However, should forecast installations in a particular country subsequently fall, the model places the excess workers in a ‘free worker’ pool. The size of the global free worker pool is calculated by summing the excesses in all countries with known installation forecasts. The workforce size in each country is estimated from GWO data, based on the location of the training centres at which the training was completed.

The model then evenly distributes the free worker pool among those countries where there is a calculated shortfall between trained personnel and the estimated workforce demand. The model currently does not account for the actual likelihood of workers transferring between specific pairs of countries due, for example, to language skills or cultural preferences. It should be noted however that the size of the free worker pool compared with the overall workforce is small in an industry seeing continued growth in most countries so the impact on the forecasts is not expected to be significant.

The free worker pool recognises the widespread movement of trained workers between countries to ‘follow the work’. The model considers the barriers to migration – and therefore restricts redistribution of the free worker pool between certain regions. For example, the model conservatively assumes that minimal movement of workers into the US market will be permitted due to local immigration policies and local content and employment requirements placed on US projects. Conversely, countries in the APAC region are more open to importing skilled personnel as a means of establishing and building their local wind industries so the model permits movement from, for example, Europe into APAC countries.

Note that in developing the model, a broad regional approach to the redistribution of 'free workers' has been taken, although country-specific profiles could be developed and incorporated into future versions of the model. The onshore part of the model further restricts the movement of 'free workers' since the movement of onshore workers between countries is less widespread than in the offshore sector. Onshore activity is, to a certain extent, contained 'in country' with a greater emphasis on local workforces and supply chains.

The model also applies adjustment factors to consider:

- Abandonment of the industry by those 'free workers' who are not able to seek employment in other countries (and are thus not 'free workers')

- Continual reduction in the 'persons per MW' value (for both construction and O&M) as average turbine size increases (offshore only). Developers and operators typically calculate workforce requirements based on numbers of turbines, rather than per MW, since the on-site effort to install each machine is reasonably constant, regardless of its size. Estimates of projected turbine size for future projects allow us to apply an annual percentage reduction in the workforce equation over the 2021-30 period based on a generic 1GW project.

- Market penetration of GWO training. We estimate that GWO training is applied to 80% of construction and O&M activity. An adjustment factor is included to forecast training needs based on 100% penetration – i.e., the best-case scenario.

- The less international nature of the onshore industry. This factor reduces the number of workers entering the free worker pool and therefore limits transfers to other countries.

The model iterates through each year of the forecast period (set at 2030 for offshore and 2025 for onshore), calculating the workforce demand and free worker pool, applying the adjustment factors and redistributing the free worker pool, to arrive at a per-year estimates of construction phase training needs in the country of interest.

The O&M workforce requirement is not subject to the free worker redistribution - and are added back into the demand forecast once the construction workforce calculation is complete - because O&M workforces are likely to consist of locally recruited personnel with limited movement between projects and countries. Therefore, even if the construction demand is met by international workers from the free worker pool, the model will always generate a non-zero training needs requirement to account for O&M personnel.

The O&M workforce consists of 'new' O&M workers required to operate the added capacity in each year plus the existing workforce employed on operational projects.

The O&M workforce is calculated using known or estimated turbine sizes, counts and project capacities. For offshore wind, the known or typical turbine and project size for future projects is considered – these can be adjusted by the model user. 'New' workers form part of the 'existing' O&M workforce in the model calculations for subsequent years.

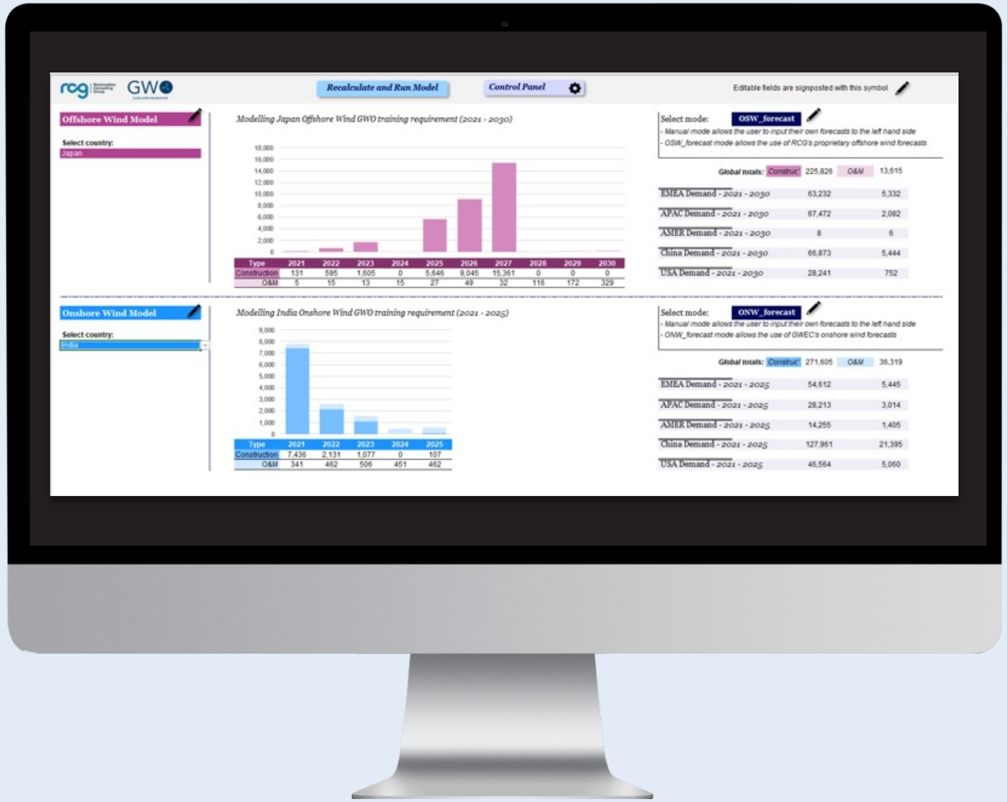
Finally, to ensure the forecast accounts for turnover of personnel, an annual adjustment factor is applied to the training needs for the existing O&M workforce. Turnover for construction personnel is contained within the baseline 'persons per MW' value.

Limitations

This model represents a significant evolution of the forecasting methodology presented in Powering the Future. Many of the limitations identified in that report have been addressed through the model – or are not considered relevant to its purpose. However, as a 'beta' version, the model has some limitations, each of which are opportunities for future refinement. However, RCG, GWO and GWEC remain confident in the forecasts and the conclusions drawn from them.

The key limitations stem from the relatively short reference period – although no significant fluctuations in the workforce equation (persons per MW) were found – and a lack of data on actual patterns of migration between the various wind markets. The model assumes a high degree of integration of the global wind industry (particularly for offshore wind) and the model does account, in broad terms, for differences in ease of movement between countries. However, there is an opportunity to gather more data on the ease of movement between pairs or groups of countries, 'local content' policies aimed at building local supply chains and workforces, and the proportion of GWO trained personnel who take up employment in countries other than where they completed their training.

The model will be subject to ongoing refinement to build-in additional baseline and project data and reduce any uncertainty in the results.



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