
GWEC | GLOBAL WIND REPORT 2023



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Word from the Chairman

COP27 may have concluded with the target of 1.5C in critical condition, but the global commitment to renewable energy is stronger than ever. Meeting the objectives of the Paris Agreement calls for us to halve global greenhouse gas emissions by 2030. That's less than seven years to replace swathes of high-emission technologies with zero- or low-carbon alternatives. In terms of energy, this means leaving behind a traditional system designed around fossil fuels and installing a new one – as fast as we can.

Aiming for 61% of total electricity generation to come from renewables by 2030, the IEA estimates that renewable energy capacity will have to triple, and that most of this growth is to come from wind and solar PV.¹

Scaling up renewable energy is key to the energy transition. Beyond the installation of renewable power, this also means installing transmission lines, building grids and storage solutions, and rolling out technologies that enable system flexibility.

Delivering to this demand requires stronger supply chains across the renewables industry – just at a time when supply chains are threatened by inflation, rising interest rates, geopolitics and bottlenecks.

Investments in wind in 2022 decreased in Europe, the Americas, the Middle East and Africa. The only exception was the Asia-Pacific region. This marks a paradox during a period when various crises are disrupting energy security and climate deadlines are drawing closer. Wind energy has never been more needed: it builds energy security, lowers the cost of electricity and supports decarbonisation. Last year's investment trends exemplify how faster political action is now critical.

This year is crucial for strengthening the supply chains that bolster renewable energy. Healthy industries require thriving markets. At present, permitting and grid bottlenecks are limiting volumes to a crippling degree. Profitable companies must be able to set cost-covering prices. Policies must seek a balance between cost-competitive electricity, viable

projects and healthy supply chains.

In the current environment, prices are often pushed to their minimum, while technical and sustainability requirements increase costs in parallel. Renewables depend on a skilled workforce, access to raw materials, infrastructure and low-cost financing.

Most market outlooks forecast an imminent increase in demand for renewables. Policymakers in major renewable energy markets have begun to address the current challenges by supporting the companies that will be driving the renewables scale-up.

The USA's Inflation Reduction Act, Europe's Green Deal Industrial Plan and China's Five-Year Plan are all clear examples of increasing political momentum. This welcome news can bring concerning underlying issues with it. The global wind industry's strength is its global footprint. Opening a subsidy race in support of loosely defined clean energy transition technologies while increasing protectionism would come at a huge cost – to industries and societies.



Morten Dyrholm
Chairman, Global Wind Energy Council

It is time for governments to realise that serious climate change mitigation and sustainable energy security go hand in hand. Governments must also accept that a thriving renewables industry is the first step to addressing both. Decarbonisation is too big a challenge for one country or region alone to overcome: only by working together can we unlock the acceleration needed to achieve a clean energy transition. GWEC and its members have an important role to play in supporting sound policies, collaboration and action. I look forward to doing just that.

1. <https://www.iea.org/reports/world-energy-outlook-2022>

We must invest in supply chain to build the next TW

The coming years will mark a crucial transition period for the global wind industry. Later this year, wind energy will reach the historic milestone of 1 TW of installed capacity. It has taken us around 40 years to get here.

However, the next TW will take less than a decade. The energy and climate policies now being pursued by the world's largest economies in both the 'West' and the 'Global South' point to a whole new level of ambition and support for wind energy and renewables.

These policies are likely to take us to 2 TW of installed wind energy by the end of 2030. They are the consequence of growing urgency in the fight against dangerous global heating; prolonged high fossil fuel prices and the impact of fossil fuel dependence on security; and the success of our industry in scaling up and establishing wind as one of the most cost-competitive and reliable power sources in the world.

While the industry pushed through the new level of 100 GW of annual installations in 2021, the last few years have not been without their challenges. Many of the manufacturers at the heart of the industry have seen mounting financial losses caused by 'race to the bottom' pricing, as a result of misguided government policies around procurement and offtake arrangements, exacerbated by higher inflation and logistics costs. Meanwhile, wind projects have been delayed or stalled by inadequate and inefficient permitting and licensing rules, from Denmark to India to Japan and beyond.

This has created the bizarre paradox of energy markets rewarding fossil fuel companies with record profits, while renewable energy companies have struggled to break even. As this report shows, while companies have regrouped to adapt to the new inflationary pressures, the market has stalled, and the industry installed only 77.6 GW in 2022.

All this has come at a time when policymakers are racing to address the energy and climate crises by dramatically increasing their targets for wind energy across the world.

The situation, however, is about to change and 2023 will mark the start of a decisive turnaround. Governments of all the major industrialised nations have enacted policies that will result in a significant acceleration of deployment.

In the US, the Inflation Reduction Act has completely changed the rule book for both onshore and offshore wind, while in the EU, policymakers are racing to introduce new rules and regulations to enable the huge increase in deployment that the REPowerEU plan foresees. In China, unstoppable momentum behind the energy transition continues, and the end of COVID-19 restrictions will see the return of faster economic growth. Large emerging market



Ben Backwell
CEO, Global Wind Energy Council

economies such as Vietnam and the Philippines are enacting new plans for wind, the sleeping wind power giant of India seems set to pick up the pace, and Brazil will continue to establish itself as a wind energy powerhouse.

By 2024, GWEC expects onshore wind to pass the 100 GW annual installations mark, while offshore wind will install more than 25 GW in a single year for the first time in 2025, and installations will accelerate rapidly after that.

Market conditions will change, as countries and regions will have to compete for badly needed



investment in their wind sectors: who gets the investment will depend on who has the most attractive market conditions and the most efficient regulators. For power equipment – and this includes key commodities such as copper and rare earth elements (REEs), power transmission equipment, wind turbines and offshore installation vessels – market dynamics are likely to change from buyers' to sellers' markets as supply chains struggle to keep up with demand.

According to the data in this Global Wind Report 2023, spare capacity in the wind energy manufacturing industry is likely to disappear by 2026. For some inputs and in some regions, the squeeze will be felt before then. Both Europe and the US are facing the risk of supply chain shortfalls, and these could be worsened by policies aimed at reshoring manufacturing away from China and protecting local industry and jobs.

As this report shows, while creating more diversity and resilience in the supply chain is an important and necessary objective, decision makers will have to design policy very carefully to make sure that it allows the fair exchange of essential

inputs for the energy transition, fosters innovation and keeps costs from rising unnecessarily.

In order to ensure that the wind industry is able to meet the expectations of policymakers and society at large, it is essential that we start investing in new capacity and

facilities, from South Korea to the US to Poland.

Much more is needed, and fast. The wind industry will need to forge new partnerships with governments, cities, communities, investors and customers in order to enable the next era of growth.

The wind industry will need to forge new partnerships with governments, cities, communities, investors and customers in order to enable the next era of growth

plant, and in training and skills, right now. Otherwise, we run the risk that we will not be able to deliver our promises, policymakers will turn to other, less efficient alternatives, and society will fail in its climate goals.

This may sound counterintuitive in an environment where companies have found it difficult to keep their businesses viable, but it is a challenge we cannot ignore. Thankfully, the sector's leaders can see the opportunity ahead, and companies are already investing – despite the highly unfavourable conditions of the last few years – in new manufacturing

Working together, we can put into place the right policies, which will allow trillions of dollars in investments to flow and the creation of millions of jobs.

As a starting point, we need to leave the hesitancy of the past behind and adopt a new mindset in our industry. The wind industry is no longer the hobby sector of forty years ago. Our technology is resilient and mature, and is poised to play a unique role in the energy transition. Now, in order to deliver on the promises we have made, we need a confident wind industry that is capable of moving boldly ahead.

Brazil's wind power revolution

In Brazil, we are living in a time of great excitement and renewed hope in our potential and in the future. The new government of President Luiz Inácio 'Lula' da Silva is resuming work on key issues that were abandoned in recent years, such as the fight against climate change, protection of the environment – especially the Amazon – and the reduction of social inequalities. These are matters dear to the wind sector, which positively impacts society from an environmental, social and economic point of view.

The Brazilian wind power revolution has been under way for some years now. The industry achieved 25.6 GW of installed capacity in 2022, with wind energy now holding a firm position as one of Brazil's strongest energy generation sectors. In addition to the continued growth of onshore wind, we have great expectations for the development of Brazilian offshore wind.

IBAMA, the Brazilian Institute for the Environment and Renewable Natural Resources, has already received project proposals for

more than 170 GW of offshore wind energy. This number is equivalent to practically the entire Brazilian electricity matrix and shows the extent of investor appetite and the enormous potential for offshore wind in Brazilian waters.

There is not enough demand for that amount of electricity, however. That's where green hydrogen comes into play. Coupling this technology with the enormous potential for offshore wind could consolidate Brazil's standing as a renewable energy superpower building on its already advanced wind energy supply chain and wider industrial and maritime capabilities.

The renewable resources available in Brazil, especially its abundance of quality wind both onshore and offshore, are certainly unique in the world. This opens a window of opportunity for the production of green hydrogen, which would have the capacity not only to revolutionise Brazil's energy matrix – already one of the most renewable in the world – but also to export green hydrogen to other

countries that may not be able to produce all the renewable energy they will need to meet their energy transition goals.

Brazilian companies and state governments have taken important steps towards the creation of a green hydrogen sector for the country, including agreements to invest more than 200 billion USD. In January, EDP produced its first green hydrogen molecule in Brazil and Unigel will have its first hydrogen and green ammonia production plant in commercial operation by the end of 2023. From 2050, according to the consultancy Roland Berger, Brazil could derive annual revenues of 150 billion BRL from green hydrogen, of which 100 billion BRL would come from exports alone.¹

What we are seeing, therefore, is an industry that is already here and ready to grow rapidly, especially considering the opportunities for domestic demand. Currently, Brazil uses fossil-fuel hydrogen in its fertiliser, refining, chemical, food and metallurgy industries. Replacing this with green hydrogen would allow



Elbia Gannoum
President of ABEEólica, Brazil's wind energy and new technologies association, and GWEC Vice Chair

decarbonisation and net zero in many Brazilian industry sectors to become a reality.

We know this is a long road, but we are also certain that we are on the right track. The Brazilian wind energy revolution is already here for all to see – and will continue to gain strength. It is just a matter of time and dedicated work by the government, investors, companies and professionals in the sector. Let's all work together to continue putting the wind in Brazil's sails.

¹ <https://valorinternational.globo.com/business/news/2023/01/22/brazil-has-potential-to-be-largest-producer-of-green-hydrogen-study-shows.ghtml>

Transforming the supply chain for the industry of the future

As the global wind industry focuses on solving the supply chain challenges ahead for the expansion of offshore and onshore wind, there are tremendous accomplishments already achieved. The transformation of steel into the key components of the energy transition is already well under way, supported by record new investment commitments.

The supply chain needs rapid expansion – in line with the ambitions of stakeholders

From new steel plant capacity, planned or already online, to pipe mills, shipyards and regional fabricators around the world, these new industry investments are driving one of the most rapid global industrialisation periods we have seen. The outcome of this process will enable the world to build and install turbines, towers and foundations (fixed-bottom and floating) of immense size, never before realised.



With the race to wind turbines of 20+ MW accelerating, the offshore wind supply chain of the future will need to produce at elevated levels, higher than ever before. However, it is clear that the present levels of investment commitment across the entire supply chain still fall well short of what is required for the global industry to hit installed capacity targets.

The supply chain of the future needs rapid expansion – in line with the ambitions of its main stakeholders. This is why GWEC's Global Wind Report 2023 is even more crucial, highlighting a number of key actions necessary in both the short and long term.

While there are many pieces of encouraging news across the global supply chain, there are also several practical challenges to overcome if we are to accelerate capacity to meet the installed targets forecast around the world.

As a key global supplier who supports the entire fabrication supply chain of assets and

infrastructure, Lincoln Electric sees the global industry through a unique lens. Key to unlocking the full capacity of the supply chain is innovation, together with new installation methods, designs and advanced technology that can drive the profitable success of the industry. Additionally, the continuous development of a highly skilled workforce will be critical, as well as the implementation of higher levels of automation solutions, which can reduce project hours and overall costs.

Today's industry leaders know that new technologies for steel transformation will play a critical role in profitability, particularly in welding and cutting, which continues to be at the core of the expanding global wind industry. Lincoln Electric and other critical supply chain businesses are leveraging decades of industry expertise and experience to innovate and solve these critical challenges through two key drivers: technology and higher involvement in workforce training



Christopher L. Mapes
Chairman, President and Chief Executive Officer,
Lincoln Electric

and development. Together, these critical initiatives will advance the growing global needs for a highly skilled workforce that can support the ambitions of industry and countries around the world.

Building on earlier success in offshore wind across Europe – and now the rapid expansion in Asia and the Americas – the future of the wind industry depends on the combined efforts of many. The industry needs continued support from governments and private investment around the world for further acceleration and expansion of the supply chain. By aligning these resources with a growing role for wind as a key part of the energy transition, the industry will thrive.

EXECUTIVE SUMMARY





Feng Zhao
Head of Strategy and
Market Intelligence, GWEC

The Data: 2022 was the wind industry's third-best year

Nearly 78 GW of wind power capacity was added last year, the lowest level in the past three years but still the third highest year in history. This was achieved despite a challenging economic environment and a disrupted global supply chain, compounded by global health and energy crises.

Market status

Globally, 77.6 GW of new wind power capacity was connected to power grids in 2022, bringing total installed wind capacity to 906 GW, a year-on-year (YoY) growth of 9%.

The onshore wind market added 68.8 GW worldwide last year, with China contributing 52%. Additions were 5% lower than the previous year. The slowdown in Latin America, Africa & the Middle East is partly responsible for the decline, but the primary reason is falling installations in the US. Despite finishing the year with a strong final quarter, the US wind industry commissioned only 8.6 GW of onshore wind capacity in 2022, due in part to supply chain

constraints and grid interconnection issues.

Thanks to record installations in Sweden, Finland and Poland – and recovering installations in Germany – Europe performed well in a volatile 2022, adding a record 16.7 GW of onshore wind capacity and bringing its market share up to 24%. Onshore wind additions in North America last year fell by 28% while new additions in Asia-Pacific (APAC) remained constant, but the three regions combined still made up 92% of global onshore wind installations in 2022.

8.8 GW of new offshore wind was fed into the grid last year, bringing total global offshore wind capacity to 64.3 GW by the end of 2022. New additions were 58% lower than the bumper year of 2021 but still made 2022 the second highest year in history for offshore wind installations.

China continued to lead global offshore wind development, although its new installations dropped to 5 GW from 21 GW in

2021 – a record year driven by the end of the feed-in tariff (FIT). Two other markets reported new offshore wind installations in APAC last year: Taiwan (1,175 MW) and Japan (84 MW). No intertidal (nearshore) wind projects achieved commercial operation in Vietnam in 2022, due to the ceiling price to be used by Vietnam Electricity (EVN) to negotiate PPAs with investors for their renewable projects missing until January 2023.

Europe connected the remaining 2.5 GW of capacity in 2022, with France and Italy each commissioning their first commercial offshore wind projects. Despite the rate of installations last year being the lowest since 2016, Europe's total offshore wind capacity reached 30 GW, 46% of which is from the UK.

With total installed offshore wind capacity reaching 34 GW in APAC, in 2022 Europe relinquished its title as the world's largest offshore wind market. Nevertheless, Europe continues to lead the way with

floating wind. Norway commissioned 60 MW of floating wind capacity last year, bringing the region's total installations to 171 MW, equal to 91% of global installations.

Market outlook

The unprecedented twin challenges of ensuring secure and affordable energy supplies and meeting climate targets have propelled wind power development into an extraordinary new phase of ever faster growth. After a challenging year, the global wind market is ready to bounce back in 2023, exceeding 100 GW for the first time.

With a double-digit growth rate of 15%, the mid-term outlook for wind energy looks very positive. GWEC Market Intelligence expects that 680 GW of new capacity will be added in the next five years. This equals more than 136 GW of new installations per year until 2027. We believe there are five pillars that will underpin this level of success in the next five years:

- Europe's renewed urgency to replace fossil fuels with renewables to achieve energy security in the aftermath of the Russian invasion of Ukraine.

- A strong uplift for renewable energy in the US over the next ten years, primarily driven by the Inflation Reduction Act (IRA).
- China's commitment to further expanding the role of renewables in its energy mix, aiming for renewable energy to contribute more than 80% of total new electricity consumption by the end of the 14th Five-Year Plan (2021-2025).
- Governments fully waking up to the opportunities that offshore wind can provide, making offshore wind truly global and increasing ambition in mature and developing markets.

- Strong growth in large emerging markets both onshore and offshore from the middle of this decade.

The CAGR for onshore wind in the next five years is 12%. Expected average annual installations are 110 GW, with a total of 550 GW likely to be built in 2023–2027. Growth in China, Europe and the US will be the backbone of global onshore wind development in the next five years. Altogether, they are expected to make up more than 80% of total additional capacity in 2023–2027.

The global offshore wind market is expected to grow from 8.8 GW in 2022 to 35.5 GW in 2027, bringing its share of total new global installations from today's 11% to 23% by 2027. In total, 130 GW of offshore wind is expected to be added worldwide in 2023–2027, with expected average annual installations of nearly 26 GW.

Beyond 2027, we expect the growth momentum to continue as global commitments to net zero, coupled



The twin challenges of secure energy supplies and climate targets will propel wind power into a new phase of extraordinary growth

with growing energy security concerns, have already brought the urgency of deploying renewables to the top of the political agenda.

Compared with the 2030 global outlook released alongside last year's Global Wind Report, GWEC Market Intelligence has increased its forecast for total wind power capacity additions for 2023–2030 by 143 GW (YoY growth of 13%). The revised growth rate will only achieve 68% of the wind power

capacity required by 2030 to stay on track for a net zero/1.5C pathway. Nevertheless, GWEC believes that the milestone of a second TW is likely to be passed before the end of 2030 – provided governments implement new policy solutions to ensure that the global supply chain can meet increasing demand from both established and emerging markets – in addition to addressing challenges such as permitting and market design.



The Story: the wind industry gears up for the coming acceleration

By mid-2023 GWEC anticipates wind energy to achieve the highly symbolic milestone of 1 TW in operation. And the 2 TW mark is expected to arrive by 2030, closing a decade of tumultuous acceleration.

The sector has changed beyond recognition over the past four decades. Long gone are the days of wind installation clusters in a handful of European countries and a few US states. Wind power has a growing presence in tens of countries worldwide. The surge of offshore wind and innovative technologies such as floating foundations promise to deliver large amounts of wind energy in locations where its deployment would have been unimaginable until very recently.

The stakes could hardly be higher for wind energy as the world strives to emerge from the 'polycrisis' of post-pandemic recovery, inflationary pressures, a war in Europe and growing climate impacts. But all the signs point to a

sharp turnaround this decade, and it is starting now.

A sluggish 2022 saw only 77.6 GW of additional wind capacity installed globally – 17% lower than the previous year but still the third highest year in history for additions. Offshore additions, at 8.8 GW, were less than half the 21 GW clocked in 2021, and yet the second highest volume ever.

Despite the relatively positive wind installation numbers, 2022 was the year when a perfect storm of 'race to the bottom' pricing caused by misguided government policies, higher logistics costs and project delays due to inadequate permitting rules created the bizarre paradox of energy markets rewarding fossil fuel companies with record profits, while renewable energy companies struggled to break even.

Change has altered the dynamics of the wind industry too. From an early obsession with demonstrating reliability to an

unrelenting drive to cut costs, the wind industry now needs a laser-sharp focus on ensuring that it can deliver the ambitious installation targets required of it.

Renewables will dominate installations

Under all credible scenarios, renewable energies will dominate installations over the coming years. The IEA forecasts that nearly all of the additional electricity generated between 2022 and 2025 will come from renewable energy sources. Alongside solar, wind will remain a leading source of renewable power.

By 2024, GWEC expects onshore wind to pass the 100 GW annual installations mark, while offshore wind will install more than 25 GW in a single year for the first time in 2025. Installations will accelerate rapidly after that, driven by most countries' ambitious green energy and climate targets. GWEC forecasts that 680 GW of wind capacity will be installed globally by 2027, of which 130 GW will be offshore.

As our heat map (see page 82) shows, there are still tens of countries where wind power development is being held back by regressive policies or ineffective processes. Increasingly, however, governments are eyeing up the vast opportunities that facilitating this sector opens up in terms of industrial development, skilled jobs and socioeconomic returns, as well as environmental benefits.

Investing to boost wind development

Wind energy has established its credentials as one of the most efficient tools for decarbonising power systems. Failing to deploy wind fast enough risks increasing costs through greater exposure to fossil fuel volatility, geopolitical pressure and higher carbon emissions. Socially, wind power has the potential to benefit communities by creating millions of skilled jobs around the world. Economically, it can act as a catalyst for trillions of dollars of investment.

Heavyweights such as the US and the EU have ramped up government support for wind energy. The Biden administration's Inflation Reduction Act (IRA) is

already mobilising massive investment in renewable generation, decarbonised transport, energy storage and improved grid connections. In Europe, the REPowerEU programme seeks to wean the continent off Russian gas while removing obstacles to green energy deployment. And approval of China's 14th Five-Year Plan, covering the 2021–2025 period, turbocharges innovation-driven low-carbon development, with GWEC estimating annual wind installations of 60–65 GW per year for onshore and 15 GW for offshore in the second half of this decade.

While these policies are providing a welcome boost to local industry and promising long-overdue action to reduce some of the complex rules associated with wind energy development, they could also threaten the sector's ability to rise to the acceleration challenge.

Growing demand for equipment and the key commodities that are required to produce it will place significant pressure on supply chains. It is essential that policymakers approach procurement with a more holistic perspective that prioritises

economic development and job creation over a narrow focus on achieving the lowest possible price.

By adopting this high-level mindset, governments will allow wind power original equipment manufacturers (OEMs), developers, shipping companies and other actors in the supply chain to invest, ensuring an optimal balance between supply and demand, and delivering benefits for all.

Facing up to the size of the challenge

Gearing up to deploy huge volumes of wind power capacity is a far from straightforward task. Adding 1 TW in seven years, when it took around 40 years to install the first TW, is no mean feat.

Following a difficult patch of retrenchment, the wind energy manufacturing industry is now facing the prospect of a rapid upturn. Spare capacity is very limited, and likely to disappear by 2026 unless urgent action is taken to invest in the supply chain.

Our analysis in Part 2 shows that 163 GW of nacelle production capacity is available worldwide, which is likely to meet projected global

demand up to 2027. But the picture is less rosy for offshore wind.

Starting in 2026, Europe's existing offshore turbine nacelle assembly capacity will no longer be able to support growth outside of Europe, and by 2030 it will have to double from current levels to meet European demand alone.

Elsewhere, nacelle bottlenecks look likely in Asia (excluding China) and in the Americas, especially once the pipeline of Brazilian projects starts being rolled out.

Spare capacity is limited and will likely disappear by 2026 unless urgent investment is made in the supply chain

Shortages are expected to emerge in the second half of this decade for key components such as blades and generators. Gearbox manufacturing capacity is well positioned to support growth up to 2027, but a concentrated supply chain and regionalised sourcing strategies look certain to create bottlenecks.

China dominates the global supply chain for other crucial components



such as castings, forgings, slewing bearings, towers and flanges, with a market share of more than 70%.

Vessels used in offshore installations are expected to be in sufficient supply in China, but Europe could see shortages towards the end of the decade, unless investments are made before 2027. And the US, with its Jones Act restrictions, will certainly struggle to meet the Biden Administration's target of 30 GW of offshore wind by 2030 unless it acts to build new vessels.

In sum, both Europe and the US are facing the risk of supply chain shortfalls as soon as 2026, particularly if they follow through with some of the 'reshoring' policies that several countries and regions are rolling out to strengthen energy resilience and boost local industry.

Supply chain pressures will alter market dynamics

Paradoxically, just as renewable energy proves itself as the most cost-effective form of energy and the one best insulated from the vagaries of geopolitical pressures, wind energy runs the risk of seeing its progress thwarted by the practical implications of untapping its immense growth potential.

As countries and regions compete for investment, the winners will be those with the most attractive market conditions and the most effective regulation. Policymakers must tread the narrow path that enables an adequate level of trade to ensure the energy transition is not delayed while boosting opportunities for their domestic supply chains.

Efforts to boost energy security and strengthen the local economy have led some countries to reach beyond manufacturing to achieve

local supply of critical inputs for their industries, including steel products and raw materials such as rare earth elements (REEs). This has the potential to severely limit the industry's capability to upscale.

When considering the localisation or reshoring of their energy sector, governments have choices: they can use incentives or preferential treatment for domestic suppliers or reserve the procurement of certain goods or services for them.

GWEC advises against prescriptive localisation requirements or restrictive trade practices, which could lead to price increases and disruption. It argues instead for flexibility that can build on national and regional competitive advantages, giving OEMs and the supply chain more flexibility in optimising their production. An incentive-based approach will also give the wind industry the confidence to overcome recent challenges and begin to scale up for the next phase of global growth.

The scale of the investment and production needed to achieve the energy transition will require continued global and regional

collaboration and the scaling up of investment everywhere. Policymakers must come together to design mechanisms that make the relevant inputs for the energy transition freely available around the world.

Policymakers have the power to avoid the crippling bottlenecks that are likely to arise if supply chains do not rise to the challenge of the growing demand for equipment. But they must ensure they engage in early and open dialogue with industry to ensure that policy goals and industry action are aligned. If designed properly and comprehensively, policies designed to enable the scaling up of the supply chain and its diversification represent a huge opportunity for the world.

For the wind industry to meet the expectations of policymakers and society at large, it is essential that investment starts right now in new industrial capacity, and in training and skills. In the absence of such impetus, the industry runs the risk of falling short of what is required to deliver the necessary capacity, leading policymakers to turn to less efficient alternatives, and ultimately causing society to miss its climate targets.



WIND ENERGY: THE COMING ACCELERATION

The coming renewables acceleration

The prolonged period of high energy prices the world experienced in the aftermath of the COVID-19 pandemic, sharply exacerbated by the Russian invasion of Ukraine, has exposed the fact that we are suffering a deep energy crisis. This is a consequence of a patchy and delayed energy transition, which has left energy markets vulnerable to volatile fossil fuel supply – much of which is driven by political agendas and anti-competitive practices.

As well as exposing consumers and industry to high energy prices, the crisis has been a significant contributor to the return of inflation as the major challenge for the world's economy. Meanwhile, the impacts of accelerated global heating are becoming ever clearer at the same time as countries continue to delay taking the actions needed to achieve the emissions trajectory outlined in the Paris Agreement.

However, the current 'polycrisis' has not gone unanswered by

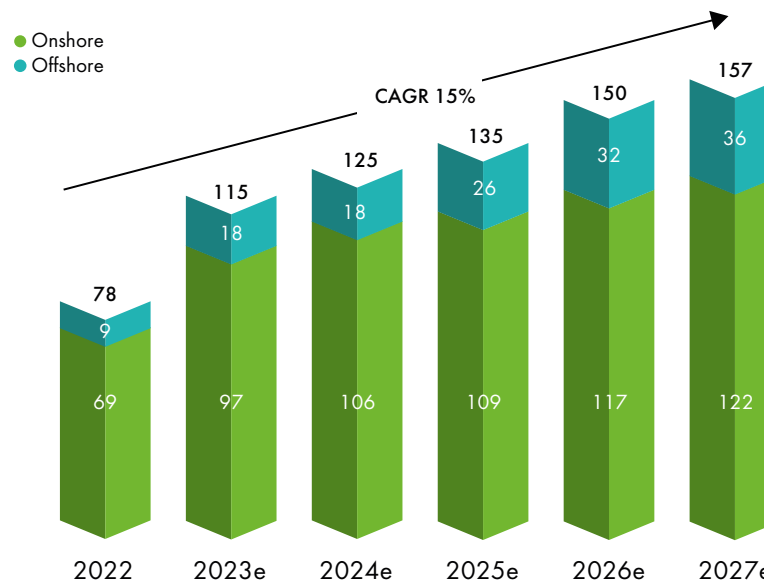
1. <https://www.iea.org/reports/electricity-market-report-2023>
 2. <https://about.bnef.com/new-energy-outlook/>

society in general and policymakers in particular. The drive towards lowering emissions and prioritising sustainability continues to gather momentum.

The past year has seen governments around the world take unprecedented steps to speed up the energy transition and wean their economies off their dependence on fossil fuels. Whether through the Inflation Reduction Act in the US, the REPowerEU program in the EU or enhanced national plans, the policy environment has evolved quickly over the past 12 months. This in turn has led to countries and regions setting new, highly ambitious targets for renewable energy and for the phaseout of fossil-based technologies in generation, transport and industry.

The leading intergovernmental energy agencies agree that renewable energy – and the two leading technologies of wind and solar especially – will dominate electricity demand growth in the coming period. According to the International Energy Agency, renewable energy will provide 98%

New installations outlook 2022–2026 (GW)



Source: GWEC, 2023

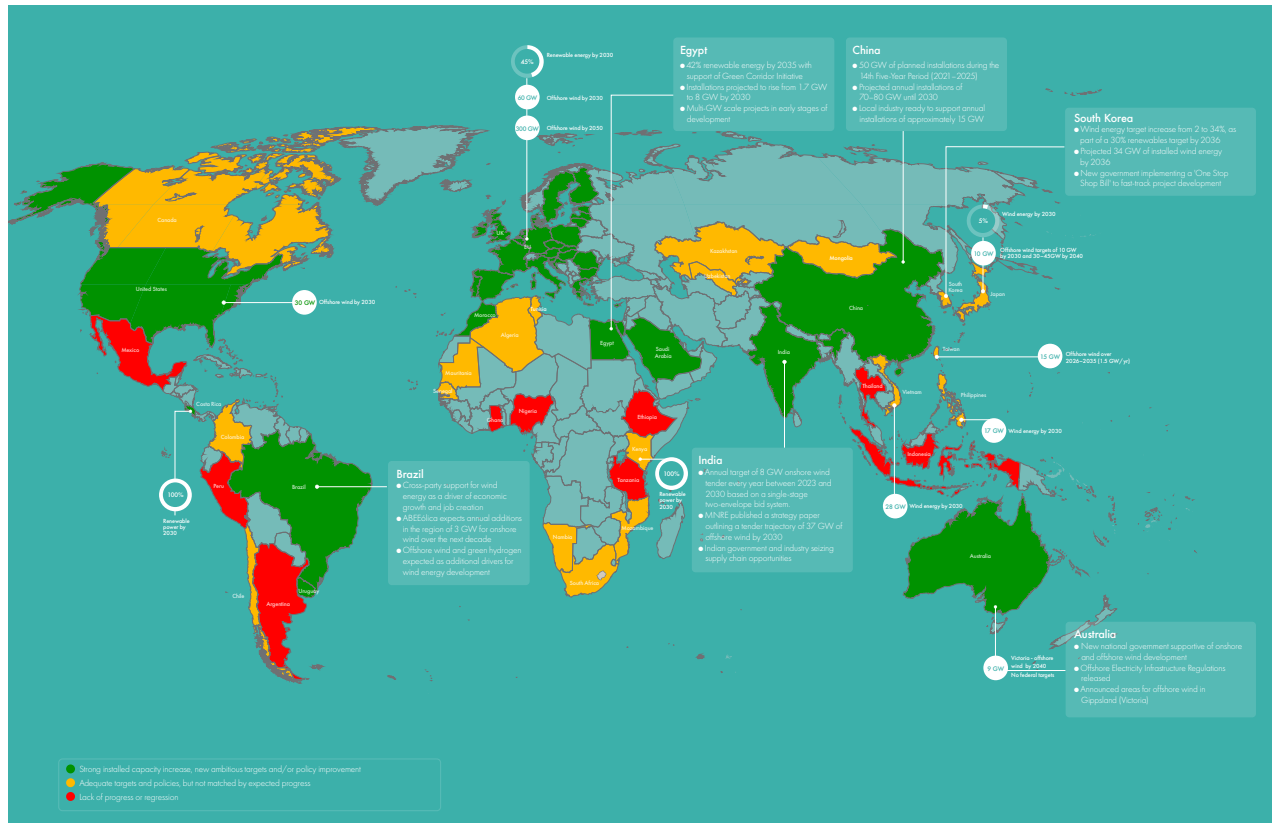
of the 2,518 TWh of electricity generation to be added between 2022 and 2025.¹

GWEC expects 680 GW of wind capacity to be added globally between 2023 and 2027, of which 130 GW will be offshore. Onshore wind in China will continue to lead installations with 300 GW, followed by Europe with nearly 100 GW. Offshore wind will play an

increasingly large role with projected global additions of more than 60 GW between 2023 and 2025, and 68 GW in 2026–2027.

Wind energy is expected to achieve the milestone of 1 TW of installed capacity by the middle of this year. In a recent report, BloombergNEF (BNEF) forecast that, having taken 33 years to reach 1 TW, wind will deliver close to another TW by 2030.²

Policy heat map



A new geopolitical era

Political conditions that have made wind deployment difficult in many countries are beginning to shift, as our heat map illustrates. There are only a few places now where wind power is neither in existence nor planned.

Under the leadership of President Luis Inácio 'Lula' da Silva, Brazil is looking at wind energy as a vehicle for achieving climate goals while boosting economic growth. As it continues to move away from regulated auctions and towards corporate power purchase

agreements, the Brazilian wind energy sector gains resilience and prepares for a very bright future.

On the other side of the globe, India is targeting wind capacity additions of more than 60 GW onshore and nearly 40 GW

offshore by 2030. It is also looking to seize supply chain opportunities, particularly by capitalising on the role of micro, small and medium enterprises (MSMEs) in the Indian wind manufacturing sector.

After a spell of virulent anti-wind rhetoric under the Trump administration – albeit with continued economics-led growth of the sector – President Biden has enacted a dramatic change of direction, both through restating the USA's climate leadership in international forums, and through the Inflation Reduction Act (IRA). This landmark piece of legislation offers funding, programmes and incentives for accelerating the transition to a clean energy economy across multiple sectors. The prospects for offshore wind, in particular, are very exciting.

The EU, for its part, is laying out a multi-pronged approach to boost European industry while achieving energy and climate goals. Renewable energy projects could be given priority permitting in special 'go-to' areas under new provisions being considered in the upcoming revision to the Renewable Energy Directive, while the REPowerEU package offers renewables a 20 billion EUR funding pot.

The coming renewables acceleration



Additionally, the EU is looking to introduce legislation that would simplify and fast-track permitting procedures for climate-neutral industrial infrastructure, with the goal of boosting Europe's key green industries and their full value chains. Efforts are also being made to reduce dependence on non-EU sources of raw materials and rare earth elements (REEs).

Responding to burgeoning demand

Demand for wind energy continues to grow and expand. The trend towards corporate power purchase agreements shows no sign of slowing down, and large

companies from outside the energy industry are increasingly keen to invest in wind development.

BloombergNEF estimates that offshore wind financing activity will hit new records in 2023³, with more than 30 GW of new projects getting the go-ahead, over half of which will be outside China. Floating offshore technology is making steady progress and will open up previously untapped markets.

However, the promise of massive expansion risks colliding with the reality of delivering turbines on land and in the water. The industry is emerging from several difficult years, during which turbine manufacturers have suffered financial losses and policymakers have often failed to provide the optimal conditions for fast and efficient market development and the necessary grid buildout.

While technological advances are happening across the sector – from China's continued lead in upsizing turbine components, to global efforts to improve the circularity of traditionally difficult-to-recycle epoxy-based turbine blades⁴ – there is a danger that an industry

scarred by years of financial losses may retreat into caution and protectionism. This would be the worst possible scenario both for the wind industry and the energy transition – as global supply diversification has supported the reduction of wind's LCOE.

As gigawatt-level projects kick off in new and traditional wind markets across the globe, GWEC anticipates a flurry of orders for turbine manufacturers everywhere, and pressure on all elements of the supply chain as a result. It is essential that the industry gears up to respond to this challenge by thinking strategically about the road ahead and setting itself up to deliver on its ambition, supported by adequate policies.

A turning point for wind

Having achieved impressive learnings and economies of scale over the past two decades, wind is now a mature sector which, like more traditional energy sources, reacts to external factors such as commodity prices, interest rates and political support – rather than its own internal dynamics.

No longer the new kid on the energy block, the wind sector is at a turning point – facing up to a host of new

challenges while looking to deploy massive amounts of additional capacity in an ever-growing number of countries. Such a huge rise in wind power development can only materialise if governments play their part, through supportive and stable market conditions, in allowing the wind industry to scale up to the ambitious targets it is expected to deliver.

In an increasingly interconnected world, the wind sector must prove that it can continue to innovate, collaborate and integrate. From the role of women and minorities in the industry to the wide-ranging challenge of sustainability, GWEC is determined to facilitate connections between the many stakeholders the sector affects.

Having long established its credentials as a reliable, effective, efficient and cost-competitive technology, the wind industry now needs the right conditions to step up to the level that is required of it to fully deliver on its promise of cleaner and cheaper energy for all.

3. <https://about.bnef.com/new-energy-outlook/>

4. <https://www.vestas.com/en/media/company-news/2023/vestas-unveils-circularity-solution-to-end-landfill-for-c3710818>



PART 1: A NEW ENERGY MARKET

A new energy market

In 2022, the world saw many of its long-established paradigms shattered by a number of deeply transformative events. Inflation reached levels not seen since the massive disruptions of the 1970s – driven at both times in large part by commodity price increases. The unprovoked attack on Ukraine by Russia laid bare the world's dependence on fossil fuels – and the energy insecurity that comes with it.

As Russia is the world's second largest gas producer, this dependence came at a steep price



for gas-importing countries, causing surges in the prices of everything – from fertilisers to heating and power – and causing low-income countries to suffer the most.

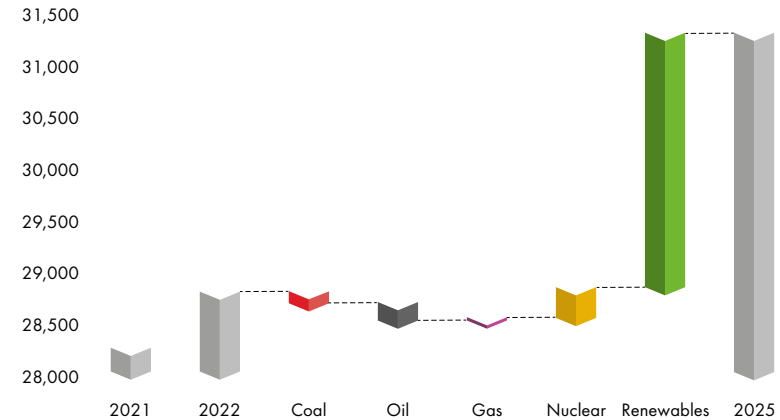
The global response has been to focus on energy security and resilience. Governments introduced measures to make energy affordable by utilising all available energy sources, including coal, gas and nuclear, and by committing to developing more renewables in the latter part of the decade.

The short-term focus on affordability and the subsequent increased use of fossil fuels led to an increase in global carbon emissions¹, even with nearly 80 GW of wind power and more than 200 GW of solar capacity installed². What this tells us is that installing 300 GW of renewables in one year is not enough to curb a rise in carbon emissions.

A tipping point for wind energy

Amid the turmoil of 2022, it is clear that we have reached a tipping point for renewable energy in general and for wind power in particular.

Projected changes in global electricity generation (TWh) by source



Source: IEA, 2023

In Europe, the REPowerEU³ programme has committed the bloc to weaning the continent off Russian gas by 2030 (or sooner). The policy also seeks to remove bottlenecks to permitting and other hindrances to the deployment of renewable energy projects.

The US passed the Inflation Reduction Act (IRA)⁴, transforming the way the country approaches renewables, decarbonised transport,

energy storage, the electricity grid and energy efficiency. The act has already accelerated large amounts of investment.

Approval of China's 14th Five-Year Plan⁵, covering the 2021–2025 period, paves the way for innovation-driven, sustainable and low-carbon development. The plan also aims to reduce the carbon intensity of the Chinese economy and targets peak CO₂ emissions before 2030.

1. <https://www.carbonbrief.org/analysis-global-co2-emissions-from-fossil-fuels-hit-record-high-in-2022/>
 2. <https://renewablesnow.com/news/global-solar-pv-additions-to-top-200-gw-in-2022-ihs-markit-761554/>
 3. https://ec.europa.eu/commission/presscorner/detail/en/IP_22_1511
 4. <https://www.epa.gov/green-power-markets/inflation-reduction-act>
 5. <https://www.adb.org/publications/14th-five-year-plan-high-quality-development-prc>

Commodity Price Index



Source: IMF, 2023

Historical London Interbank Offered Rate (LIBOR, %)



Source: IMF, 2023

Significantly more wind will be required to achieve those goals.

Substantiating this trend, the International Energy Agency (IEA)'s Electricity Market Report 2023 sees renewable energy sources supplying pretty much the totality of the additional electricity generated between 2022 and 2025.⁶

In its Renewables 2022 report – the agency's primary analysis of the renewable energy sector – the IEA forecasts capacity additions reaching record highs through 2027⁷, led by solar and wind. It expects annual additions to range from 350 GW in the main scenario to 400 GW in the accelerated case.

What does a wind energy boom mean?

Wind power is not just growing bigger, it is also spreading more widely. Beyond the current world leaders, many other countries are also refocusing on renewables – driven both by the insecurity of relying on fossil fuels and the desire to remain economically competitive. Economic drivers are becoming increasingly important

as companies globally commit to environmental, social and governance (ESG) goals that require them and their suppliers to decarbonise.

This is a mega-trend to watch as GWEC believes the demand side will become much more vocal in its desire to see more renewables come online to help them and their suppliers meet their decarbonisation targets. An example of this is the Asia Clean Energy Coalition⁸ – launched by GWEC, the World Resources Institute and The Climate Group and including Google, Apple, Samsung, Nike and many other large corporates with significant commitments to decarbonise.

But while these trends and commitments are very positive for renewables in general and wind energy in particular, there remains much to do to fully enable the renewables sector to deliver the ambitious deployment levels required to achieve these wider ESG goals.

Take, for example, the supply of wind turbines. Based on the

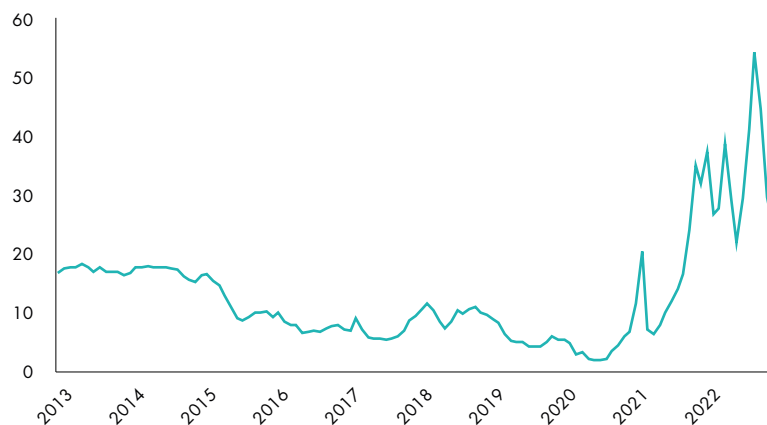
6. <https://www.iea.org/reports/electricity-market-report-2023>

7. <https://www.iea.org/reports/renewables-2022>

8. <https://gwec.net/acec-launches-to-rapidly-drive-corporate-clean-energy-procurement-in-asia/>

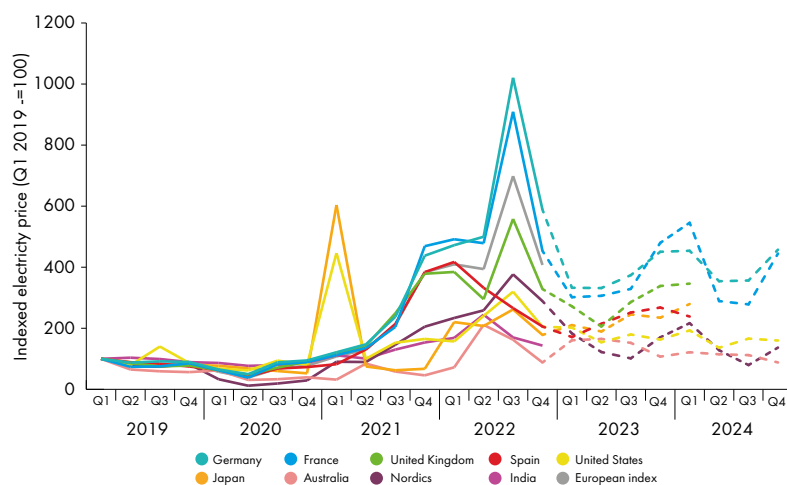
Part 1: A new energy market

LNG spot prices in Asia (USD/mmbtu)



Source: Federal Reserve, 2023

Average quarterly wholesale electricity prices



Source: IEA, 2023

GWEC Market Intelligence database of global wind supply side, the industry had a potential turbine production capability of 120 GW in 2020. Since 105 GW of turbines were delivered in 2021, that leaves approximately 10% of spare capacity. However, because of low profitability in 2021 and 2022, many turbine manufacturers have cut back on staff and closed some production facilities.

As the industry starts to grow again, will turbine manufacturers have enough visibility on turbine demand to rapidly ramp up production capacity?

Another significant recent trend is the growing China–US/EU tension on trade and other policies, possibly marking a move away from globalisation in an attempt to shore up regional economies and security of supply. What are the implications for wind energy, especially with China being such a dominant producer across the renewables supply chain?

These are some of the questions we will look to address in detail in later chapters of this report. At the high level, it seems inevitable that a significant, global ramping up of

production capacity will be needed to meet fast-growing demand.

All energy costs are on the up

Following the massive disruptions to supply chains caused by the COVID-19 pandemic, energy demand bounced back as economies reopened. Stretched supply chains tried to balance supply with demand, while shipping and logistics bottlenecks added to the strain. Prices for a range of goods, from cars and wind turbines to washing machines and food, rose dramatically.

Meanwhile, as inflation soared, central banks became concerned about its impacts on the economy and embarked on a series of interest rate rises, leading the cost of capital to also increase. Higher cost of capital leads to increased costs for all investments.

The historically high commodity prices seen in the last two years, and the upturn in the cost of capital seen in 2022 as central banks tightened monetary policy, has impacted all energy sources worldwide.

From 2010 to 2020, Newcastle coal futures, the benchmark for the top

coal-consuming region of Asia, ranged between \$50/tonne and \$120/tonne⁹. After sharp increases in 2021, they averaged \$350/tonne in 2022, making the cost of coal-fired power generation substantially higher than the cost of wind in almost every country. And that is before the cost of carbon or its abatement is even taken into account.

Over the past two years, prices for Asian liquified natural gas (LNG) have spiked against 2020 levels. While most LNG-importing countries have long-term contracts in place, they are unlikely to cover 100% of demand, leaving countries exposed to importing spot cargoes. This has come at a very high financial cost, particularly in the past year. And because LNG markets are global the price impacts are felt globally.

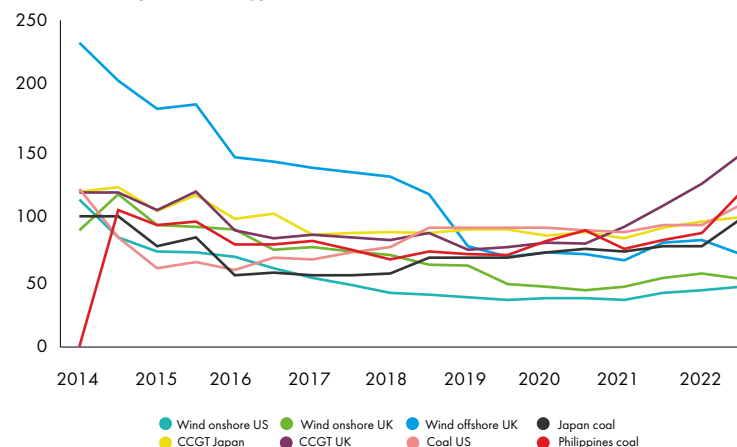
These trends contributed to a historic increase in wholesale electricity prices. Average quarterly wholesale electricity prices spiked in much of the world through the end of last year, and while the IEA projects prices to drop in 2023, the projections are not close to where they have been in previous years.

Equipment manufacturing for gas-fired and coal-fired generation – as for wind and solar generation – has benefited from the efficiency improvements achieved over the decades. But with high inflation and massive disruptions to global supply chains, coupled with higher expenditure in shipping and logistics, the capital cost (CAPEX) of electricity generation for all technologies has risen.

Wind has achieved significant cost reductions over the last 20 years and the wind industry is now considered fairly mature, especially onshore wind. Offshore wind is newer but, having been commercial for at least 15 years, it is also reaching maturity. This means that the dramatic price reductions that we have seen historically are likely to slow and future cost fluctuations in the cost of wind are likely to reflect the underlying cost of capital, commodity costs (steel, copper), and logistics costs, as noted above.

For example, the cost per kilowatt (kW) for a gas-fired turbine, a mature technology, has been roughly 1,000 USD/kW for the last

Historical LCOE by technology (USD/MWh)



Source: BNEF 2023

20 years (+/-30%) with the variation caused by the usual movements in supply and demand, and particularly by the cost of materials such as steel and copper.¹⁰ There is no reason to think that wind, as it matures, will act differently.

Relative costs of wind power remain low

The cost profile of electricity generated from wind and solar energy versus electricity generation powered by traditional fossil fuels appears very favourable – it has been for some time and will continue to be.



9. <https://tradingeconomics.com/commodity/coal>
 10. <https://www.sciencedirect.com/science/article/abs/pii/S1364032117305531?via%3Dihub>

Part 1: A new energy market



Wind power still maintains price advantages in most countries, even without considering the impacts or future carbon pricing schemes. There is no reason why wind power should lose its price advantage over LNG and coal in most markets globally.

To make wind power as cost-efficient as possible going forward, it is essential that governments continue to provide visibility on future demand through ambitious nationally determined contributions and sectoral targets while introducing enabling regulations and removing bottlenecks in permitting and other phases of development.

11. Wind Power's 'Colossal Market Failure' Threatens Climate Fight

From cost to value

At the same time, to achieve their ambitions, countries will also have to move decisively to fix current market and regulatory imbalances, which have seen leading companies in the wind industry supply chain declare losses over a period of several years while fossil fuel-producing companies make record profits.

This situation, referred to by leading commentators in the energy sector as a 'bizarre paradox', has been 'a colossal market failure', according to GWEC CEO Ben Backwell.¹¹ Poor market design and procurement have led to a 'race to the bottom' on wind pricing, while inflationary pressures combined with government price caps have exacerbated the squeeze on profitability. As we shall see, this in turn has led to underinvestment in manufacturing and has created the likelihood of supply chain bottlenecks in the years to come.

In order to enable the huge amounts of supply chain investment needed to meet increased demand, governments and regulators will need to act smartly to fix current market imbalances and set the stage for growth.

While the focus over the last two decades or more has been on achieving cost reductions, with procurement arrangements largely led by concerns from treasury departments, policymaking now needs to focus on the societal and economic value of wind energy. Wind energy is already highly competitive compared with fossil fuels and nuclear, but its wider social value needs to be recognised in market and procurement frameworks.

Wind energy, in combination with other renewable energy technologies, is the most efficient way of decarbonising power systems. The evidence shows that a failure to deploy wind rapidly enough carries with it far higher costs in terms of exposure to fossil fuel volatility, geo political pressure and higher carbon emissions leading to damage from climate change.

Wind energy has the potential to create tens of millions of new skilled jobs around the world and act as a catalyst for trillions of dollars of investment. It is essential that policymakers move the discussion around procurement away from a narrow focus on achieving the lowest price

possible, to one around how they can achieve the maximum amount of economic development and job creation, while moving rapidly to fulfil their emission reduction targets.

GWEC and its member companies, alongside sister organisations and partners like IRENA and the IEA, are working hard to achieve the necessary change in focus and create improved market and regulatory conditions for a rapid and confident transition.

This will allow wind original equipment manufacturers (OEMs), developers, shipping companies and other actors in the supply chain to invest, ensuring an optimal balance between supply and demand, and delivering benefits for all.

In later sections of this report, we look at how policy discussion is shifting in key markets for the renewables transition. But first we examine the current state of the global wind supply chain and discuss the potential impact of policies aimed at achieving a larger share of national and regional content in wind turbine manufacturing.

An aerial photograph showing the construction of a wind turbine. A tall yellow lattice crane is positioned next to the white tower of the turbine. A red cabin is being lowered into place by the crane. In the background, another completed wind turbine stands on a green hillside under a blue sky with scattered clouds. The foreground is dominated by dense green foliage.

PART 2: CHALLENGES IN THE SUPPLY CHAIN

Challenges in the supply chain

While 2022 saw only 78 GW of new capacity connected worldwide, the market is ready to bounce back in 2023, primarily driven by expected explosive growth in China. Cumulatively, nearly 940 GW of wind power had been installed globally (without taking into account grid connection) by the end of 2022. GWEC Market Intelligence forecasts that the 1 TW milestone will be reached sometime mid-2023.

What is the expected demand in this decade?

Compared with the 2030 global outlook released alongside last year's Global Wind Report, GWEC Market Intelligence has increased its forecast for total wind power capacity additions for 2023–2030 by 143 GW (13% YoY). The main reasons behind this upgrade include:

- Energy system reform in Europe, replacing fossil fuels with renewables to achieve energy security in the aftermath of Russia's invasion of Ukraine;

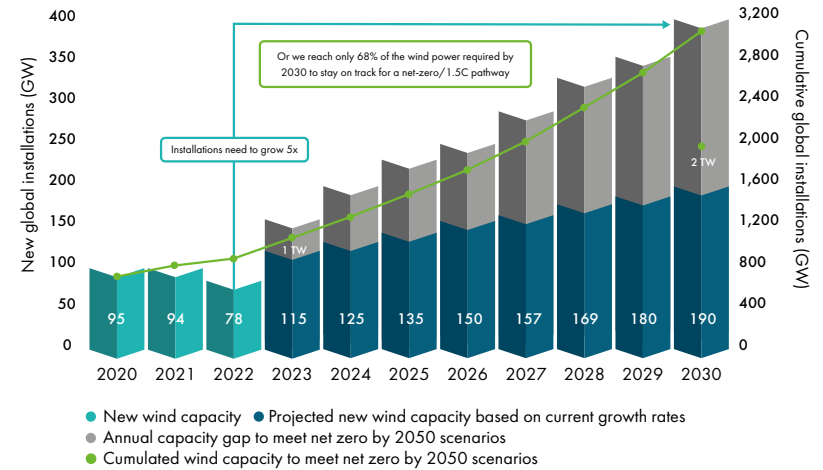
- China's commitment to further expand the role of renewables in its energy mix;
- An anticipated ten-year installation uplift in the US, driven by the passage of the IRA.

Although the revised rate of wind growth is still not rapid enough to enable the world to achieve its Paris Agreement targets or net zero by 2050, GWEC believes the milestone of a second TW is likely to be passed before the end of 2030 – provided the anticipated growth materialises in the three key wind markets of China, Europe and the US.

What is the state of the global wind supply chain?

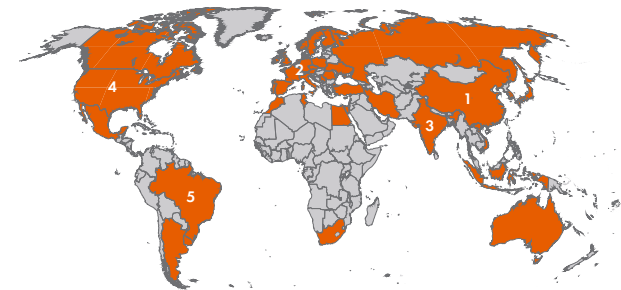
As the birthplace of the wind industry, Europe enjoys a mature supply chain spanning from turbine nacelles through to key components and raw materials. However, since establishing a local wind supply chain in 2008–2010, China has not only become the world's leading wind turbine manufacturing base, but also the largest production hub for key components and raw materials.

The 2 TW milestone is expected to be achieved in just seven years



Source: GWEC Market Intelligence; IEA Net Zero by 2050 Roadmap (2021); projected new wind capacity from 2023–2030 assumes a ~7.2% CAGR, which is based on GWEC's Q1 2023 Global Outlook; capacity gap figures are estimations based on the IEA Roadmap milestone for 2030. Cumulative global installations for wind energy are roughly in alignment with the IRENA World Energy Transitions Outlook: 1.5°C Pathway (2021). This data represents new and cumulative capacity and does not account for decommissioned projects.

World's top five wind turbine and component production hubs by annual output



Source: GWEC Market Intelligence, February 2023

European and American turbine OEMs decided to diversify their supply chain to ensure security of supply, in the aftermath of the COVID-19 pandemic. India, the second-largest Asia-Pacific (APAC) hub for turbine assembly and key components production, has since gained an increasingly prominent role in the global wind supply chain.

While most of the suppliers to the wind industry are still based in APAC, Europe and the Americas, new entrants have also emerged in the Middle East and North Africa (MENA) region.

Will there be enough supply chain capacity to feed growth?

Turbine nacelles

Globally, there are 153 turbine assembly plants currently in operation, with another 74 facilities either under construction or in the planning stage. China has more than 100 nacelle assembly facilities in operation and another 64 under construction. With a turbine nacelle production capacity of 98 GW per year, the country accounts for 60% of the global market share, making it by far the world's dominant turbine nacelle manufacturing hub.

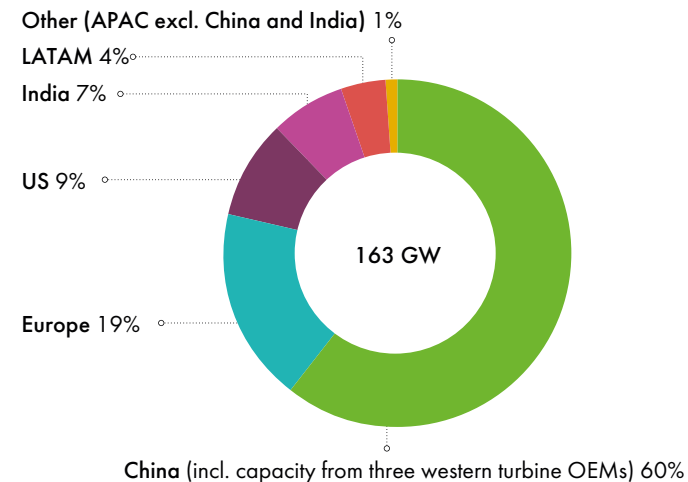
Overview of global wind turbine nacelle facilities								
	China	Europe	India	USA	LATAM	Asia Pacific	Africa & ME	Total
Total number of nacelle assembly facilities (onshore)	77 (4)*	16	13	4	6	3	1	123
Total number of nacelle assembly facilities (offshore)	20 (1)*	5	0	0	0	4	0	30
Number of announced nacelle assembly facilities (onshore)	17	0	2	0	0	0	0	19
Number of announced nacelle assembly facilities (offshore)	47	1	0	3	0	4	0	55

* facilities owned by western turbine OEMs

Europe is the world's second-largest turbine nacelle production base, with assembly facilities mainly located in Germany, Denmark, Spain, France, Portugal and Turkey. The US is the world's third-largest wind nacelle manufacturing hub, followed by India and LATAM – primarily Brazil.

Globally, 163 GW of nacelle production capacity is available in 2023. At first glance, the wind industry appears to have enough nacelle assembly capacity to meet the projected global demand up to 2027. However, the picture is different if separate benchmarks are applied for onshore and offshore wind, especially at a

Global wind turbine manufacturing capacity in 2023

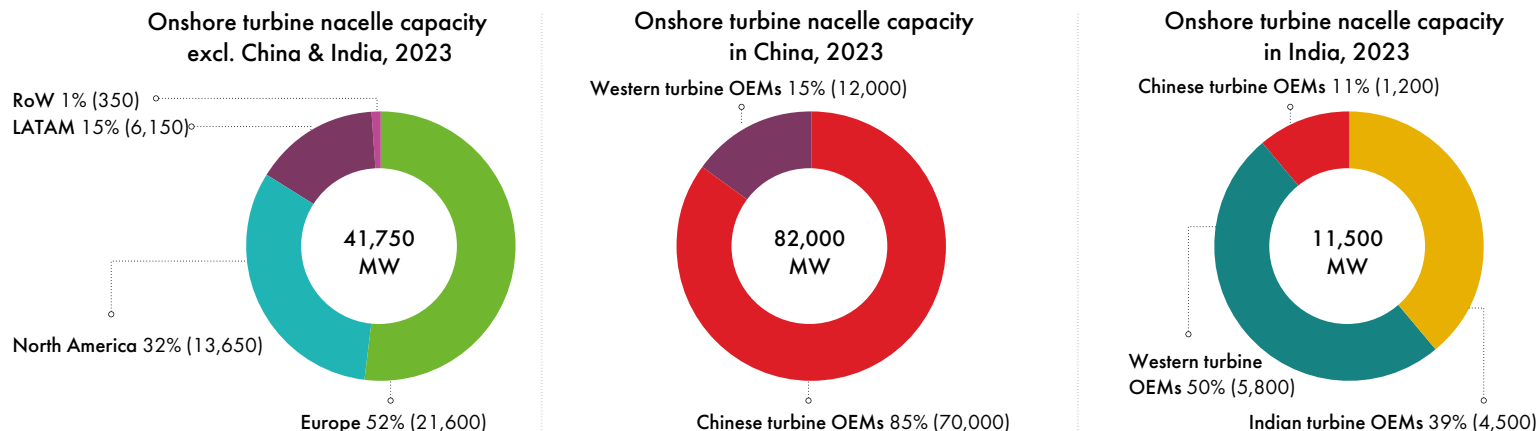


Note: Wind turbine manufacturing capacity refers to wind turbine nacelle assembly capability and doesn't represent actual nacelle production in 2023.

Source: GWEC Market Intelligence, February 2023

Part 2: Challenges in the supply chain

Onshore wind demand and supply benchmark, 2023–2030 (MW)



Source: GWEC Market Intelligence, February 2023

	Demand vs supply analysis 2023-2030 (MW)							
	2023e	2024e	2025e	2026e	2027e	2028e	2029e	2030e
Europe	14500	17750	18920	20950	23290	23500	24000	25000
US	8000	9000	10000	13000	15000	17000	18000	20000
LATAM	5860	5362	5200	5050	5030	5000	5000	5000
China	60000	60000	60000	60000	60000	65000	65000	65000
India	3400	4200	4500	4700	4500	4500	5000	5000
RoW	5619	9955	10424	13560	13705	14000	14300	15000
Global	97379	106267	109044	117260	121525	129000	131300	135000

Source: GWEC Market Intelligence, March 2023

● Sufficient ● Potential bottleneck

regional level.

Challenges in the supply chain for onshore wind nacelles

China dominates global onshore wind turbine nacelle assembly with 82 GW of identified annual capacity.

Out of this total, 12 GW is from the three western OEMs: Vestas, SGRE and GE Renewable Energy.

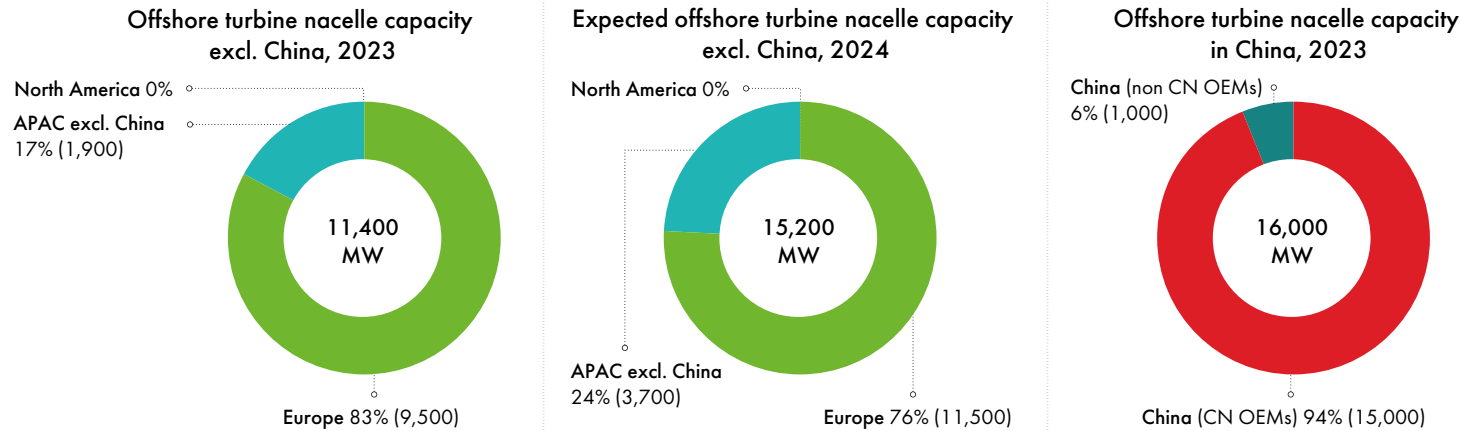
With 21.6 GW of annual assembly capacity per annum, Europe is the world's second largest onshore

turbine nacelle production base, followed by the US (13.6 GW), India (11.5 GW) and LATAM (6.2 GW).

When we compare these production capacities with the onshore wind demand projected

for this decade, we conclude that the supply chain in China, India and LATAM will have enough nacelle production capacity to accommodate demand, while the rest of world, in a business as usual scenario, will continue to

Offshore wind demand and supply benchmark, 2023–2030 (MW)



Source: GWEC Market Intelligence, February 2023

	Demand vs supply analysis 2023-2030 (MW)							
	2023e	2024e	2025e	2026e	2027e	2028e	2029e	2030e
Europe	5760	2955	7002	10036	12143	15403	21440	25950
China	10000	12000	12000	15000	15000	15000	15000	15000
APAC excl. China	1751	1569	2884	2615	3855	4770	6900	7900
North America	535	1660	3780	4750	4460	4500	4500	5000
LATAM	0	0	0	0	0	0	500	1000
Global	18046	18184	25666	32401	35458	39673	48340	54850

Source: GWEC Market Intelligence, March 2023

● Sufficient ● Potential bottleneck

rely on imported wind turbines to cope with the anticipated growth.

For Europe and the US, we expect sufficient supply throughout this decade if western turbine OEMs can smoothly mobilise the capacity they own in China and India. However, if the free flow of the global wind

supply chain is interrupted by proposed regional initiatives such as 'Made in Europe' and 'Made in the USA' – and no new nacelle assembly capacity is built at the same time – we expect to see supply chain constraints in both regions by the middle of this decade. Even assuming that all of the existing nacelle production capacity in

Europe and the US can be fully utilised – an unlikely occurrence as buffer room is normally required to ensure sufficient supply and production capacity will be impacted by the introduction of new onshore turbines with greater power rating – we foresee a bottleneck occurring from 2026.

Challenges in the supply chain for offshore wind nacelles

Compared with onshore wind, the supply chain for offshore wind turbines is more concentrated, due to the fact that more than 99% of total global offshore wind installation is presently located in Europe and the APAC region.

China is the world's number-one offshore turbine nacelle production centre with annual assembly capacity of up to 16 GW, of which 1 GW is owned by one western turbine OEM. Excluding China, the APAC region has an offshore turbine nacelle capacity of 1.9 GW, mainly located in Taiwan and South Korea.

In Europe, current nacelle assembly capacity for offshore wind is about 9.5 GW, which we anticipate reaching 11.5 GW next year when a new nacelle facility comes into operation in Eastern Europe.

No offshore turbine nacelle assembly facility is currently in operation in North America, although GE Renewable Energy, SGRE and Vestas have announced nacelle investment plans for New York and New Jersey in Q1 2023. Similar to North America, LATAM has no offshore nacelle assembly facilities despite Chinese turbine OEM Mingyang looking for offshore wind investment opportunities in Brazil since 2020.

Looking at the demand and supply situation for this decade, our benchmark results show more challenges for offshore wind than for onshore wind.

GWEC Market Intelligence does not see any problems arising in the near term, given that European OEMs are able to share spare offshore nacelle assembly capacity with emerging markets in APAC and North America in 2023–2024.

However, the situation is going to change. Starting in 2026, we expect Europe's existing offshore turbine nacelle assembly capacity to no longer be able to support growth outside of Europe.

In fact, we expect that from 2027 Europe's offshore wind turbine nacelle assembly capacity will struggle to cope with the growth expected in Europe alone. Existing capacity needs to double in order to meet the projected demand for this region in 2030.

Looking at APAC (excluding China), although offshore turbine nacelle capacity is likely to increase to 3.7 GW after expansion work is completed at one of the existing facilities in 2024, it will still be insufficient to meet demand in this region from 2027. Taking into account estimates that demand for offshore wind turbines in this region will reach 7.9 GW in 2030, it is imperative that the investment

plans announced by western OEMs in partnership with Japanese and Korean firms materialise in time.

In the US, considering local content requirements (LCRs) associated tax credits and incentives under the IRA and the two-year lead time needed to build a new offshore wind nacelle production facility from scratch, it is of the utmost urgency that GE Renewable Energy, SGRE and Vestas turn their investment plans into concrete action.

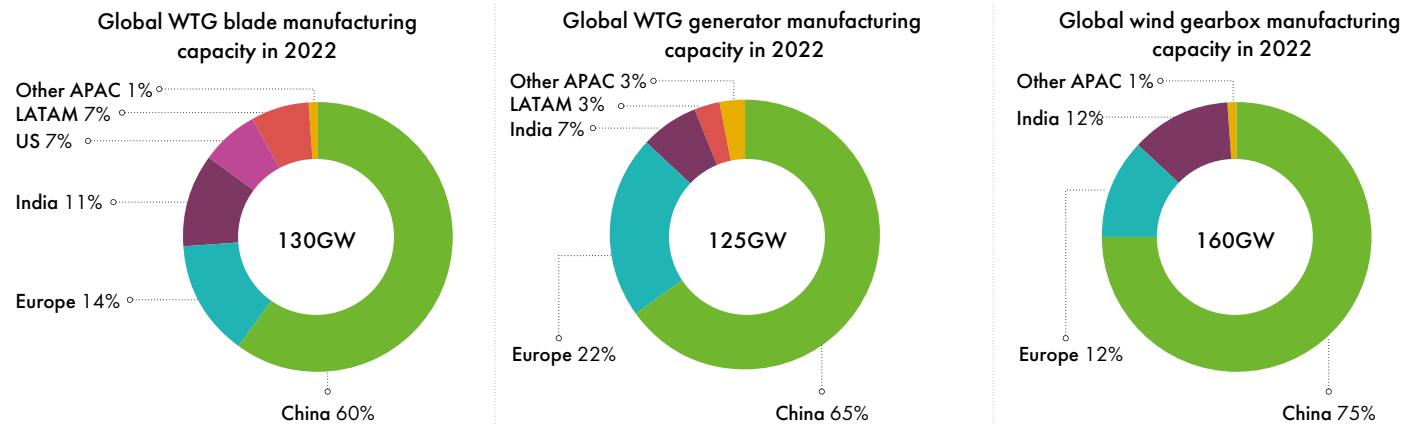
There are no plans for offshore wind projects to be built in LATAM until the latter part of this decade. However, early investment is needed to avoid bottlenecks. This is especially true of Brazil, where 71 offshore wind projects, totalling more than 170 GW, had filed environmental investigation licences by the end of 2022, according to the country's Ministry of Mines and Energy.

Key components

GWEC Market Intelligence has been monitoring the supply chain for key wind turbine components since 2019. Based on our latest supply chain update, no bottlenecks are expected in 2023–2024 for key components such as



Global wind key component supply chain overview



Source: GWEC Market Intelligence, February 2023

blades and generators, but further investment in both components is needed to accommodate growth after 2024.

Following recent investment, gearbox manufacturing capacity

is well positioned to support the expected growth up to 2027. A concentrated supply chain and regionalised sourcing strategies, however, look certain to create bottlenecks.

It is also important to note that the supply chain for key components is highly dependent on China. In addition to gearboxes and generators, China controls the global supply chain for castings, forgings, slewing

bearings, towers and flanges with more than 70% global market share. How other regions enact policies designed to reshore production or restrict trade will have a strong impact on the supply picture and on cost.



Case study: Sourcing rare earth materials for wind energy from local supply chains

The increasingly ambitious wind energy targets being set to reduce reliance on traditional energy sources – both in terms of geographical and material dependence – present a challenge from a supply chain perspective. This is particularly true for rare earth elements (REEs), with top policymakers increasingly calling for de-risked supply chains.

Wind energy uses large amounts of rare earth permanent magnets (REPMs), contributing significantly to global demand. Wind energy OEMs have faced challenges in obtaining the quantities of REPMs they need, despite supply growing at record speed and demand softening thanks to 'hybrid' wind energy technologies increasingly replacing standard direct drive (DD) turbines over the past five years. Hybrid systems (medium-speed drivetrains) use just one-tenth of the REPMs needed in a DD drivetrain.

In the fourth quarter of 2022, China accounted for 68% of rare earth mining and 94% of downstream processing. Only a meagre amount of materials was processed elsewhere, principally in Malaysia and Estonia.

Because the wind industry is exposed to the impacts of geopolitical tensions

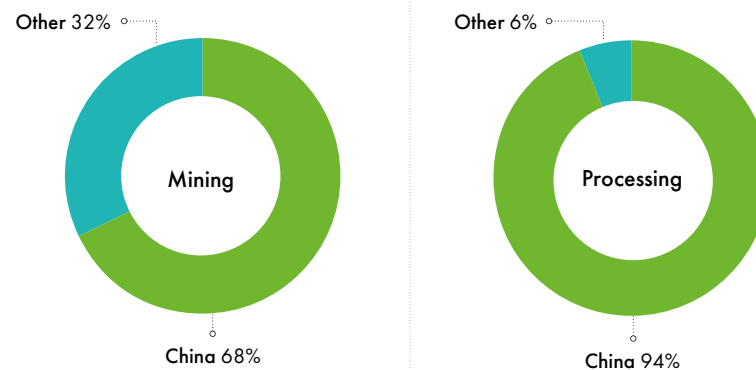
– and following a toughening of China's export restrictions of rare earth-related technologies – there is growing policy and industrial concern in Europe, North America, Australia and elsewhere.

While sourcing enough REPMs for wind energy generation can be difficult, the greatest challenge for the industry is being able to source them domestically or from a de-risked supply chain. In major markets such as Europe, the US and Australia, demand for REPMs in wind energy is substantially larger than local supply.

Policymakers have made some efforts to bridge this gap, for example in the US, the UK and Australia, where Benchmark Mineral Intelligence (Benchmark) expects to see rapid processing capacity growth by 2024-2025.

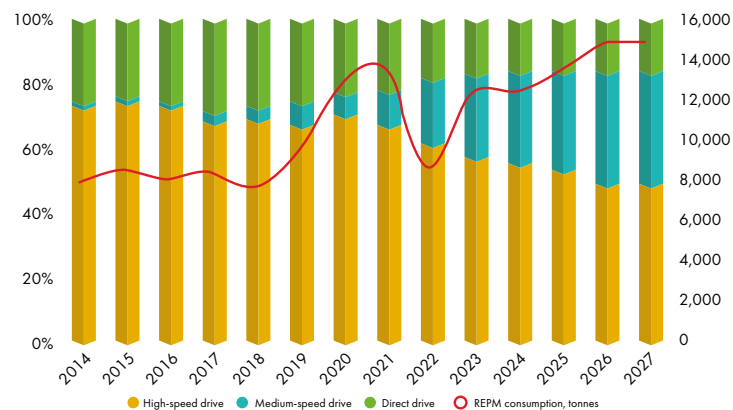
- The US Department of Defense has awarded two high-profile contracts to MP Materials and Lynas Rare Earths, at 35 million USD and 120 million USD respectively, to expand rare earth oxide (REO) separation capacity. Additionally, bill H.R. 5033 proposes to support magnet producers in the US to help them compete with their Chinese counterparts. Benchmark forecasts

China dominated REE mining and processing in Q4 2022



Source: Benchmark Mineral Intelligence

Wind turbine technology forecast (%) and equivalent direct REPM use (tonnes)



Source: GWEC, Benchmark Mineral Intelligence

Note: This chart displays direct REPM use (magnet volumes) in DD and medium-speed drivetrains per annum. It is not normalised to final raw materials demand.



Case study: Sourcing rare earth materials for wind energy from local supply chains (continued)

active production from multiple REPM facilities in the US, notably by MP Materials in Texas and USA Rare Earths in Oklahoma.

- The UK's 850 million GBP Automotive Transformation Fund will develop Pensana's 145 million GBP separation facility at Saltend Chemicals Park, in northern England. This facility is expected to consume a growing input of external feedstocks – as the facility scales and the company's own mine reduces production – to produce separated oxide, and is the UK's largest effort to date to establish domestic rare earth processing.
- In Australia, Iluka Resources has received 1.25 billion AUD in non-recourse financing from Export Finance Australia. This is part of the government's wider 2 billion AUD Critical Minerals Facility to establish the Eneabba refinery in Western Australia, with additional capacity to consume external feedstocks.

While the pipeline of processing facilities in North America, Australia and Europe is significant, it will take time for the first inputs to be converted into saleable material, and to fund and construct the required facilities.

The availability of locally processed and manufactured REPMs may be further limited, in the short and medium term, by offtakes securing sizeable portions of planned production for EV manufacturers. Whereas a facility such as Solvay's La Rochelle, in France, may be able to scale up fast thanks to existing knowledge and experience, other parts of the puzzle need to align. Before a diversified, de-risked and sizeable local supply chain is established, more than 300 GW of additional wind power capacity may already have been built.

Benchmark forecasts a more diversified and regionally scaled rare earth processing market beginning to take shape after 2025, particularly in Europe, North America and Australia. Environmental protections and economic concerns, such as high CAPEX requirements and low Chinese costs, together with considerable project lead times, cast a shadow on capacity addition forecasts, however. A large part of the wind industry will, as a result, have to rely on sourcing REPMs from China in order to meet clean energy demand in the short term.

With input from Benchmark Mineral Intelligence

Part 2: Challenges in the supply chain

Wind turbine installation vessels (WTIVs)

According to GWEC Market Intelligence's Global WTIVs database 2022, China and Europe operate the majority of jack-up and heavy-lift vessels used for offshore wind turbine installation. No global shortage of WTIVs is expected up until 2026.

Following an offshore wind installation rush in 2021, new installations in China slowed down in 2022, and we do not expect to see 2021-level installations again until 2026.

In Europe, the current WTIV supply chain can cope with demand, given that annual offshore wind installations are relatively flat and unlikely to reach the 10 GW milestone until 2026 – which also explains why European vessel operators are able to release their jack-up and heavy-lift vessels over the next two years to support the demand from emerging markets in Asia, mainly Taiwan and Japan, and the US.

Looking at the supply chain situation for the 2027–2030 period, however, while GWEC Market Intelligence does not expect WTIV supply chain constraints in China, it

foresees a likely shortage in Europe towards the end of this decade, unless investment in new WTIVs is made before 2027 (assuming a lead time of three years for delivering a new WTIV vessel).

In the US, where only two tailor-made Jones Act compliant WTIVs are currently under construction, plans for new WTIVs will have to be executed in the next two or three years to avoid bottlenecks, if the Biden Administration's target of 30 GW of offshore wind by 2030 is to be met.

All of this has brought the urgency of building supply chain security for renewables to the top of the political agenda and created a global green investment race.

The Inflation Reduction Act (IRA), signed into law by the Biden Administration in August 2022, promises to move the US closer to its climate goal. Its provisions on tax credits and LCRs associated incentives have generated concern in the EU and other countries about the IRA's potential negative impact on their domestic manufacturing industries. In response, the EU unveiled its Green Deal Industrial Plan, which aims to boost Europe's cleantech competitiveness and to keep green investments at home.

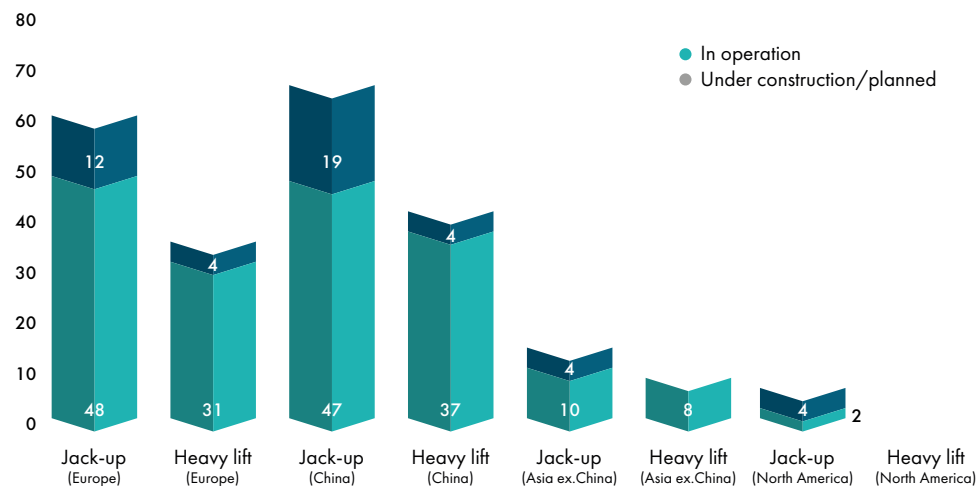
What we are witnessing now is a clear misalignment between government, industrial, trade and financial policies. It must be understood that without well-functioning and competitive global wind supply chains – alongside equal access to raw materials and components – the energy transition will not materialise. There is a danger that the restrictive trade policies proposed by the EU and the US may risk delaying the global energy transition.

Restrictive trade policies could delay the energy transition

The past three years have shown the exposure and vulnerability of renewable industries to geopolitical dependencies, commodity price cycles, logistics bottlenecks and trade barriers. The sudden post-lockdown recovery of industrial production in 2021 led to fierce competition for raw materials, as well as ongoing bottlenecks in manufacturing capacity.

Russia's invasion of Ukraine also deepened geopolitical concerns and intensified the existing trade tensions between China and other markets, such as Europe and the US.

Number of wind turbine installation vessels in 2022



Source: GWEC Market Intelligence Global Offshore Wind Turbine Installation Vessel Database, October 2022

PART 3: THE RISKS AND OPPORTUNITIES OF REGIONALISATION





Regionalisation and decoupling supply chains – risks and opportunities

As a result of the combined effects of geopolitical threats, climate imperatives and energy security challenges, the deployment of renewable energy capacity is expected to accelerate substantially over the coming years (see Part 1). This acceleration comes as countries and regions move to implement their ambitious energy and climate targets and is driven by continued cost advantages compared with fossil fuels.

GWEC Market Intelligence has increased its forecast for additional wind power installations in the 2023–2030 period by 143 GW (+13% YoY). We now expect the first TW of wind power to be installed by mid-2023 and the second TW to be reached at the end of this decade.

This massive increase in installations will create a need for significant additional capacity across the entire wind supply chain (see Part 2). For example, there are 153 turbine nacelle

assembly plants in operation today, with another 74 facilities either under construction or in the planning stage. These assembly plants will need components from across the global supply chain, requiring substantial investment to meet demand.

Our analysis in Part 2 also reveals that shortages for both nacelles and key components may develop in the US and Europe mid-decade if the free flow of the global wind supply chain is impacted by regional initiatives aimed at achieving 'Made in Europe' and 'Made in the USA' supply chains.

GWEC is concerned that governments around the world do not understand the potential impacts of their poorly coordinated actions, which is why the availability of key data on supply chain development is critical, and why continuous dialogue with industry must be undertaken.

The Inflation Reduction Act (IRA) provides significant incentives for US-based manufacturing, which could render uncompetitive any projects that do not use the levels of local content required to qualify for the extra tax incentives stipulated in the law. The EU has expressed 'serious concerns' about the IRA, alleging it may breach WTO international trade rules, and has responded with its Green Deal Industrial Plan. Within this plan is the Net Zero Industry Act (NZIA), which requires national governments to apply non-price criteria – defined as environmental sustainability, energy system integration, and contribution to the resilience of cleantech supply chains – to procurement mechanisms. These measures would allow governments to award higher prices in procurement mechanisms to enable companies to invest in EU-based supply chains, and make production more sustainable through circular economy and other practices. However, policymakers should beware of introducing more

Part 3: The risks and opportunities of regionalisation

Country/ Region	Actions taken to reshore supply chains
USA	Passed Inflation Reduction Act (IRA) in August 2022.
	Provides a tax credit, the advanced manufacturing production credits (AMPC), for US-made renewable energy equipment, including vessels, with sunsets beginning in 2030.
	Extends the existing ITC and PTC to 2024 and then replaces them with the Clean Electricity Investment Credit and the Clean Electricity Production Credit, both applying to designated renewable energy and storage technologies. They sunset in 2032 or when the Treasury determines that annual greenhouse gas emissions from electricity production in the US are less than 25% of 2022 levels.
	Incentivises developers of US renewable projects to purchase domestically produced equipment by providing an additional tax credit if they meet domestic content requirement (DCR) thresholds.
	To qualify, onshore wind projects installed before 2025 must source 40% (20% for offshore wind) of all equipment in the US. This rises to 55% after 2026 (2027 for offshore wind).
	100% of steel and iron construction materials must be manufactured in the US.
	Requires certain wage and apprenticeship requirements to qualify for some of the incentives.
	Introduces other incentives to induce additional investment in everything from rural small business loans for energy efficiency to R&D grants.
According to consultancy Wood Mackenzie, incentives under the IRA will cut the cost of solar, wind and storage equipment by anywhere from 20% to 60%.	
European Union	The European Commission presented its Green Deal Industrial Plan in March 2023, consisting of a Net Zero Industry Act (NZIA) aiming to strengthen the EU's industrial base for clean technologies, a Critical Raw Materials Act (CRMA) to increase Europe's capacity to source and refine critical raw materials, and more flexible state aid rules.
	The NZIA aims to support investment in manufacturing capacity in 'net-zero emissions' technologies in Europe. For wind, it sets an annual manufacturing capacity target of 36 GW. The commission envisages a new Sovereignty Fund to support cleantech supply chains and identifies the EU Innovation Fund as a bridging instrument.
	The CRMA includes a list of materials important for the wind industry such as REEs used in permanent magnets, copper for cables and lithium for batteries. With the aim of building its own domestic critical raw materials supply chain, the CRMA wants the EU to extract at least 10% of the critical raw materials it uses from within Europe by 2030. At least 40% should be processed within the EU by then. Under the CRMA, 15% of the EU's annual consumption of raw materials would need to be recycled by 2050.
	New EU State Aid Guidelines for Climate, Energy and Environment entered into force in January 2022, allowing governments to include up to 30% non-price elements in the selection criteria of their auctions. The NZIA now requires national governments to apply non-price criteria, defined as: environmental sustainability, energy system integration, and contribution to resilience of cleantech supply chains.
	More flexible state aid guidelines were also proposed for national investments in cleantech manufacturing under the Temporary Crisis and Transition Framework. This allows national governments, for a limited time, to support CAPEX investments in their national cleantech supply chains. It does not cover OPEX.
	The European Commission has imposed anti-dumping duties on towers imported from China, increasing tariffs from 7.2% to 19.2%.
Germany	Following European Commission proposals to allow more 'state aid', Germany is considering offering financial support to investments in domestic energy transition supply chains, as well as wind and solar projects.
UK	Through negotiation, the industry has agreed to a local content requirement (LCR) of 60% by 2030.
	According to the UK government, making a LCR reality will require "significant inward investment activity" on capex elements of offshore wind projects.
Poland	Under the Polish Offshore Wind Sector Deal, a level of LCR must be achieved at different stages: "at least 20-30%" of a project's total value in the preparatory, installation and operational stage for projects implemented under the first, pre-auction stage of the support system; at least 45% for projects implemented by 2030 under the second, auction stage; and at least 50% for projects implemented after 2030.
Japan & South Korea	Both have strong requirements for local content in wind projects that effectively require localisation of parts of the supply chain.
Taiwan	Has produced a specified 'list' of components that must be localised, depending on the completion date of offshore wind projects.



requirements and restrictions on industry that do not result in better rates of return for companies.

The NZIA also sets an annual wind-turbine manufacturing capacity target of 36 GW for EU member states, which is more than double the 16 GW of wind turbines installed in Europe in 2022. However, unlike the clarity and long-term visibility provided in the IRA, the NZIA does not directly address the poor market conditions that caused the profitability of European wind turbine manufacturers to fall. Nor does it establish new EU funding or financing mechanisms to scale supply chains to the level required.

Another key pillar of the EU's plan, the Critical Raw Materials Act, states that by 2030 10% of raw materials should be extracted and at least 40% of them processed in the EU. However, what's not yet clear is how the potentially higher costs of those materials will be distributed fairly among western supply chain companies.

Many other major economies, including Japan, Korea, the UK, Poland, India, Taiwan, Saudi Arabia and Brazil already have – or are in the process of designing –

Range of options for localisation



Prescriptive

Highly prescriptive taxes
Component-specific requirements



Incentive based

Income or production tax credits
More collaborative approach

measures to ensure high levels of local content in their wind energy sectors. The table below summarises some of the measures being introduced by major actors.

Some countries are reaching well beyond manufacturing, going 'upstream' to achieve local supply of critical inputs for their industries, including specific steel products used in the wind industry and raw materials such as rare earth elements. In some cases, this includes inputs that are currently not produced locally, or are produced in small quantities.

The COVID-19 crisis and its aftermath (including widespread disruption of logistics and increased geopolitical tensions)

have created a greater understanding of the need to create a more diversified and resilient supply chain. However, global trade flows continue to be critical to global economic manufacturing. Additionally, actions attempting to decouple from China and to reshore or localise manufacturing capabilities are likely to create unintended consequences in terms of bottlenecks and higher costs. These in turn, could have the potential to slow, delay or even derail the global energy transition.

It is of critical importance that, as they are urged to act on the energy crises, governments around the world do not underestimate the potential impacts of poorly

coordinated interventions. This is why GWEC advocates urgent and continued dialogue with the wind and renewables industry – along with the wider network of key components and commodities suppliers – to ensure that policies achieve the intended goals of supporting cost-effective and faster deployment of larger quantities of renewables while boosting local economies and employment.

Governments have several choices when they look to localise or reshore their energy sectors. They can encourage the use of locally produced content either through incentives and/or preferential treatment, such as tax incentives or favourable customs duties. Alternatively, they can specify which goods or services must be provided by domestic suppliers. Or they can use a combination of both of these approaches.

For GWEC members, localising production is a desirable approach that can lead to significant efficiencies and logistical savings. However, achieving necessary scale to amortise investments in industrial plants is a key concern. The industry has advised governments against prescriptive

localisation requirements and argued instead for flexibility in order to build on national and regional competitive advantages. As a rule, GWEC is more supportive of incentive-based rather than prescriptive policies as the former tend to give more flexibility to both OEMs and the supply chain in optimising their production.

Measuring the impacts of reshoring

As more reshoring policies are being proposed and introduced globally, it is important to reflect on the potential impacts on costs and timing of wind installations. Any time policies require local content, either through restrictions or incentives, there is a risk of increasing the overall costs of the wind power produced. Another significant unintended consequence is the creation of supply chain bottlenecks.

Currently the wind supply chain is highly globalised but with China as the principal supplier at a component level. GWEC Market Intelligence's global wind supply chain analysis shows that China controls more than 70% of the global supply chain for powertrains (main shaft and gearbox plus

generator), slewing bearings, towers, flanges, castings and forgings. By comparison, according to consultancy Wood Mackenzie, no powertrains or castings were made in the US in 2021. Even in some countries where sophisticated manufacturing supply chains exist, for example India, China is the primary supplier of castings.

How politicians, policymakers and regulators globally try to address this concentration in the supply chain will have a critical impact on the wind industry and its ability to deliver the capacity necessary for carrying out the energy transition in the timelines outlined in the Paris Agreement.

Industry approaches to localisation

As we have noted, wind project operators and OEMs must take into consideration a series of complex, interconnected factors when they decide where to locate manufacturing facilities. These include:

- the size of local wind markets
- logistical factors
- the existence of national and regional incentives
- the existence of specific rules around local manufacturing

- the availability of critical components and materials
- the existence of a skilled workforce
- the need to create or maintain political support for continued market growth.

For the offshore wind sector, a strong degree of localisation is imperative, since producing and assembling very large components is best done portside, facilitating installation in nearby waters. Transporting fully assembled nacelles plus blades and towers from remote locations and installing them in limited numbers would likely make projects uneconomical.

There is no exact formula for managing the trade-offs between localisation and affordability. Achieving the right balance can be particularly challenging in new markets that have yet to deploy wind projects – and as such do not have fully developed and/or competitive wind supply chains.

From a purely cost-driven point of view, it makes more sense for countries to take a phased approach that allows imports of key components and aims to increase localisation as scale



to their own advantages. For example, for offshore wind, the countries around the North Sea have built an array of interlinked industrial capabilities, a skilled workforce, port facilities and logistics around installation and operations and maintenance. It would be desirable for a similar cooperative ecosystem to evolve to address APAC's strong demand for offshore wind, rather than every country trying to quickly evolve its own complete offshore wind manufacturing and installation supply chains.

The incentive approach will be a key differentiator for countries and regions in attracting the huge investments that the energy transition will require

increases. It is also important for countries to carefully consider their specific advantages in terms of access to materials and components at competitive prices, existing industrial footprints and availability of skilled labour.

Countries with relatively small domestic markets need to look to regional markets and plan how their industries can make the most of regional supply chains while playing

However, as we have seen, cost considerations often take second place to concerns such as local investment and job creation; the position of local industrial conglomerates; and political considerations around national control and rivalries with other actors. In many cases, strong political factors make commitments to creating a local wind energy manufacturing industry a prerequisite for achieving the

regulatory support the wind sector needs to take off. This is particularly true given the predominance of government-run auctions as the main procurement mechanism for wind energy and the strong political levers that these create.

In the long run, as markets develop, the growth of the wind energy manufacturing sector and related service sectors can play a key role in maintaining social and political support for the industry. As we have seen in places as diverse as the UK, the US, Brazil and Denmark, local manufacturing and employment eventually translates into long-term, bipartisan support for the wind industry, and creates a virtuous circle of growth, investment and higher political ambition for the sector.

In short, industry is usually willing to accept some increase in costs in order to achieve political and regulatory support and wider social licence. But some ways of achieving this are better than others.

The debate around the proposed approaches for achieving more local content is developing rapidly. GWEC, as already noted, is strongly supportive of the incentive-led approach that has

been adopted in the US through the IRA and would suggest that this approach be adopted – and adapted, of course, to local circumstances – in other major energy markets such as the EU, the UK, Japan and elsewhere.

As the world enters a phase of significant acceleration of renewable energy deployment, with governments and the private sector seeking to realise heightened ambition, GWEC believes that the incentive approach will be a key differentiator for countries and regions wishing to attract the huge amounts of investment that the energy transition will require. Although the panorama is evolving rapidly, it seems clear that other countries and regions are now scrambling to match the ambitious approach the US has taken and will risk losing out if they don't.

GWEC also believes that the incentive-based approach will play a key role in enabling the wind industry to push beyond the challenging period it has faced over the last few years and begin to scale up for the next phase of global growth with confidence.

As has been widely noted, current market and procurement arrangements – including ‘race to the bottom’ pricing, unfavourable tender rules around ‘negative bidding’ and low price caps – have created a highly unfavourable environment for the wind energy manufacturing industry. The evidence so far suggests that incentive-based approaches to stimulating supply chain investment, such as the IRA and its precursors, will be much more effective than approaches based around prescriptive LCRs or trade restrictions.

Government packages that enable transparent and widely available access to incentives will improve project economics and demand, provide strong impetus to sourcing from domestic manufacturing and provide the visibility for the supply chain to make long-term investments. In contrast, attempts to force localisation without any measures to improve the economics of the wind energy value chain risk increasing costs in an already inflationary environment, ultimately further undermining the profitability of the sector.

Government and industry need to find the right balance between

countries’ legitimate expectations to benefit from the energy transition while maintaining a cooperative environment where fair competition and scale benefits play out. In the absence of frank, evidence-based dialogue, there is a risk that low-carbon targets will be missed and the overall cost of the energy transition will increase.

Continued collaboration and dialogue are needed to achieve the energy transition

As the data in this report shows, policy- and market-led demand for wind energy will increase dramatically in the coming years. And yet, due to unsatisfactory market conditions, permitting bottlenecks and stop-start political support, investment in the global supply chain has been insufficient to prepare the industry for the anticipated growth ahead.

Investment has been made most consistently in China, creating a world-class wind manufacturing sector on the one hand, but creating a highly imbalanced global supply chain on the other, sparking legitimate concerns around dependency and a lack of resilience, particularly in the wake of COVID-19 and the post-pandemic crisis in logistics.





In order to meet the ambitions of governments, energy consumers and wider society, the wind industry needs to invest strongly in increasing the capacity of the supply chain while simultaneously building resilience and diversification.

GWEC believes that policymakers' approach to this task in the present period could greatly impact the success of the energy transition. Supply chain diversification and reshoring will undoubtedly affect the costs of the transition, but to what extent will depend on how decisively

policymakers intervene, and over which time period.

If poorly conceived or executed, actions to impose rapid reshoring could lead to supply chain bottlenecks (particularly in the EU and the US, but also in other large economies), potentially leading to material delays in the transition. We have already seen the impact of such bottlenecks on a more localised scale in the past – the current situation could see far more significant impacts.

GWEC recommends that policymakers, international institutions, the private sector and civil society engage in a comprehensive dialogue to build supply chains that can meet the requirements of the Just Energy Transition while ensuring that necessary inputs are available at the right pace and without the risk of sharply higher costs and bottlenecks.

Similarly, the intensification of more restrictive trade practices and trade disputes could also lead to price increases and disruption – although the evidence suggests that, despite increasingly loud debate, we are a long way from an end to

globalisation. GWEC has advocated a cautious approach from policymakers involving full consultation with relevant actors in order to fully understand impacts from trade restrictions.

The scale of the investment and production needed to carry out the energy transition will require continued global and regional collaboration and the scaling up of widespread investment. We believe that it is imperative for policymakers to come together to collaboratively design mechanisms that facilitate a streamlined, incentivised and accelerated energy transition.

If designed properly and comprehensively, policies created to enable the scaling up of the supply chain and its diversification represent a huge opportunity for the world. We will see in subsequent sections how different countries and regions are approaching the task.

GWEC and the wind industry will be engaging in intensive dialogue with all stakeholders in the coming months and years to ensure we are playing our role in achieving the scaled-up, confident and diverse supply chain the world needs.

Trends in globalisation – here to stay?

Global trade is highly complex, and no region is close to being self-sufficient, a McKinsey Global Institute report points out. It makes a few key points:

- No region is close to being self-sufficient. Every region relies on trade with others for more than 25% of at least one important type of good.
- About 40% of global trade is 'concentrated', with importing economies relying on three or fewer nations for this share of global trade.
- Over the past five years, the largest economies have not systematically diversified the origins of imports.
- All economies have vulnerabilities, some more than others.
- Informed reimagination of global trade requires a granular approach both in mapping concentrated trade relationships and in deciding on action – whether to double down, decouple or diversify.

A silhouette of a wind turbine is positioned on the right side of the frame, extending from the bottom towards the top. The background is a vibrant sunset sky with a gradient from orange at the bottom to yellow at the top, interspersed with dark, silhouetted clouds. A thin blue horizontal line is located above the text.

PART 4: THE IRA IS SET TO TURBOCHARGE THE US WIND SECTOR

Inflation Reduction Act sets the stage for fundamental transformation of the US wind sector

The Inflation Reduction Act (IRA) is not only the single largest investment in renewable power in the history of the United States, but simply the largest investment in climate action the world has ever seen. It is clear why the IRA has been widely received as 'transformative' in its projected impact domestically, from renewable energy growth to job creation and society-wide benefits such as cleaner air.



For the American government, the IRA amounts to a fundamental reshaping of the global renewable energy supply chain, by repatriating significant segments to American soil. From a global climate standpoint, the IRA keeps hope alive for meeting the Paris Agreement's goal of limiting global warming to 1.5C.

With so much to deliver, there is a sharp focus from the wind industry on local content requirements and effects on the global supply chain. In the wider global context of an expected significant increase in wind energy deployment across many regions, it is worth exploring the overall impact of the IRA as a model for transformative climate action and as a source of national and regional competition.

While the IRA has already yielded results in a short time, a crucial part of the big picture will be how the supply chain adapts over time to facilitate the projected growth.

Since President Biden signed the IRA into law, the American clean energy industry has announced:

- More than 65 billion USD of capital investment into clean energy projects, enabling more than 30 GW of new clean energy capacity
- 32 new or expanded clean energy manufacturing facilities, including:
 - 6 new wind power manufacturing facilities (or reinvestment in existing plants)
 - 18 new solar manufacturing facilities
 - 8 new grid-scale battery storage manufacturing facilities
- Nearly 14,000 new manufacturing jobs associated with new facility announcements
- 3 billion USD in consumer savings from accessing clean energy sources.

'Transformative' impact

It is hard to overstate the transformative effects the IRA will have on the US electricity grid and

the broader economy. The American Clean Power Association (ACP) estimates the IRA will deliver upwards of 550 GW of new clean power through to the end of the decade. Once in place, renewable energy projects will deliver around 40% of the country's electricity, equivalent to meeting the electricity needs of 160 million homes in the country.

The impact on the American economy will be profound as well. The business community will need to invest upwards of 600 billion USD to bring these projects to market and create and support a workforce of at least one million. Local communities will earn valuable dividends from these projects in the form of local jobs, state and local tax revenues, and increased economic activity. ACP estimates rural American communities will see 17 billion USD in new state and local tax revenues.

Critically, the investments enabled via the IRA will deliver emission reductions and consumer energy

cost savings. According to the ACP, US emissions will decline 40% while each consumer will experience a saving of more than 1,000 USD per year on energy bills.

A national supply chain in a global industry

The IRA extends the production tax credit (PTC) and investment tax credit (ITC) for wind and solar through 2024 before transitioning to a technology-neutral tax credit that will remain in place until 2032

of the country historically dependent on the fossil fuel industry, and in domestic manufacturing capabilities.

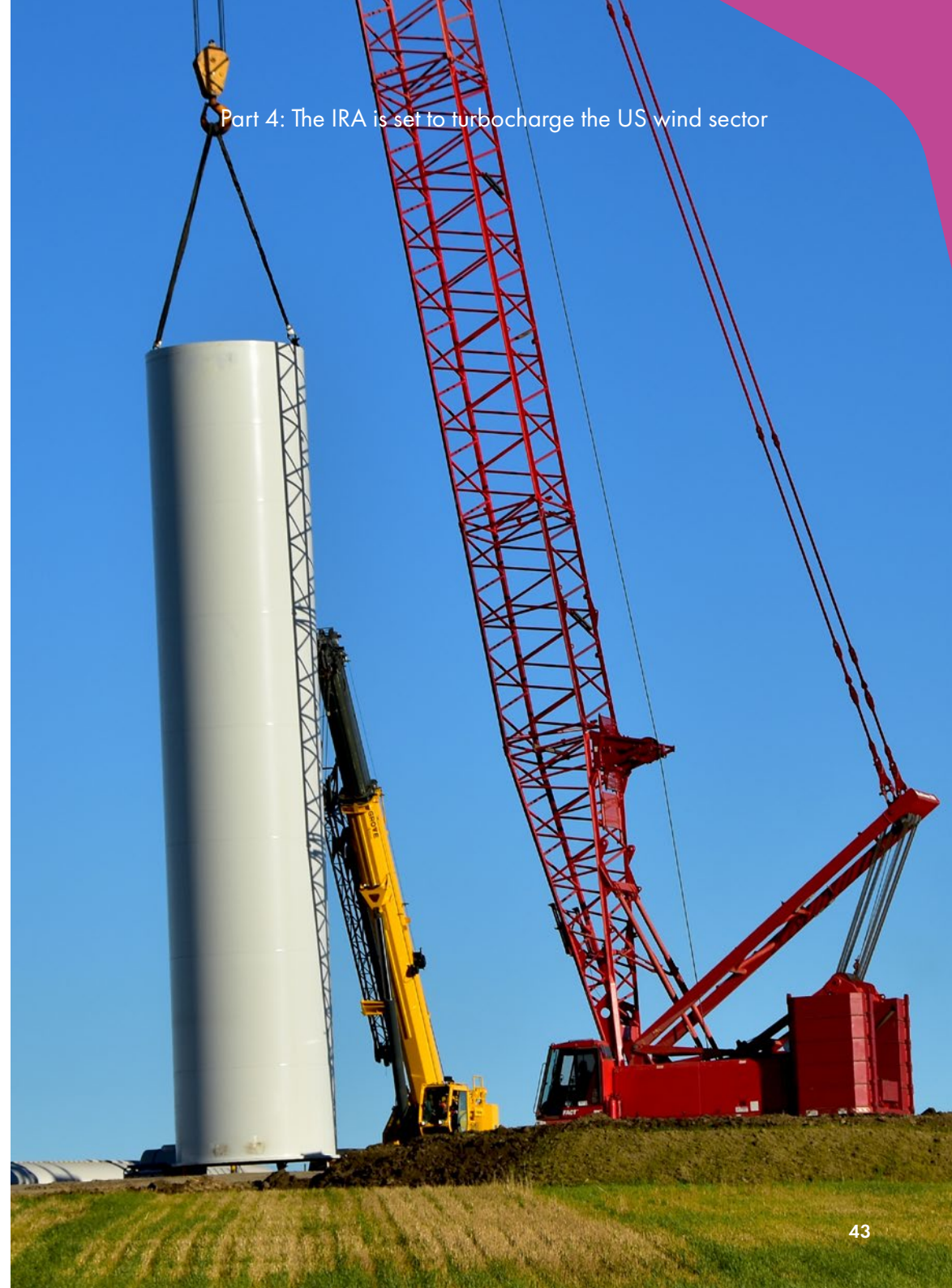
Support for domestic manufacturing is poised to spur the buildout of a robust domestic supply chain for both onshore and offshore wind. Component facilities that have been idle in recent years are contemplating restarting production, while numerous equipment providers to the

Support for domestic manufacturing is poised to spur the buildout of a robust domestic supply chain for both onshore and offshore wind

or when electric-sector emissions fall to 75% of 2022 levels, whichever is later. The legislation introduces a new clean energy component manufacturing PTC – providing equipment manufacturers with a component-specific tax credit for each unit produced domestically. Importantly, the US Congress included provisions to boost renewable energy investment in low-income communities, regions

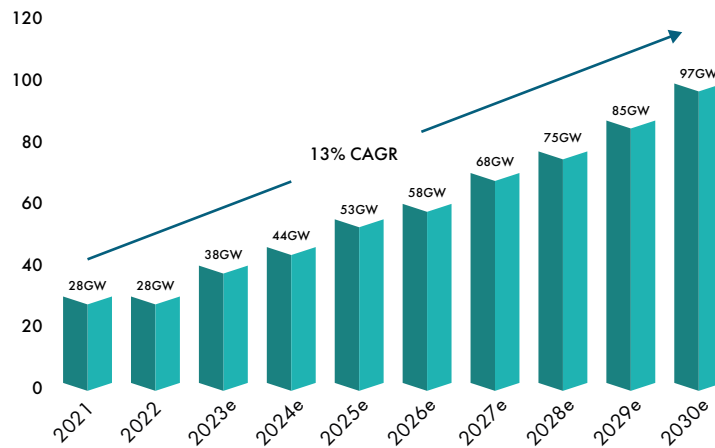
offshore wind industry are pursuing plants along the East Coast. Recently, GE and Siemens Gamesa announced intentions to build offshore wind nacelle manufacturing plants so long as sufficient orders materialise from recent solicitations.

Preferences for domestically manufactured components and materials point to the emergence of a more robust US clean energy



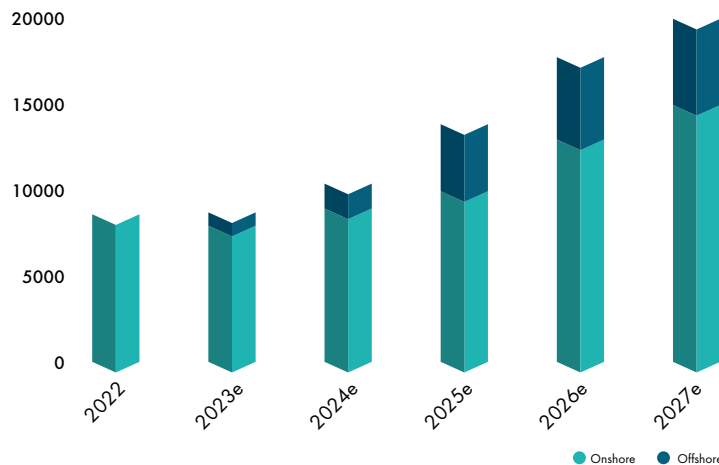
Part 4: The IRA is set to turbocharge the US wind sector

Projected annual clean power capacity installations under the IRA



Source: ACP, 2022

US new wind power installations forecast (MW)



Source: ACP, 2023

supply chain. New manufacturing facilities, processing plants and raw material production will further catalyse economic growth and job creation, with the intention of insulating the US from geopolitical supply chain risks.

Protecting against those risks has engendered criticism that the act disadvantages foreign companies, but the IRA has also set in motion a new wave of climate and clean energy ambition. The EU has responded with its Green Deal industrial plan and other countries are exploring their own responses. However, uncoordinated government activity leading to an entrenchment of national and regional supply chains risks stalling the global wind industry's growth. A coordinated and balanced expansionist approach from governments is necessary for domestic markets to grow while ensuring a healthy global supply chain that can deliver cost-effective clean energy.

Uncertainty remains on how quickly the global and American supply chain can adapt to the new conditions created by the IRA, to deliver the scale of projected

growth. China produces nearly 70% of all powertrains and 65% of castings, while the US produced none of either in 2021¹. While the US has enough manufacturing capacity to supply most domestic demand for onshore turbine equipment to 2031, the story is different for offshore, where the US is at a standing start. Whether enough capacity will come online to supply all US offshore wind developments planned for installation by 2027 remains a key issue.

Beyond wind power, energy storage is eligible to qualify for the investment tax credit for the first time, and green hydrogen can access a production tax credit rationed depending on the lifecycle emissions profile of the fuel's production.

With clear incentives and stable policies for the renewables industry in place, the ACP expects annual wind, solar and energy storage capacity installations to grow to over 90 GW by the end of the decade, more than tripling the 28 GW installed in 2021. This growth will require unprecedented supply chain mobilisation and

1. <https://www.woodmac.com/horizons/boom-time-what-the-inflation-reduction-act-means-for-us-renewables-manufacturers/>

careful coordination between the federal and state governments, and also on a global level.

Solidifying the wind energy supply chain

The US wind industry is a successful example of onshoring manufacturing. Strong growth beginning in the 2000s attracted core equipment providers to establish US facilities. These major component manufacturers brought their supply chains with them. As a

providers are looking to reinvest in their domestic supply chains. In effect, the legislation will help ensure the US maintains a thriving US-centric supply chain.

The offshore wind industry is, in many ways, in a similar situation to the onshore wind industry 20 years ago. Growth prospects are enticing equipment providers to explore strategic investment in new manufacturing plants. In fact, firms have already announced more than

Growth prospects are enticing equipment manufacturers to invest in new plants: firms have announced plans to spend more than 2 billion USD

result, over 85% of wind turbine nacelles are manufactured domestically and the broader supply chain includes more than 500 factories churning out parts and components for the industry.

Previously, policy uncertainty including impending expiration of the PTC had put much of the wind industry's supply chain at risk. Now, with over a decade of policy support in place, equipment

2 billion USD in planned investment over the next few years, according to the ACP. The IRA's manufacturing PTC and the domestic content bonus for the PTC/ITC will firm up and potentially accelerate these investments.

However, challenges remain. The absence of Treasury guidance implementing the manufacturing production credits and outlining the qualification requirements for





the domestic content bonus are currently hindering investments. In February 2023, the Treasury issued the first of two notices to provide guidance on how taxpayers can benefit from the manufacturing programme in the IRA. The Advanced Energy Project Credit – first enacted by the American Recovery and Reinvestment Act of 2009 –

awards up to a 30% investment tax credit for qualifying ‘advanced energy projects’, including those that enable the production or recycling of wind turbines, solar panels, heat pumps, batteries and electric vehicle components.

Moreover, 4 billion USD will be set aside for investments in energy communities that have seen closures of coal mines or retirements of coal-fired power plants in recent years.³

Wind at the heart of a clean energy future

The Biden Administration is targeting a 50-52% reduction in economy-wide emissions by 2030 and a net-zero emissions grid by 2035. The electricity sector is expected to make the largest contribution to economy-wide emission reductions this decade. This means that renewables will be the largest driver, and that wind energy – both onshore and offshore – is critical to achieving these targets.

Annual wind additions are expected to more than double from roughly 10 GW per year today to more than 20 GW by the end of the decade. These volumes will support continued investment in the domestic supply chain and position the US as a top market within the global industry.

Striving towards a net-zero emissions grid by 2035 will require further significant increases in annual installation volumes. All signals point to the same conclusion: the wind industry will be a central component of the USA’s clean energy future.

Co-authored with American Clean Power

3. <https://www.whitehouse.gov/cleanenergy/clean-energy-updates/2023/02/13/treasury-issues-new-guidance-to-unleash-clean-energy-manufacturing/>

A photograph of two offshore wind turbines in the ocean at sunset. The sun is a bright yellow circle in the center of the sky, which transitions from yellow to orange and then to a soft pink. The water is dark with a shimmering reflection of the sun. The turbines are dark silhouettes against the bright sky. A thin teal horizontal line is positioned above the text.

PART 5: HOW EUROPE PLANS TO RISE TO THE CHALLENGE

How Europe plans to rise to the energy security challenge while cementing the competitiveness of its wind supply chain

Europe has a big challenge ahead. In order to reach the objectives of Europe's new energy security strategy, REPowerEU, it needs to build on average 30 GW of new wind energy capacity each year to 2030. Yet, last year EU countries only installed 16 GW of new wind capacity. And wind turbine orders went down 47% YOY whilst we saw hardly any final investment decisions in offshore wind.

This is the result of higher uncertainty for new wind energy investments in 2022. Inflation caused turbine prices to go up over the past two years. And EU governments enacted unhelpful and uncoordinated power market interventions to cope with the energy crisis. The permitting situation in Europe is still not what it should be. All of these factors are making the situation for Europe's supply chain more precarious.

Permitting

Slow and cumbersome permitting remains one of the biggest obstacles for the expansion of renewables in Europe. Some 80 GW of wind energy projects are stuck in permitting procedures across Europe: they must be unlocked as quickly as possible. The EU has set out to simplify permitting rules by amending the EU Renewable Energy Directive and by putting forward 'emergency measures' allowing governments more leeway to simplify permitting.

As part of the REPowerEU strategy the European Commission proposed a number of important reforms last summer to speed up the permitting of renewables. These now need to be negotiated and enshrined in EU legislation in a revised EU Renewable Energy Directive.

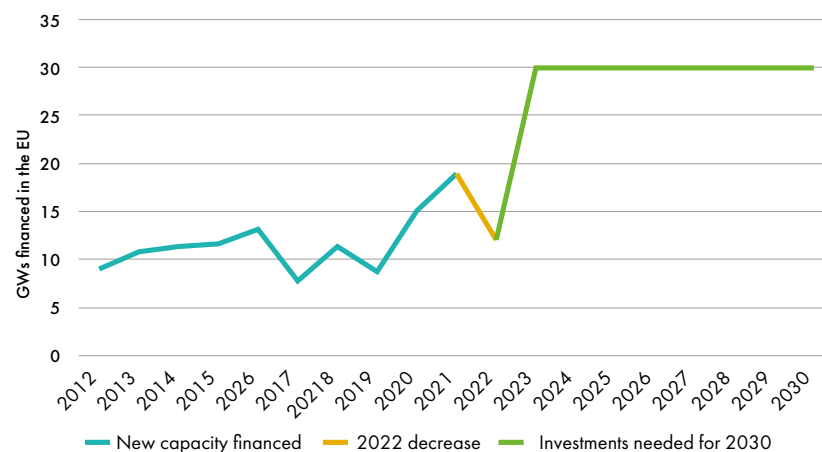
First is the proposal to consider the expansion of renewables a matter of 'overriding public interest', enabling the EU to reach climate

neutrality. This could speed up permitting significantly by helping solve the legal challenges related to new wind farms more quickly.

The revised directive also aims to clarify which permits are included in the mandatory deadlines (two years for new, one year for repowered projects) for governments to complete the permitting process. This means that all administrative steps, grid permits and environmental impact assessments (EIAs) will need to be finalised within these permitting deadlines. Achieving clarity on the procedural side is crucial for speeding up installations as it removes uncertainty for developers on the interpretation of EU rules across the EU-27 national, regional and local jurisdictions.

The revised EU renewables law will also ensure that wind energy development goes hand in hand with biodiversity protection. The amendments to the directive will strengthen the population-based approach to species protection,

Evolution of wind energy investments in EU-27



Source: WindEurope, 2023

which is already part of EU environmental law. Doing so will ensure a good working balance between the parallel sets of public policy interest that are renewables and biodiversity while contributing to Europe meeting both its climate objectives and its energy security goals. In addition, the revision envisages even faster permitting deadlines in selected 'go-to' areas where biodiversity risks are minimal.

The final revision of the EU Renewable Energy Directive is due to be completed in mid-2023. In the meantime, EU governments can apply the EU emergency permitting framework adopted in December 2022, which confirmed renewables as projects of 'overriding public interest' so long as site location is correctly selected and mitigation measures are in place to protect biodiversity. It also clarified the permits that need to be delivered within the mandatory permitting deadlines for new and repowered projects, advanced grid connections approvals, and allowed simplified EIAs for repowering – covering only the additional impacts linked to wind farm expansion. The measures are mandatory for new projects and new permits, but governments could also apply

them to existing ones should they wish to do so.

Some EU countries are already making use of the emergency rules and are taking ambitious steps nationally to improve permitting. Germany's cabinet has already approved and enacted most of the emergency measures. It is applying the concept of 'overriding public interest' in court cases. France has voted on legislation that will speed up the expansion of renewables, and Spain is making an effort to fast-track the approval of wind and solar projects stuck in a large backlog of environmental permit applications.

Industrial policy

Europe is also fast-forwarding its green industrial policy. 2022 was a difficult year for the wind energy supply chain, with Europe's turbine manufacturers and suppliers hit hard by inflation, dysfunctional trade flows, bottlenecks in the sourcing of materials and poor auction designs in some EU countries.

The EU agrees that it needs a reliable and cost-competitive wind supply chain to achieve its energy security goals. And that it must continue investing in its wind industrial base to deliver a made in

Europe clean and digital transition. Keeping and expanding a European wind supply chain will reduce costs and energy bills for end consumers while creating jobs and growth.

In response to the US IRA, the EU presented its Green Deal Industrial Plan in March 2023 to strengthen Europe's clean energy industries. The plan contains two important pieces of legislation for the European wind industry which could allow it to deploy the right investments and volumes going forward.

First is the Net-Zero Industry Act, which targets the industrial manufacturing of key technologies and equipment that are central to the European energy transition. For wind, it sets an annual manufacturing capacity target of 36 GW. The act focuses on simplifying the permitting processes for new factories. It also identifies strategic dependencies across supply chains and proposes actions to remove existing bottlenecks and increase supply chain resilience.

Second is the Critical Raw Materials Act, which plays a key role in improving the sourcing of materials for clean energy that Europe needs. The act explores opportunities for





mining and processing more raw materials in Europe while forging new trade deals with partners that can diversify supply routes. It also emphasises the importance of recycling and reusing key materials to help increase the resilience of Europe's supply chains.

All of this will be underpinned by some degree of EU public financial support, including, for instance, channelling existing resources from the EU and national Recovery Plans towards critical supply chains. The European Commission and member states are discussing in parallel a more flexible framework for the allocation of state aid that can support industrial competitiveness. The EU is also considering setting up a new EU Sovereignty Fund to finance investments in the strategic sectors charged with delivering the EU Green Deal.

Electricity Market Design

Crucially, Europe is reforming its Electricity Market Design (EMD) this year. The current market design has been beneficial by facilitating the integration of large amounts of cost-effective renewables.

EU policymakers are under pressure to deliver a quick reform

that alleviates the energy crisis burden for end-consumers while avoiding a reversal of 20 years of European energy market integration. The EU cannot afford to get this wrong.

The central response to the current crisis remains more energy supply, in particular with more homegrown renewable electricity generation. Europe's EMD must therefore send the right investment signals to deploy wind energy at scale and ensure that the EU's investment environment for future wind farms remains attractive.

Therefore, the existing revenue caps on inframarginal generators must be removed and cannot serve as a starting point for EMD reform. In 2022, the EU adopted a temporary emergency framework that allowed governments to intervene exceptionally on power markets to control prices. Many EU governments scrambled to introduce revenue caps for inframarginal power generation in an uncoordinated fashion – some even taxed unrealised revenues. This has undermined investor confidence and halted investment in renewables.

The new EMD should allow developers to leverage the

potential of Contracts for Difference (CfDs) and Power Purchase Agreements (PPAs). It should also leave space for investors to access some market revenue so they can meet their PPA obligations. This will be key for companies managing large portfolios of energy investments across different markets, and for building sound financing strategies for renewables.

Equally importantly, the new rules must cement investment certainty. Market scale is achieved in countries where governments respect the stability of existing and awarded support schemes and market-based arrangements, and where governments plan ahead and provide regulatory visibility for the wind industry and its supply chain with concrete wind deployment objectives. The EU Renewable Energy Directive prohibits retroactive changes to existing support mechanisms and requires governments to outline forward-looking auction schedules (timeline, budget, capacity) and technology-specific auctions to attract investments. None of this should be put into question as Europe reforms its EMD.

Co-authored with WindEurope

PART 6: WILL CHINA CONTINUE TO BE THE MARKET LEADER?





Will China continue to be the market leader?

China is the world's largest wind market. The country achieved record additions of 68.6 GW of grid-connected onshore wind in 2020 and 16.9 GW of offshore installations in 2021 – a miracle driven primarily by the complete phaseout of renewables subsidies.

Shifting from a subsidy-driven market to a pro-renewables market

Since 2022, China's renewable energy market has entered a new stage. The support for renewables has switched from a feed-in tariff (FiT) model to a 'grid parity' model, whereby electricity generated from renewables will receive the same remuneration as that from coal-fired power plants.

Nevertheless, the phaseout of subsidies has not slowed the pace of renewable energy development in China. Although new grid-connected wind capacity in 2022 was only 37.6 GW – a 21% drop from the previous year, mainly driven by COVID-19 restrictions – installations of all renewables including hydropower, wind, solar and biomass recorded a stellar year, accounting for 76% of the

country's newly installed power generation capacity. China's renewable energy capacity will continue to grow as the country strives to meet at least half of its incremental power demand growth with renewables under the 14th Five-Year-Plan.

Political commitment paves the way for long-term development

Since China's President Xi Jinping announced the '30-60' target in 2020 – to achieve peak emissions by 2030 and carbon neutrality by 2060 – China has started working on the long-term goal of creating a new type of power system with renewables at its core. Speaking at the 20th Party Congress Report in 2022, the President said that the planning and construction of the new energy system should be accelerated, providing a blueprint for energy security and low-carbon, green development.

By the end of 2022, standing at 1,213 GW, China's installed renewable energy capacity surpassed coal power for the first time. Renewable energy now accounts for 47.3% of the country's total power generation capacity,

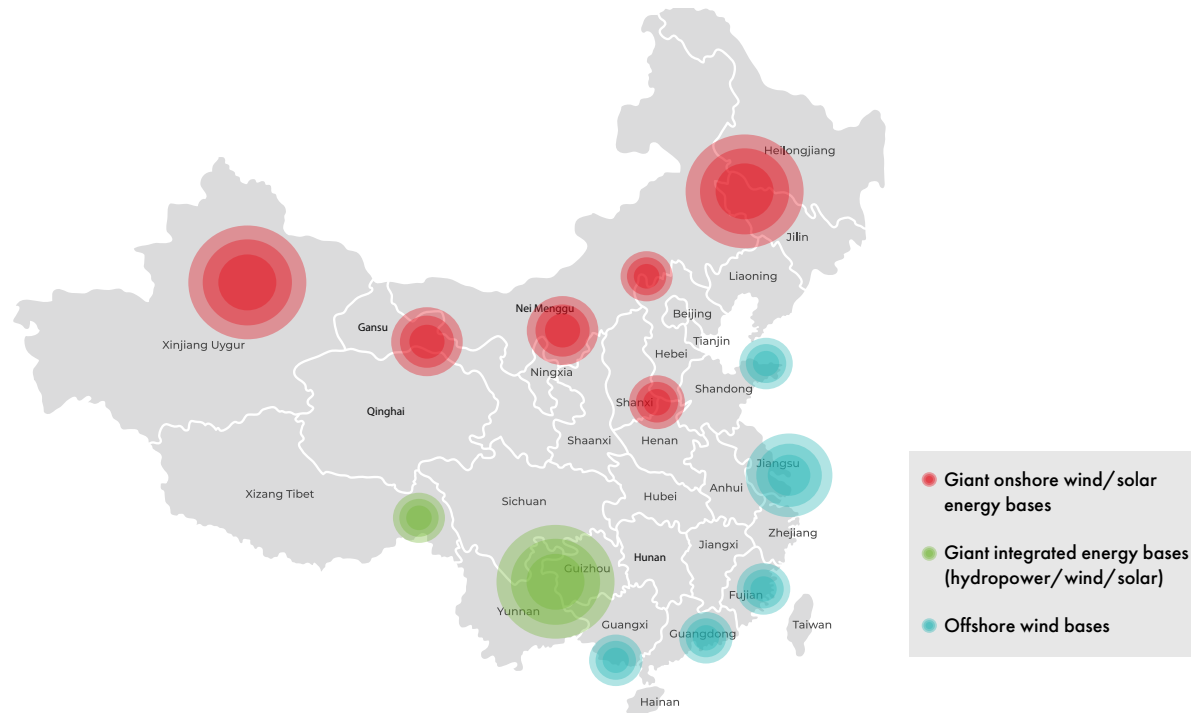
with wind and solar power generation, at more than 1,000 TWh, providing 13.8% of China's electricity consumption.

Although renewable energy is growing fast, coal power generation will still play a crucial role this decade. A severe drought last summer saw Sichuan province suffer electricity shortages due to its reliance on hydropower. New coal-fired power projects in Sichuan were approved late last year to prevent a recurrence of this situation but will be built next to large-scale renewable energy facilities so that the flexibility offered by thermal power plants can support renewable energy integration.

How the 14th Five-Year Plan will support renewables

From the Gobi Desert to the sea, and from the Tibetan Plateau to the vast plains, several 10 GW-level wind and solar farms have been completed and put into operation, such as Jiuquan in Gansu, Hami in Xinjiang, and Zhangjiakou in Hebei. Gobi and other desert areas, including the upper reaches of the Yellow River,

China's 14th Five-Year Period renewable energy development plan



Source: NDRC, NEA, 2021

the Hexi Corridor, the 'Ji' bend of the Yellow River and Xinjiang, are seeing the construction of seven new energy bases. Hydro, wind and solar installations are planned for southeast Tibet, Sichuan, Yunnan, Guizhou and Guangxi, with a number of offshore wind power bases also planned.

The government plans to support a number of demonstration projects, such as deep-water wind, high efficiency solar cells, energy islands, large-scale renewable hydrogen, hybrid energy solutions and smart microgrids in order to promote technological innovation.

In Inner Mongolia, seven energy

storage technology verification platforms, including solid-state lithium-ion batteries, sodium-ion batteries and flywheel energy storage, are under research and development.

Zero-carbon industrial parks being built across the country will require large amounts of renewable

energy. Data centres are being located in the vicinity of huge wind farms in northern China to use green electricity locally.

Long-term plans for green hydrogen production are in place in several provinces. Leading energy companies have established specialist subsidiaries to develop hydrogen technology and business. In 2022, North China Electric Power University started offering a major in hydrogen science and engineering.

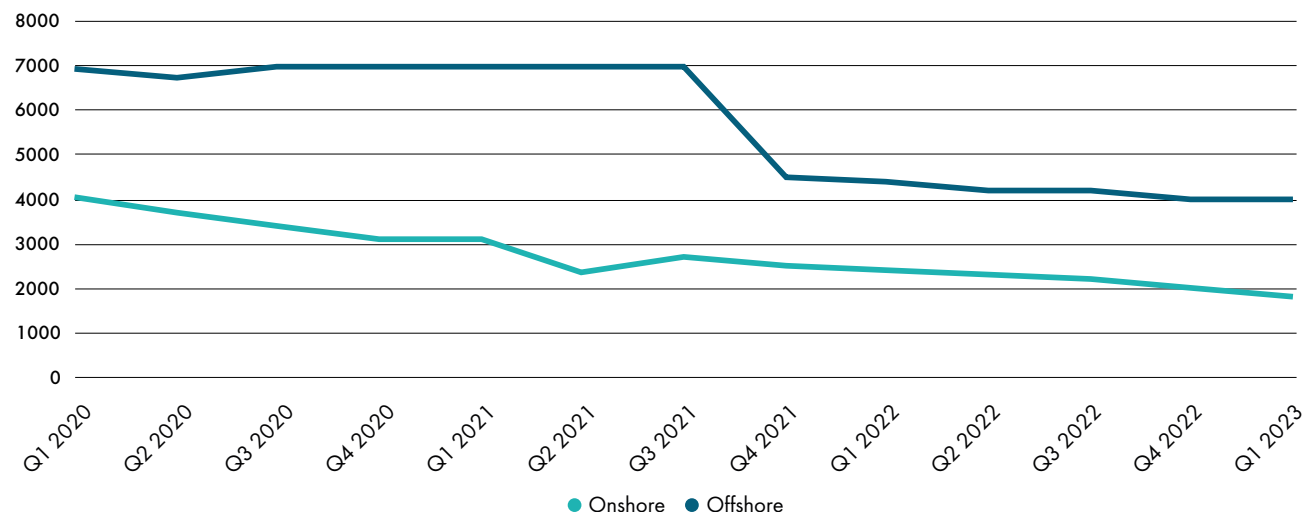
Distributed wind projects will be promoted in the vast rural areas of China's central and southeastern regions. It is estimated that 10,000 turbines, totalling 50 GW, will be installed near 5,000 villages during the 14th Five-Year Period.

How the local supply chain will cope with growth

With more than two decades of development, China has a well-established supply chain for the wind power industry. The production of wind turbine nacelles and key components accounts for 60-70% of the global market share (see Part 2), which makes China a crucial contributor to the global response to climate change.

Part 6: Will China continue to be the market leader

Average tender prices of wind turbines in China (CNY/kW)



Note: Prices are based on date of tender and include wind tower
 Source: China Bidding Centre, February 2023

More than 15 wind turbine manufacturers are active in China. Although the domestic market is large, competition has become increasingly fierce, with record-low prices being reported in the past two years. To survive the domestic price war, Chinese OEMs started exploring opportunities overseas. Additionally, as the Chinese government announced in September 2021 that it would stop funding new coal projects abroad, this will drive wind turbine exports

in the long term as the large Chinese EPC contractors will likely shift their investment from thermal power plants to renewable projects.

Leading wind turbine technology

Price pressure has acted as a driver of technology innovation, as Chinese wind turbine OEMs have continued to launch new turbines with greater power rating and bigger rotors to remain competitive. Over the past

two-to-three years Chinese turbine OEMs like Mingyang, Goldwind and Haizhuang have released offshore turbines in the 16–18 MW range. In February 2023, Envision launched the EN-220/10 MW model and two weeks later SANY rolled out the 230/8-11 MW prototype in Beijing – the largest onshore wind turbine in the world.

The Chinese wind power equipment industry has achieved a

historic leap – from ‘following’ to ‘running alongside’ and now ‘leading’ – in wind technology development.

Ambitious targets will boost offshore wind development

Construction of several 10 GW offshore wind bases is anticipated off the eastern coast, while a number of provincial and municipal governments have been working on offshore wind development plans since 2020.

The market potential for offshore wind is growing and the local industry is ready to support annual installations of approximately 15 GW. Last November, at the Global Offshore Wind Summit-China 2022 co-organised by GWEC in Haikou, Hainan, the Chinese wind industry released an initiative that calls for 100 GW of offshore wind in China by 2025, 200 GW by 2030 and 1,000 GW by 2050. If this happens, China will make up 50% of the Global Offshore Wind Alliance’s global offshore wind target for 2050.

China’s first floating offshore wind turbine, the Three Gorges Pioneer, was installed in July 2021 in Yangjiang, Guangdong. Two demo platforms have been installed

since, and a couple of projects have been announced. China's first floating wind platform with a water depth of more than 100 metres and further than 100 kilometres from shore, the 'CNOOC Guanlan' – will be operational in June 2023. It will provide electricity for the Wenchang offshore oilfield in Hainan.

In addition to these demonstration projects, China also has a 1 GW floating offshore wind farm planned by 2027 – potentially the first project of this scale to be installed globally. Planned for a location off Wanning, Hainan province, the first phase completed a feasibility study in 2022. As Chinese projects are usually announced with very short lead times, more floating wind projects with expected commissioning dates before 2030 may be announced in the coming years.

China will continue to lead global wind power development

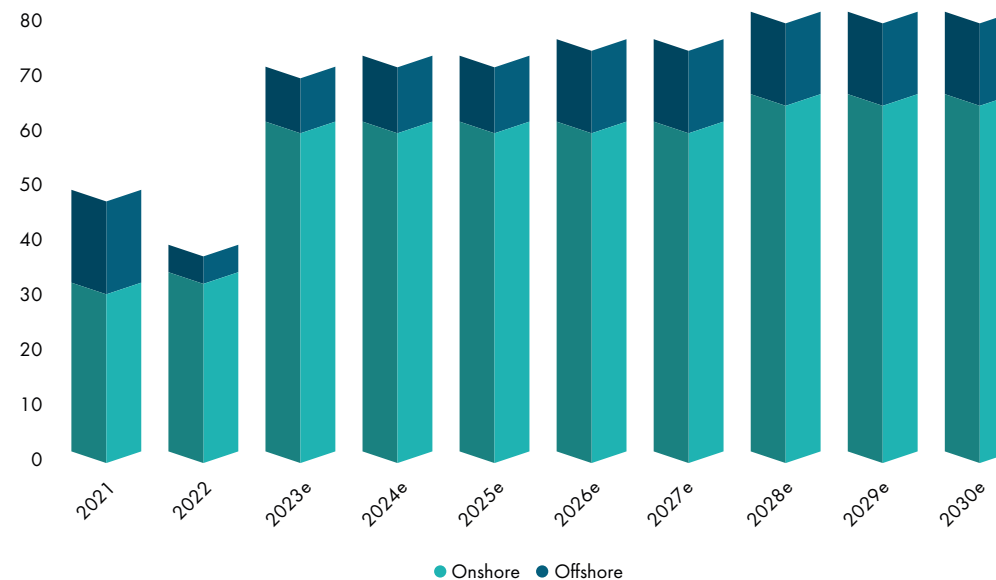
Following its '30-60' pledge, the Chinese government committed to non-fossil fuels achieving 25% of the country's primary energy mix by 2030. In February 2023, the National Energy Administration (NEA) predicted that generation from wind and solar power will double by 2025

Floating offshore wind projects in Southern China Sea



Source: GWEC Market Intelligence, March 2023

Chinese wind market development (GW)



Source: GWEC Market Intelligence, March 2023



With annual installations of 70–80 GW until 2030, China will remain the world’s largest wind market

from 2020 levels, with renewable energy accounting for more than 80% of total new electricity consumption by the same year.

To reach these targets, 250–300 GW of wind power capacity needs to be added between 2021 and 2025. Since a total of 758 GW of wind and solar power has already been grid-connected by the end of 2022 – and more than 80 GW of wind turbine orders were announced and awarded in 2022 – GWEC Market Intelligence expects China to hit its 1,200 GW solar and wind target by 2025, five years ahead of schedule.

With annual installations of 70–80 GW for the rest of this decade, there is no doubt that China will remain the world’s largest wind power market.

PART 7: HOW TO ACHIEVE A JUST TRANSITION



Part 7: How to achieve a 'just transition'

A just and equitable energy transition (JET) is indivisible from a successful pathway to global net-zero emissions. Because people are at the centre of the energy transition, communities cannot be left behind in the effort to mitigate harmful climate change.

As a leading agent of the global energy transition, the wind industry must play an active role in

transitioning workers from carbon-intensive sunset industries and encouraging their entry into the renewables sunrise industry. A wind and renewables-driven JET promotes the socioeconomic welfare of all affected workers and communities.^{1,2}

Investment and education are key drivers of a JET. Investment can facilitate education, support

displaced workers and create demand for wind energy workers along the supply chain. Education can range from retraining or re-skilling programmes to wider community outreach.

JET received much attention at COP27 last November signalling a clear appetite from the climate change community for a people-centred transition. Looking ahead,

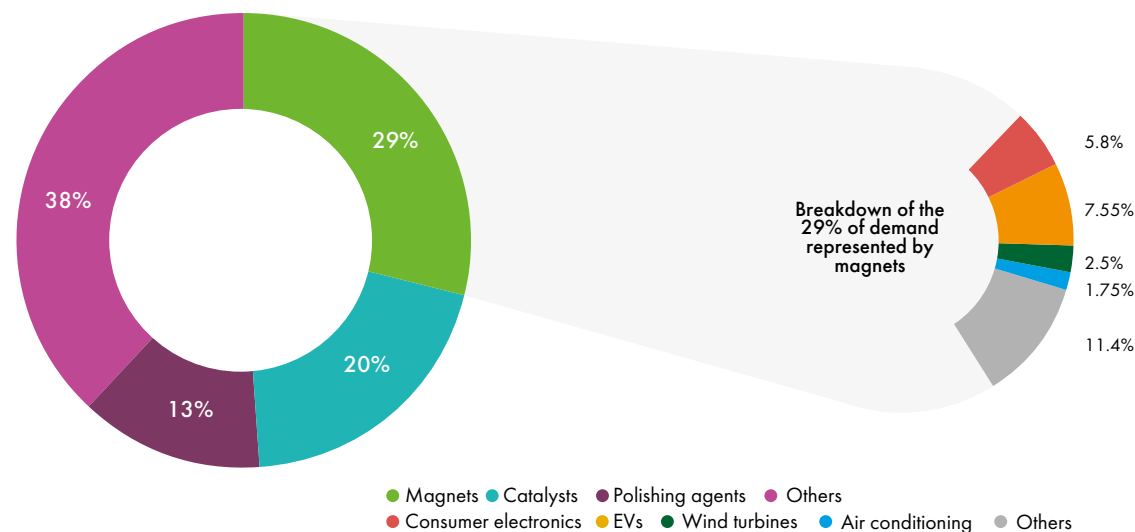
this is essential both to meet net-zero scenario pathways and to ensure that the necessary workforce is available to enable the massive expansion required of the global supply chain.

The role of the wind industry in enabling a JET

Energy transition pathways must be designed to incorporate countries' emissions, financing needs and energy profiles – especially fossil fuel dependencies. A multidimensional transition must take place at a national level, with appropriate policy support, and locally through value creation that ensures the dividends of a JET are fed down to impacted stakeholders.

There is often little understanding at the local level of what a JET means for communities. The wind energy industry can increase local awareness by highlighting the job

Rare earth demand by end-use sectors and breakdown of magnet demand by mass, 2020



Source: IRENA, 2022

1. ILO, 2015, Guidelines for a just transition towards environmentally sustainable economies and societies for all
2. ILO, 2022, Just Transition Policy Brief, Gender equality, labour and a just transition for all
3. IRENA (2017), Leveraging local capacity for onshore wind
4. IRENA (2018), Renewable Energy Benefits: Leveraging Local Capacity for Offshore Wind

creation potential of viable projects.

Renewable energy employs people of all trades and levels across the full value chain, from project planning to decommissioning. IRENA's analysis³ shows that a 50 MW onshore wind facility creates opportunities for more than 144,000 person-days, and a 500 MW fixed-bottom offshore facility⁴ for around 2.1 million person-days.⁵

The analysis also shows that over 60% of the workforce in onshore wind, and over half in offshore wind, requires minimal formal training. Science, technology, engineering and mathematics (STEM) graduates make up around 28% of the onshore wind workforce – 21% for offshore wind. Highly qualified non-STEM professionals such as lawyers, logistics experts, marketing professionals and experts in regulation and standardisation account for roughly 5% and 20% respectively, while administrative personnel make up 4% and 8%, respectively.

The proportion of women in the renewable energy workforce is estimated at around 32%, with 21% in wind energy.⁶ GWEC is in

the process of updating these figures and will report on progress later this year. As in other sectors, there is a higher proportion of female workers in more junior roles.

Upstream supply chain impacts

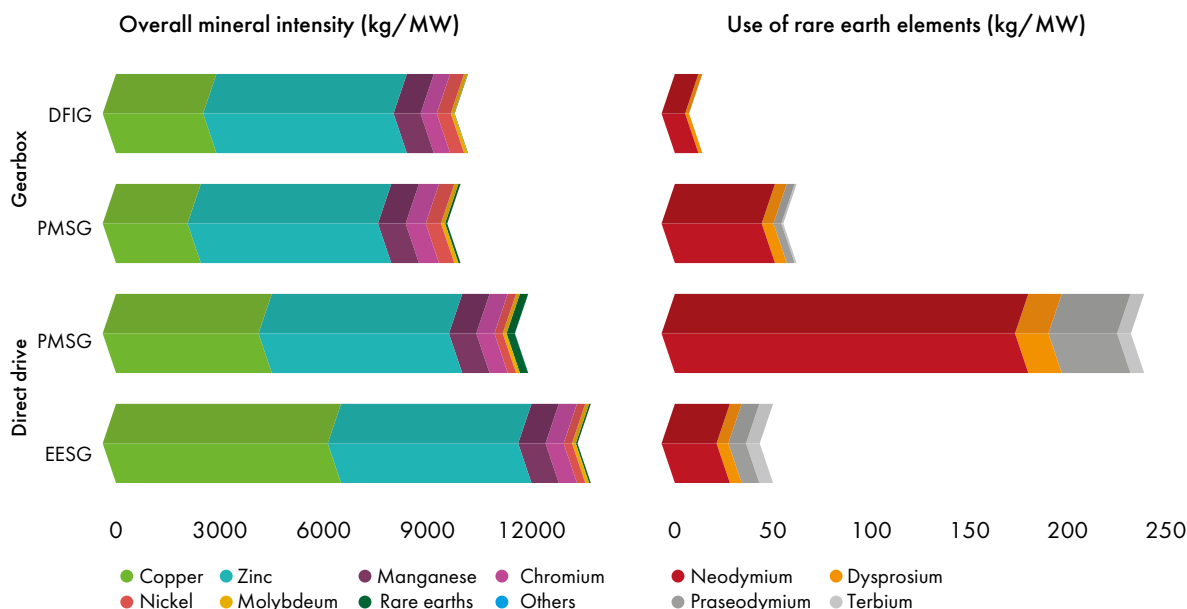
As the wind energy industry grows, so will its impact on several sectors and communities. With up to 90% of a wind turbine's mass being made of concrete, iron and steel, there will be an increase in demand for these three critical materials as installed wind capacity grows.⁷

Increased wind turbine manufacturing will also lead to greater demand for REEs – a trend compounded by similar pressures from other renewable energy technologies and other sectors. Increased demand is expected for REEs including neodymium, dysprosium, praseodymium and critical minerals such as copper, nickel and zinc.⁸

5. IRENA (2019), Future of wind: Deployment, investment, technology, grid integration and socio-economic aspects
 6. IRENA (2020), Wind Energy: A Gender Perspective
 7. WindEurope, 2022, response to the EU's consultation on the Raw Materials Act
 8. GWEC (2022), Global Wind Report
 9. IEA (2021), The Role of Critical Minerals in Clean Energy Transitions



Mineral intensity for wind power by turbine type



Source: KIM Tae-Yoon, IEA/STO/ESIO

Demand for REEs under sustainable development scenarios is forecast to increase fourfold by 2040.⁹ The wind energy industry must operate sustainably and with good governance across the supply

chains for these materials, protecting disadvantaged or vulnerable mining communities.

South Africa and Indonesia: the rise of the JET Partnership

The Just Energy Transition Partnership (JETP), announced at COP26 in November 2021, is a collaborative agreement between South Africa and France, Germany, the UK, the EU and the US to create a synergy between the global

South and the global North. The JETP model includes 8.5 billion USD in funding coupled with access to technical expertise for knowledge-sharing.¹⁰

South Africa has been a frontrunner in JET engagement, acknowledging it in the country's climate commitments (NDCs) under the Paris climate agreement as early as 2015.¹¹ While it understands the need for a JET, the government has

so far failed to sufficiently engage with the communities that are most affected – the highly coal-dependent regions.

The Planning for Climate Commission (PCC) has made significant progress in accelerating a JET dialogue through a series of multi-stakeholder consultations. The PCC developed a just transition framework that seeks to engage in tackling various aspects of the energy transition including social support.¹² These consultations are ongoing and should continue in order to ensure that the core principles of what the just transition framework seeks to do are fed down the value chain to all those affected.

Multilateral social dialogue is crucial to involving and engaging all stakeholders in a JET. Including the communities most affected by the coal phaseout, educating and supporting them through the transition, will make the difference between conceptualisation and implementation of a JET.

Other countries will use similar JETPs as a financing mechanism for JET implementation. The G7 alluded in 2022 to using JETPs to

10. Annex to G7 Leaders Statement Partnership for Infrastructure and Investment
 11. <https://www.wri.org/update/south-africa-strong-foundations-just-transition>
 12. <https://www.climatecommission.org.za/just-transition-framework>

support a JET in African and Asian countries such as Indonesia, India, Senegal and Vietnam.¹³ At the Bali G20 summit, held in November 2022, Indonesia launched its JETP supported by the International Partners Group (IPG), which includes the US, Canada, Japan, the EU, the UK, Norway, Germany, France, Italy and Denmark. Over a period of three to five years, the Indonesian JETP promises to mobilise 20 billion USD worth of investment.¹⁴

Increased investment will only drive a JET if the funding is actually fed into localities to accelerate renewables projects. One challenge the wind sector and other renewables are facing is a lack of agency, with funding being set out but not fed into the project pipeline. This must be actively challenged: if local projects and infrastructure are not implemented, the JETP risks losing credibility.

If coal is to be phased out in coal-dependent areas, the supply of renewables needs to grow significantly. To achieve this, countries need to create enabling regulatory and economic conditions that support and facilitate not only the deployment of renewable energy assets but

also their supply to the grid. This will underpin the case for a coal phaseout driven by the credible prospect of a sufficient volume of clean energy to replace it.

The South Africa initiative has the potential to pave the way for longer-term climate action through policy instruments like the JETP. Other coal-dependent countries can look to South Africa to see the links between a just transition, achieving national decarbonation goals, and meeting NDCs.

United States and the Inflation Reduction Act: investment in training and local supply chains

The Biden Administration's Inflation Reduction Act (IRA)¹⁵ is a national policy framework that promises to further the just transition by enabling local production and job creation through an unprecedented array of measures facilitating investment into good jobs and mitigation measures that protect impacted workers and communities.

By specifying the workforce and communities as key stakeholders that should benefit from this investment, it sends a clear signal to investors and civil society that a green economy can provide stability.

States in the US have typically taken a localised approach to assessing the impacts of the energy transition on their workforce. The growth of the offshore wind sector is opening up opportunities for workers in other industries to pursue a career in the green economy – facilitated by reskilling and training investment, alongside stakeholder engagement.

Examples of this include:

- BOEM Carolina Long Bay offshore wind auction: bidders are awarded a 20% monetary credit to support workforce training programmes to develop the local supply chain.¹⁶ The total credit awarded is around 42 million USD.
- The North America Building Trade Union (NABTU) and Ørsted: a Project Labour Agreement (PLA) brings together the private sector and the unions to help the US workforce meet the requirements of the offshore wind farm supply chain.¹⁷

Policy recommendations

1. Commit to a diverse, equitable and inclusive workforce through outreach.

Mainstreaming diversity, equity and inclusion in the workforce requires commitment and action across company segments, from human resources to marketing to senior leadership. The wind sector should be seen as an attractive and welcoming place

Diversity should encompass gender, ethnicity and physical ability

to work at different career stages. Youth outreach and education can ensure that the industry's diversified job opportunities are understood, particularly in early-stage wind countries. Diversity should encompass gender, ethnicity and physical ability. A cultural change in companies will enable them to leverage the talent of

13. <https://www.g7germany.de/resource/blob/974430/2057928/1315842ed9de069fa1be82dab18dabb2/2022-06-28-leaders-communicative-executive-summit-data.pdf>

14. <https://www.gov.uk/government/news/indonesia-just-energy-transition-partnership-launched-at-g20>

15. <https://www.epa.gov/green-power-markets/inflation-reduction-act>

16. <https://www.doi.gov/pressreleases/biden-harris-administration-announces-winners-carolina-long-bay-offshore-wind-energy>

17. https://nabtu.org/press_releases/nabtu-orsted-sign-landmark-mou/



women and people from minorities.

2. Drive social dialogue and increased stakeholder engagement both nationally and locally.

Creating space for social dialogue and increasing stakeholder engagement supports social cohesion and a common understanding of the challenges and opportunities ahead. Stakeholders include displaced workers, residents of communities hosting projects and members of affected communities such as the fishing industry for offshore wind. The need to discuss a JET is well understood but the dialogue needs to translate into national ambition, alongside transparent local engagement, for communities to understand and feed into the actions that will affect them.

3. Promote public-private collaboration to create value locally.

Regions that depend on the production of fossil fuels for revenue may face economic displacement in a rapid phaseout. On the path to decarbonising their energy systems, they must be encouraged to transition to

more sustainable local supply chains and jobs. Governments and the wind industry should collaborate to review local industrial supply chains and foster the creation of decent jobs. Schemes to incubate businesses and capabilities for the wind sector, such as favourable loans and the promotion of industrial clusters, will support the creation of viable local supply chains.

4. Tailored reskilling/retraining pathways to transfer from carbon-intensive industries to wind industry jobs.

Acknowledging varying skill sets and providing tailored training programmes will reduce the barriers to entry into the wind workforce. Having identified viable projects, the public sector and the wind industry should work together to identify communities of need and match them with anticipated workforce gaps. By supporting career progression pathways for fossil-fuel workers into renewable energy, the public sector will encourage labour mobility and upskilling.

5. Investment to facilitate retraining, reskilling and sustainable job creation.

Governments and the private sector should provide funding towards training and reskilling programmes that can benefit them both. Investing into the workforce will benefit the economy at large while enabling the private sector to tailor skills to its project requirements. The investment will pay off in multiple ways and boost the green economy.

6. Regulations in mining and extractive communities to ensure an ethical work environment.

National policies must ensure that working conditions do not allow the exploitation of workers, and that mining communities for REE and other critical materials are sustainable. Because these materials come from a limited number of countries, targeted regulation is needed to protect the workforce and promote growth in the wind energy sector. Standards must be set to avoid greater demand leading to more exploitation, and strictly enforced to protect the rights of workers and provide them with decent working conditions.

CASE STUDIES

A photograph of a wind farm at sunset or sunrise. Several wind turbines are visible in the foreground and middle ground, set against a backdrop of a mountain range. The sky is a mix of orange and blue, and the overall image has a blue tint. The text 'CASE STUDIES' is overlaid on the left side of the image, with a horizontal line above it.

Global Alliance for Sustainable Energy

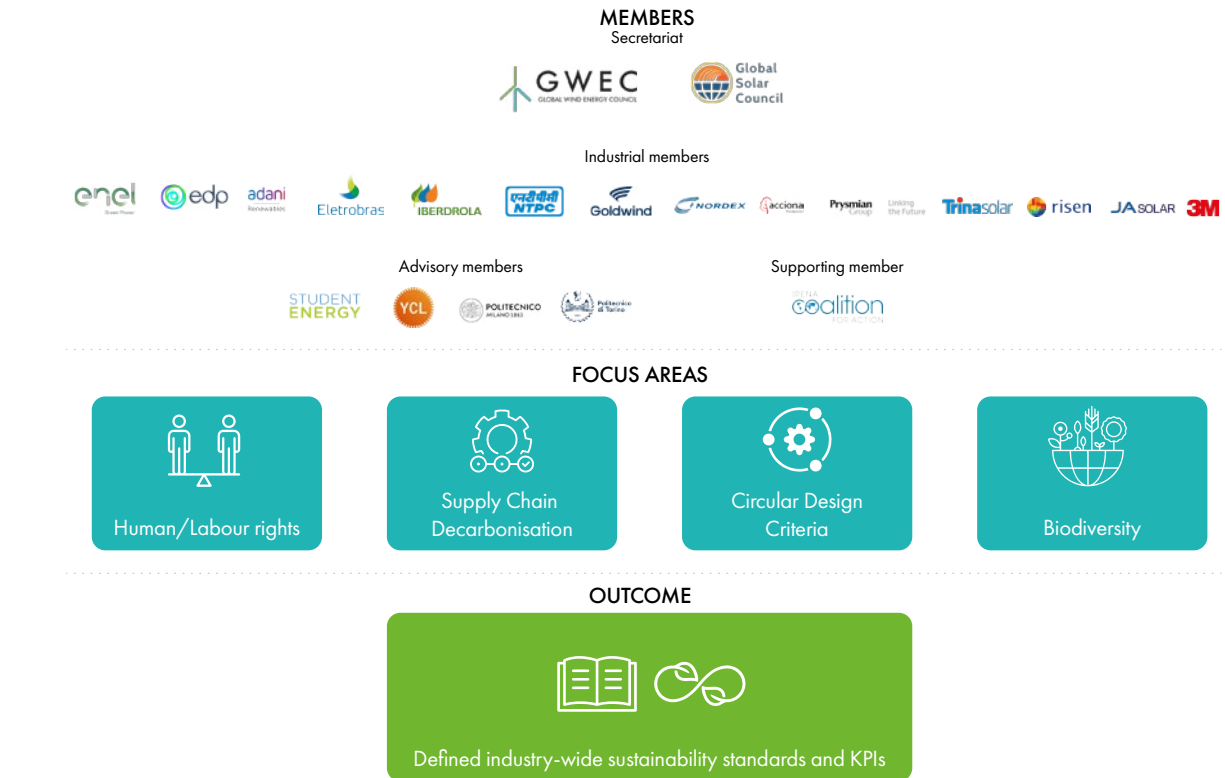
The Global Alliance for Sustainable Energy is an independent organisation that aims to make the renewable energy sector fully sustainable throughout its value chain. The alliance brings together NGOs, utilities, suppliers, developers and end-users to tackle the climate emergency and reach net zero while improving people's quality of life.

The Alliance's scope of work spans supply chain decarbonisation, circular design criteria, human and labour rights, biodiversity, and more general progress towards a just and sustainable energy transition.

Since its inception in 2022, the Alliance's work has been focused on Circular Design Criteria.

The Circular Design Working Group's position paper outlines a circular design strategy that aims to minimise waste and pollution while preserving resources. The world's current linear economy model, defined by a take-make-dispose approach – which results in the depletion of natural resources, waste generation and

Structure of the Global Alliance for Sustainable Energy



environmental degradation – must evolve into a circular economy system that considers the entire lifecycle of a product, from raw material sourcing through to 'end

of life' reuse, repurposing or recycling of component parts.

The Alliance's ambition is to be the missing link that connects all

the relevant participants in the energy sector to improve transparency, circularity and the overall sustainability of the sector by widely spreading the definition

of sustainability standards and the adoption of best practices.

The following are examples of elements put forward by the alliance for integrating into tender processes between suppliers and clients:

- A 'bill of materials' and Environmental Product Declarations (EPD) / Life Cycle Assessments (LCA) to be used as metrics to reward suppliers aligned with requirements such as limits or bans on specific raw materials, thresholds for recycled raw materials, CO2 and water footprint.
- Traceability information to guarantee the complete visibility of all the actors involved in the supply chain.
- A raw material assurance framework to drive visibility and adoption of materials that are transparently certified according to international industry standards.

Alliance members have set the following targets based on the recommendations put forward:

- 100% of new equipment

produced/acquired with Certified EPD/LCA with explicit bill of materials by the end of 2024.

- Traceability and auditing for at least two key raw materials used in one main component by the end of 2024.

Utilities and suppliers must establish a common understanding on climate-compatible buying strategies to drive supply chain decarbonisation

- Traceability and auditing for all applicable key raw materials used in one main component by the end of 2025.
- One key raw material used in one main component to be certified by the end of 2024.
- All applicable key raw materials used in one main component to be certified by the end of 2025.

Complementary to the Alliance's Circular Design work is a focus on supply chain decarbonisation across scopes 1, 2 and 3, driven by the need to establish a

common understanding between utilities and suppliers on climate-compatible buying strategies.

The Global Alliance for Sustainable Energy was initially convened by the Enel Foundation.

It includes industrial members Enel Green Power, Energias de Portugal, Adani Renewables, Electrobras, Iberdrola, NTPC, Goldwind, Nordex Acciona, Prysmian Group, Trina Solar, Risen, JA Solar and 3M.

Advisory members include Student Energy, Youth Climate Leaders, Politecnico di Milano and Politecnico di Torino. It counts IRENA's Coalition for Action as a supporting member.

As of 2023, GWEC and the Global Solar Council are jointly running the Secretariat.





Women in Wind

The wind energy industry is still heavily male-dominated, with only 21% of the global wind energy workforce being women – lower than the renewables sector overall and lower than the oil & gas industry – according to the landmark *Wind Energy: A Gender Perspective* report, published in 2020 by the Women in Wind Global Leadership Program (WiW) in partnership with IRENA.¹

Women in Wind (WiW) was formed in 2019 to address this gap in the wind industry. It aims to support and encourage the advancement of women in the wind energy sector by providing them with the necessary skills and opportunities to become leaders in their field.

Looking ahead, WiW aims to lead by example and to work with companies within the wind sector

WiW supports and encourages the advancement of women in the wind energy sector

While GWEC and its partners are proactively working to make progress on this – and the data is being updated – the report, which was based on a survey of more than 1,000 people working in wind, revealed a significant leadership imbalance, with women occupying just 8% of senior management positions in the global wind energy sector. Most women in the sector are employed in administrative and non-STEM roles.

to actively implement the principles of equality by curating organisation-wide policies that promote gender diversity in areas such as recruitment, and career progression for women at all levels. This will require regular reporting to ensure progress is well communicated, visible and fully accountable.

By addressing the underrepresentation of women in leadership positions in the wind energy industry, WiW also seeks

1. <https://www.irena.org/publications/2020/jan/Wind-energy-A-gender-perspective>

to drive innovation and growth in the sector, and to encourage a more diverse and inclusive culture.

Programme methodology

Currently recruiting its fifth cohort, WiW is an intensive 12-month programme covering a range of learning and development activities including online courses, workshops, mentoring and networking events.

The programme has been designed to be flexible, allowing participants to fit their learning and development activities into their existing work schedules.

Key outcomes

Increased representation in leadership positions

As a result of the programme, several participants have been promoted to leadership positions within their organisations, and many others have taken on additional responsibilities and expanded their professional networks.

Improved leadership skills and confidence

Participants have reported a marked improvement in their leadership skills and confidence,



Case Study: Women in Wind

with many citing increased visibility, better communication skills, and a more positive outlook as key benefits of the programme.

Increased diversity and inclusivity

The programme has helped to raise awareness of the importance of diversity and inclusivity in the wind energy sector, and has provided a platform for participants to share their experiences and best practices.

Stronger professional networks

Participants have established strong professional networks with their peers, mentors and industry leaders, which provides valuable opportunities for collaboration and support.

Over the past five years, WiW has succeeded in supporting the advancement of women in the wind energy sector and encouraging a more diverse and inclusive culture in the industry. The programme has provided participants with the skills and opportunities they need to become leaders in their field, and has helped increase the representation of women in leadership positions in the wind energy industry.

Profiled participants from the 2022 cohort



Van Nguyen Thanh
Head Of Engineering And Construction, UPC Renewables Vietnam Management LLC

Van Nguyen manages Vietnam projects at UPC Renewables. Since June 2018, she has worked on projects through various stages, from development to construction, including Lac Hoa and Hoa Dong. Van is currently leading on two 50 MW projects, Tran De and Song Hau. Her project control team saved up to 9 million USD during contract negotiation and claim resolution. She holds a master's degree in International Project Management from Glasgow Caledonian University, Scotland. Her career goal is to promote clean energy and to be part of a team that inspires the Vietnamese people to transition away from coal and thermal energy.



Kholoud Bakry
Site Engineer, Lekela Power

Kholoud Bakry is a Site Engineer, working on optimizing the operational performance of a 250 MW utility scale wind power project of Lekela Power. Kholoud has been with Lekela, since 2020, leading multiple project management activities during construction and until commercial operation. Kholoud holds a Master's degree in Renewable Energy Engineering from the British University in Egypt. Kholoud's career in renewables started with the Arab Program for Sustainable Energy Youth with the Regional Center for Renewable Energy and Energy Efficiency, where she worked on the development of RE & EE regional programs.

A photograph of three large white offshore wind turbines in the ocean under a clear blue sky. The turbines are spaced out across the horizon. The central turbine is the largest and most prominent. The water is a deep blue, and the sky is a lighter blue. The text 'FOCUS ON OFFSHORE WIND' is overlaid in white, bold, sans-serif font, with a thin teal horizontal line above it.

FOCUS ON OFFSHORE WIND

Offshore wind: turning targets into turbines

As a scalable, affordable and commercially available energy technology with the capacity to produce tremendous amounts of power, offshore wind has the potential to rapidly displace fossil fuels – delivering economic growth and bolstering energy security. Offshore wind also opens up the opportunity to scale the production of green hydrogen and power-to-X, thereby aiding in the decarbonisation of energy-intensive sectors. As a major source of green jobs, from manufacturing of turbine components through to installation and operation, offshore wind is increasingly seen as a positive economic driver.

In 2021, GWEC and IRENA signed a UN Energy Compact, pledging to work together to deploy the 2,000 GW of offshore wind needed by 2050 to reach net zero.¹ This requires a huge upsurge in installations, with 35GW of offshore wind to be added annually in the coming decade, starting from a global total of just over 60 GW today. Only China has so far shown the ability to deliver offshore wind at this scale and speed.

Alongside net-zero targets, many countries are setting specific offshore wind targets – with at least 16 governments² setting or increasing them since the 2022 edition of this report. This includes subnational jurisdictions like the Australian state of Victoria (9 GW by 2040) and the Canadian province of Nova Scotia (5 GW by 2030).

In September 2022, energy ministers from the nine members of the North Seas Energy Cooperation (NSEC) agreed to reach at least 260 GW of offshore wind capacity by 2050. China targets 100 GW by 2025, 200 GW by 2030 and 1,000 GW by 2050. South Korea's 10th Basic Plan, released in December 2022, targets 14.3 GW by 2030.

Despite setting such ambitious targets, countries and governments are still struggling to turn them into action at the speed needed to fuel the global energy transition. Offshore wind is a complex infrastructure requiring detailed knowledge and experience of robust marine governance frameworks, electricity market

design, and supply chain and industrial policy. GWEC observes that many markets are still lacking adequate policy and regulation to facilitate offshore wind development. At the same time, there is a great deal of global best practice to learn from, especially through public-private partnerships, to help nascent and emerging markets speed up the regulatory process.

There have been some notable achievements in a number of emerging offshore wind markets. Australia launched its first offshore wind leasing round in the Gippsland area. The US market continues to expand rapidly, with the landmark Inflation Reduction Act (IRA) heralding a new era in the international race for offshore wind and a green economy. With a new government in place, Brazil is making great strides in establishing an offshore wind industry (see page 84). Meanwhile, offshore wind in India is moving forward rapidly (see page 87).

1. UN Energy Compact

2. South Korea, China, Victoria, Nova Scotia, Belgium, Denmark, France, Germany, Ireland, Luxembourg, the Netherlands, Norway, Sweden, Portugal, New Jersey, Louisiana



Progress has been less marked elsewhere. Vietnam, with 599 GW of offshore wind potential, faces major policy uncertainty as the Power Development Plan 8 (PDP8) targeting 7 GW of offshore wind by 2030 remains in draft form since its release in March 2021³. Vietnam's Ministry of Industry and Trade (MOIT) is seeking to develop an auction framework for offshore wind but regulations on site surveying and marine spatial planning are unclear.

In the past year, the Philippines

lifted restrictions on foreign ownership in renewable energy and awarded more than 50 wind energy service contracts for more than 40 GW of offshore wind capacity. However, the government has yet to draft the rules and regulations governing the activities of offshore wind farms, from pre-development to operation.

More mature markets like Japan, Taiwan and South Korea have basic policy frameworks that enable the initial deployment of offshore wind projects but lack robust policy,

predictable project pipelines and the policy infrastructure for massive scale-up.

There were high hopes for Japan following the launch of its First Vision for the Offshore Wind Power Industry in 2020. It has since started drawing out designated sea areas that will be dedicated for general auction. However, concerns have been raised about the transparency of the selection criteria for the offshore tender, compounded by lengthy Environmental Impact Assessment

(EIA) timelines, largely stemming from local fishing community resistance.⁴ GWEC welcomes the government's intention to move to a central system of allocation and stands ready to support these efforts.

Taiwan's Round 3.1 was highly contested with seven offshore wind projects being awarded to nine developers. However, concerns persist about auction design,

3. Global Wind Report (GWEC, 2022)

4. Japan's Offshore Wind Faces High Risks on the High Seas (BNEF, 2019)



including an unrealistically low price cap and poor flexibility in terms of the localisation requirement.

Vestas recently invested 300 million USD in South Korea⁵, confirming the country's increasing attractiveness as the next high-potential offshore wind market. Despite a relatively mature supply chain, South Korea has yet to finalise a one-stop-shop (OSS) bill that would truly kickstart offshore wind development.

Public private partnerships will accelerate deployment

Accelerating offshore wind globally at the scale required to deliver on the energy transition will require unprecedented efforts from both governments and the private sector, working together in partnership.

As the test bed of large-scale, commercial offshore wind deployment, Europe has enabled the industry to acquire considerable knowledge and expertise. The cumulative offshore wind experience will advance across a variety of structures including regions, states and countries with different demand profiles and growth aspirations as

more and more areas look to build their offshore wind capacity. This calls for initiatives that facilitate skills and knowledge transfer, and for national governments to move away from 'business as usual' approaches. Strengthening collaboration through public-private partnerships is the key to closing the gap between reality and ambition by building on existing industry strength to unlock the world's offshore wind potential and enable global scale-up.

transformation programme that promotes collaboration across the supply chain to improve productivity and facilitates shared growth opportunities between developers and the supply chain.

The Global Offshore Wind Alliance (GOWA)⁸, a global diplomatic initiative launched at COP27 by Denmark, IRENA and GWEC, aims to create a multi-stakeholder community to achieve 380 GW by 2030 and beyond (see page 79).

Industry and governments can work together to accelerate deployment through existing technologies and robust policy frameworks

The UK's Offshore Wind Sector Deal⁶ is an attractive model that brings the government and industry together, each with clear roles and responsibilities, to overcome challenges to offshore wind development. The sector deal sets out collaboration across areas such as supply chain growth, system integration, skills and future workforce. The Offshore Wind Growth Partnership⁷ sits alongside the sector deal as an industry-funded long-term business

Conditions for accelerating offshore wind development

Industry and governments can work together to unblock bottlenecks and accelerate offshore wind deployment through existing technologies and robust policy frameworks.

5. <https://www.koreaherald.com/view.php?ud=20230119000218>

6. <https://www.gov.uk/government/publications/offshore-wind-sector-deal>

7. <https://owgp.org.uk/>

8. <https://www.irena.org/Energy-Transition/Partnerships/GOWA>

GWEC has identified some urgent next steps that we recommend governments take if they are to take full advantage of the energy independence and socioeconomic benefits that offshore wind can bring.

Permitting

Globally, offshore wind projects typically take up to nine years to move from early development stage to full commissioning⁹. The bulk of this time is spent in the permitting and consenting stage, with timelines stretching even further when there are barriers or delays in the permitting process¹⁰. Generally, once permitted, large-scale offshore wind projects can be constructed very quickly – typically in two years, depending on project size.¹¹

Done right, effective permitting regimes can unlock significant amounts of offshore wind capacity, enabling it to contribute to economic growth, as well as to the provision of large-scale, homegrown clean electricity. Holistic approaches to permitting

can also help capture benefits and opportunities related to biodiversity and nature conservation, ensuring the wind industry continues to be a leader in delivering positive socioeconomic outcomes for all communities. Effective permitting relies on streamlined regulatory frameworks and a coordinated approach within a country, including models like an OSS approach, the open-door scheme, and fast-track procedures.

Establishing a single contact point will ensure a smooth and administratively lean process from consenting through to decommissioning. The concept of an OSS has long been used in mature European markets like the UK and the Netherlands. Learning from European best practices, other countries are now starting to adopt this approach. In 2022, Brazil introduced an OSS system through an information portal that manages offshore areas used for power.¹² South Korea's National Assembly has been discussing a proposed OSS Bill¹³ to make progress on the

9. GWEC, Five Point Plan (2022)

10. GWEC's Statement on Implementing Vietnam's PDP 8 Target and Net Zero Commitment (2022)

11. Joint Statement by GWEC and the Global Solar Council at the G20 Investment Forum on Energy Transition (2022)

12. Ordinance N.3 of 19 October 2022, <https://www.in.gov.br/en/web/dou/-/portaria-interministerial-mme/mma-n-3-de-19-de-outubro-de-2022-437756126>

13. Special Act on Offshore Wind Power Development (SAOWPD)





Seabed allocation is rarely linked to offshore wind or climate targets, leading to overheated seabed markets

current system, which requires offshore wind developers to spend up to ten years or longer consulting 29 pieces of law across 10 ministries, according to the SFOC¹⁴. In Vietnam, an OSS model has been mooted, grounded in the National Steering Committee on Marine Economic Development established in 2020, chaired by the Prime Minister.¹⁵

Fast-track permitting procedures are also helpful. In December 2022, the European Council agreed on accelerated permitting rules for renewables in the REPowerEU.¹⁶ The updated policy creates dedicated 'go-to' areas for renewables including shortened and simplified permitting processes in areas with lower environmental risks. For renewable

go-to areas, the Council agreed that permit-granting processes should not take longer than one year for onshore – and two years for offshore – renewable energy projects, to be extended by up to six months in extraordinary circumstances.

Leasing

A significant barrier for the global wind industry is a scarcity of sites: seabed allocation is rarely linked to offshore wind or climate targets,

leading to overheated seabed markets in some countries or regions, as a result of lengthy, decentralised approaches to seabed allocation and constraining auction caps. The 'lumpy' procurement that results from this approach can limit supply chain growth. Most jurisdictions also fail to consider the environmental impacts from competing uses of the sea in a holistic way. In the absence of a strategic approach to spatial planning, wind projects can

14. SFOC is a Seoul-based non-profit organisation focused on climate action and energy transition

15. Do, T. N., Burke, P.J., Hughes, L., & Thi, T. D. (2022). Policy options for offshore wind power in Vietnam. *Marine Policy*, 141, 105080. <https://doi.org/10.1016/j.marpol.2022.105080>

16. <https://www.consilium.europa.eu/en/press/press-releases/2022/12/19/repower-eu-council-agrees-on-accelerated-permitting-rules-for-renewables/>

be delayed, creating bottlenecks to growth and to the achievement of climate targets.

GWEC would urge governments looking to establish their first leasing process to consider the short- and long-term trade-offs when it comes to leasing fees and allocation. Uncapped competitive allocation of leases, for example, may result in higher short-term revenues for leasing authorities, but to the longer-term detriment of electricity consumers. Uncapped competitive allocation may also not contribute to more holistic supply chain growth outcomes.

In the UK, The Crown Estate, which owns the territorial seabed out to 12 nautical miles off England, Wales and Northern Ireland, is legally required to achieve 'best consideration' for its dealings. The competitive bidding approach, however, raises the concern that additional costs will find their way into prices paid by consumers. GWEC would instead encourage emerging markets to look towards Scotland's ScotWind leasing model, where bidding fees were capped to 100,000 GBP per square kilometre. The ScotWind process includes a mandatory Supply Chain

Development Statement to drive longer-term supply chain investment.

Deploying offshore wind at the speed and scale required for the energy transition will necessitate new approaches to leasing that prioritise volume. An intriguing new model has emerged from Denmark, where the Open Door policy would allow developers to identify potential sites, undertake preliminary investigations and secure grid connections. At the time of writing, the scheme had regrettably been suspended. The industry hopes that the Danish government reconsiders.

Hydrogen

Green hydrogen and power-to-X can drive the transition in transport and the hard-to-abate sectors. Green hydrogen solutions could decarbonise iron and steel, long-haul aviation and shipping. As renewable electrification and storage technologies continue to advance, green hydrogen has the potential to be employed across all sectors. With accelerated deployment, its costs can be competitive with blue hydrogen by the early 2030s. Green hydrogen also has great export potential.

While the commercialisation of this technology is still in its early stages, to date 35 countries have a hydrogen plan and 17 are preparing one, according to BNEF. IRENA identifies China, the EU, India, Japan, South Korea and the US as early adopters.

In Australia, green hydrogen is at the centre of global decarbonisation strategies. In preparation for Australia to become a major hydrogen exporter, the government published in early 2022 a National Hydrogen Strategy. With a vision to be at the forefront of renewable hydrogen production and export, the Queensland State Government launched the Hydrogen Industry Workforce Development Roadmap 2022-2032 at the Australian Clean Energy Summit in July 2022.

Offshore wind has a central role to play in green hydrogen production. In 2022, the world's first offshore green hydrogen production platform was inaugurated in France. The electrolyser, supplied by Plug Power and developed with Lhyfe, is the first capable of operating on a floating platform.¹⁷ It will use electricity supplied by BW Ideol's floating offshore wind turbine

Floatgen, installed at the offshore test site in 2018.

Auction design (non-price criteria)

After a decade of cost reductions, offshore wind is at an inflection point with a highly competitive LCOE that is now 3 USD/MWh below that of coal and 18 USD/MWh below that of gas.¹⁸ While achieving

Deploying offshore wind at the speed and scale required necessitates new approaches to leasing that prioritise volume

affordable electricity remains the key priority, it is also important for the industry to scale up while maximising the overall industrial and system value for offshore wind.

The introduction of the IRA in the US to drive domestic manufacturing capability, regional transmission and investment is heralding a new era in the international race for offshore wind. The beneficial changes to the tax credit available, when

¹⁷ Lhyfe (2022) inaugurates world's first offshore renewable hydrogen production pilot site

¹⁸ 2H 2022 Levelized Cost of Electricity Update (BNEF)



implemented successfully, will create a robust domestic supply chain to enable project development in the long term.

One way to encourage effective system design, and to capture the greater socioeconomic value that offshore wind brings, is to gradually move away from a just-on-price auction model to a design that incorporates non-price criteria that incentivise innovation and supply chain build-up. A healthy auction mechanism should account for the total net impacts on society and not focus on price alone.

The use of minimum local content requirements (LCRs) as a form of non-price criteria has substantially increased in recent years as governments claim the measure can help develop domestic manufacturing capacity for renewable technologies, create local jobs and encourage technology innovation.

Australia, Ghana, Japan, Oman, Taiwan and the UK have implemented green LCRs since 2015.¹⁹ In Japan, LCRs accounted for 40 out of the 120 points

19. Overcoming Barriers to International Investment in Clean Energy (OECD)

available in the project feasibility evaluation for their first offshore tender round in 2020. One of the requirements was a track record of engagement with key stakeholders and impact on local and national employment and manufacturing.

In Taiwan, stringent LCRs required developers to locally procure 26 'key development items' for at least 60% of a project's proposed capacity. Without a clear implementation pathway and sufficient support mechanisms from governments, LCRs can be counterproductive by driving up prices while hampering competition and innovation. Local value is best created through naturally local jobs, particularly in transport, construction and O&M – as the servicing of wind farms creates jobs over the full project lifetime of 20+ years while job creation in manufacturing requires a market with long-term stability.

Including non-price criteria should enable a shift from focusing on lowest-price projects to rewarding project delivery with highest value.²⁰ The use of these criteria recognises the wider societal value that wind energy brings.

Non-price criteria can be prioritised if they fall under three categories²¹:

sustainability and biodiversity; system integration and innovation; supply chain development and benefits to communities.

Selected criteria should be:

- Clear and objective to identify the right project without being discriminatory against any group of stakeholders.
- Transparent and measurable to avoid introducing additional administrative processes and complex bidding activities.
- Reasonable and practical to build on current industry capabilities without further inflating the cost or delaying project development.

In 2022, the German Parliament adopted a new offshore wind law (WindSeeG) establishing two types of auctions, one of which involves negative bidding with no caps on the amounts developers bid. The industry sees this change as doing more harm than good, as uncapped negative bidding means additional costs for electricity consumers and the supply chain.²²

Non-price criteria are increasingly accepted in Europe, with all successful offshore wind auctions in 2022 including non-price criteria as part of the evaluation. Site VII of the

Hollandse Kust West (HKW) tender placed a high priority on non-price criteria as the tender focused on how well the wind farm can be integrated into the Dutch energy system. Site VI of HKW, on the other hand, focused on biodiversity.²³

Ultimately, non-price criteria in auction design should encourage healthy competition and innovation while enabling rapid scale-up of offshore wind development and the recovery of costs.

Floating offshore wind

With 80% of the world's offshore wind resource potential in areas with a water depth of more than 60 metres, from 2030 we expect to see a rapid acceleration of floating offshore wind.²⁴ Many of the emerging offshore markets, such as Vietnam and the Philippines, are predominantly floating markets. Mature markets are increasingly looking at floating offshore as they run out of seabed areas suitable for fixed-bottom offshore projects.

20. <https://www.weforum.org/projects/system-value>

21. <https://windeurope.org/policy/position-papers/windeurope-position-on-non-price-criteria-in-auctions/>

22. <https://windeurope.org/newsroom/press-releases/negative-bidding-in-german-offshore-wind-law-threatens-supply-chain/>

23. <https://windeurope.org/newsroom/press-releases/europes-latest-offshore-auction-mainly-using-non-price-criteria-is-a-success/>

24. Floating Offshore Wind - A Global Opportunity (GWEC)



Non-price criteria in auction design should encourage innovation while enabling rapid development



GWEC market intelligence forecasts the floating offshore wind market to reach 16.5 GW by 2030. Seabed and subsidy auctions planned for 2023 show that the sector is preparing for the next step up in scale.

As it brings down costs floating offshore wind will create the opportunity to open up more markets

A number of countries are also joining the race to establish themselves as a global floating wind supply hub.

In Asia, Japan's 'Program for Promoting Investment in Japan to Strengthen Supply Chains' is an initiative that aims to establish a manufacturing base for offshore wind. Korea's 300 million USD MoU²⁵ with leading wind turbine manufacturer Vestas is a similar step towards solidifying Korea's position as one of the offshore supply chain hubs in the region. Taiwan has updated its floating offshore wind demonstration project guidelines to increase

project capacity from 100 MW to more than 200 MW. Developers with existing floating wind sites are preparing to enter the Round 3.2 auction scheduled later this year.

In Europe, more than 60 million GBP of public and private investment will be used to develop floating technologies and to place more turbines across the UK's coastlines. In early 2022, the ScotWind auction alone awarded more than 13 GW of floating offshore wind sites, representing more than half of the existing offshore wind capacity in the UK.²⁶ France was to announce the winner of a 250 MW floating wind project in South Brittany at the time of writing.

Floating offshore wind is likely to rapidly bring down costs, creating the opportunity to open up more markets. The industry can also use existing maritime and petrochemical expertise to transition into floating offshore wind. Floating wind will need to move to a larger scale, and the first commercial project will be key to setting a model that enables future floating offshore wind project deployment.

25. <https://www.koreaherald.com/view.php?ud=20230119000218>

26. <https://www.ft.com/content/d894424c-6d29-497d-b728-2083a5d038e2>

The Global Offshore Wind Alliance (GOWA)

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

GOWA envisions offshore wind making a significant contribution to the energy transition and the achievement of the sustainable development goals through large-scale renewable power generation benefiting regions, nations and critical sectors such as industry and transportation.

To benefit from the substantial potential and opportunities deriving from offshore wind it is pivotal that governments, private sector actors, international organisations and other relevant stakeholders work together to remove the barriers to scaling up investment and finance.

GOWA is a multi-stakeholder, diplomatic and workstream based initiative that has public private partnership as its guiding principle.

GOWA will work to:

- Raise ambition on offshore wind amongst governments and other public and private stakeholders.
- Support the creation of policy frameworks and efficient offshore wind value chains to bring new and existing markets

to maturity through, for example, the sharing of best practices and capacity building.

- Create an international community of practice to drive action on offshore wind deployment as a key to achieving 1.5C pathways.

To support countries as they seek to develop offshore wind, GOWA will address the major building blocks for the sector, such as framework conditions, financial de-risking, system integration and economic benefits.

These are all important drivers to reduce costs, ensure competitive market prices and create project pipelines at country and regional level. GOWA activities will be based on a demand-driven approach.



At the time of writing, GOWA has 14 country members



Australia



Denmark



Japan



Portugal



UK



Belgium



Germany



The Netherlands



Spain



USA



Colombia



Ireland



Norway



St Lucia

Ocean Energy Pathway (OEP)

The Ocean Energy Pathway (OEP) is a large-scale, multi-year programme for contributing to the acceleration of the global energy transition. OEP aims to ramp up the delivery of offshore wind through collaboration between industry and civil society that unlocks the potential of ocean-based renewable energy in new and underdeveloped markets.

The OEP's fundamental tenet is that sustainable scaling up of the sector will only come from high-quality, locally appropriate policy and regulation that encourages nature-positive outcomes, delivers for local communities, and enables wider economic development.

A trusted partner for all stakeholders

Being independent of industry, the OEP is a trusted partner that works with governments, investors, communities and NGOs to build a competitive and sustainable offshore wind sector. Its key aim is to proactively address the major challenges offshore wind faces through three thematic pillars: market design and supply chains, limited government capacity, and

providing benefits for nature and community.

Market design: how policy drives investment

The development of domestic supply chains – a trend increasingly arising from political necessity – can also become a limiting factor for the rapid expansion of offshore wind to new countries. Governments and local industry must work together on new policy instruments and strategic support in developing their own supply chains in a way that does not hinder offshore wind development.

The wind industry needs confidence in policy measures to drive increased investment in manufacturing, infrastructure and talent. Unless the correct industrial policy choices are made, success for offshore wind will be severely constrained.

Government capacity: why appropriate regulation matters

Delivering offshore wind is a complex policy design challenge for developed bureaucracies – and an even greater one for countries

that lack the regulatory and institutional underpinnings to build delivery frameworks. This adds uncertainty and stretches out wait times for developers.

New offshore wind markets need a huge amount of locally appropriate and fully aligned policy and regulation if the sector is to scale up to meet its targets.

Dealing with socio-political and ecosystem impacts

Socio-political challenges increasingly threaten project viability. Offshore wind operates in a complex, multi-stakeholder landscape where the technology is often poorly understood, engendering conflict that causes additional costs and delays.

Offshore wind competes with existing ocean users – sectors that may feel their prospects are threatened by ocean-energy technologies. The ecosystem impacts of offshore wind projects are also poorly understood, especially in new markets, leading to 'green-on-green conflict' where conservation NGOs push back against wind projects.



Accelerating ocean-based renewable energy requires new approaches to deployment, including a sustainable approach to ocean stewardship, to avoid the industry being caught in the crossfire of wider conversations around ocean management.

In new markets especially, the offshore wind industry needs to establish early partnerships with conservation groups and local communities to shape emerging regulations and political narratives.

The OEP knows that while there are common elements to building a successful offshore wind sector, it is essential to work within the unique economic and political contexts of each country. For this reason, it focuses on a number of actions that are crucial to successful project delivery.

Expertise and networking
Because the wind industry has so far deployed and invested in the vast majority of offshore wind projects, the OEP occupies a

The OEP will create a network of regional experts that can work with governments and stakeholders to build knowledge on offshore wind. Serving as a catalyst for longer-term systematic change, the OEP intends to provide experts who can sit alongside officials in governments, rather than work remotely from within large consultancies. This will allow us to support learning inside new country markets and accelerate growth in expertise.

The OEP will also make an ongoing effort to create and/or invest in local networks to facilitate dialogue and shared working between ocean and nature NGOs, community groups, industry groups and government stakeholders.

While there are common elements to a successful offshore wind sector, it is essential to work with the unique context of each country

How to accelerate deployment

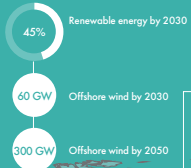
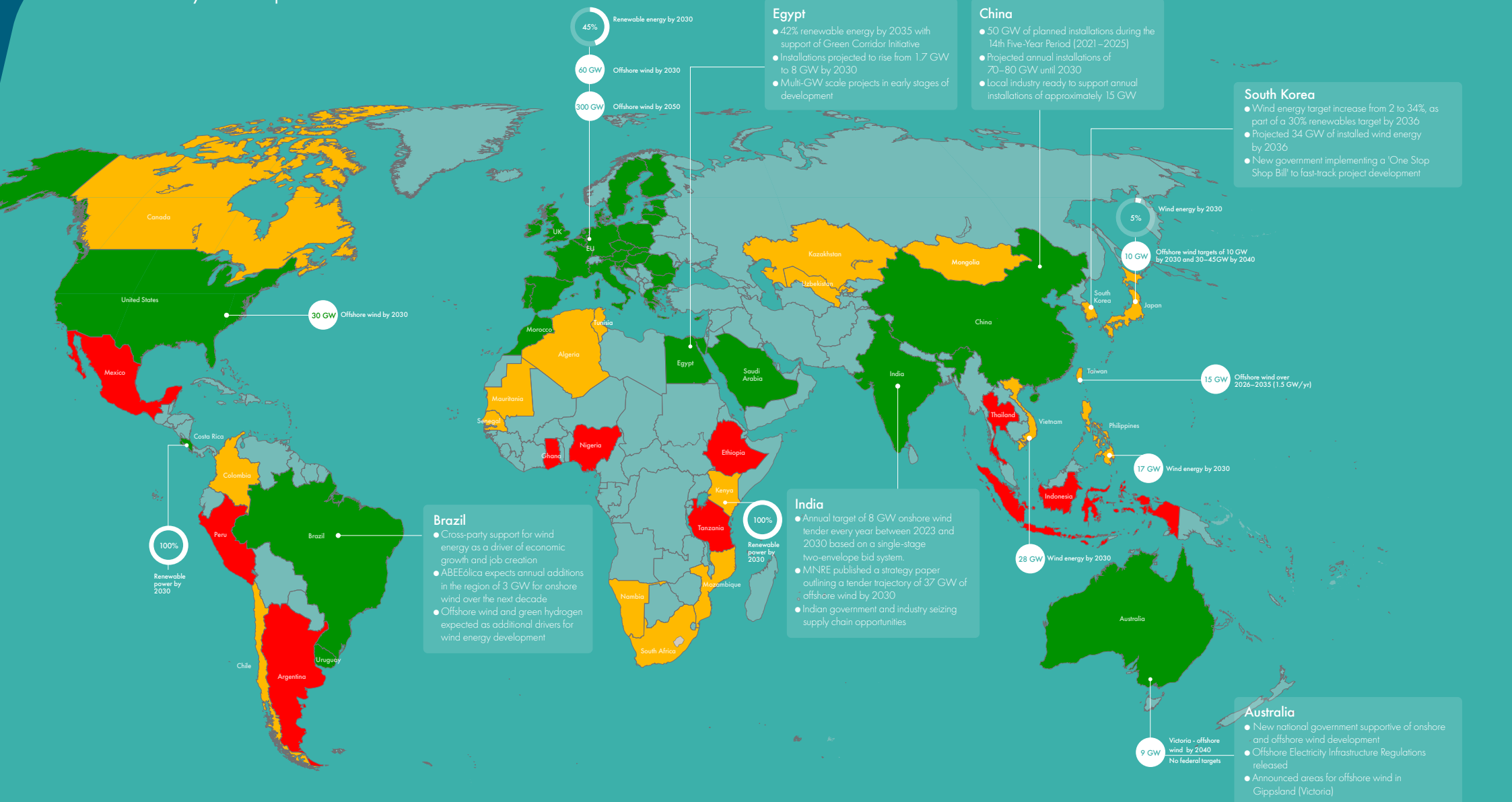
In the medium to long term, the wind industry and investors may be able to continue to single-handedly bring offshore wind to scale in several markets. But given the huge role offshore wind must play in displacing fossil fuels and getting us on track for a 1.5C world, we cannot wait for the market alone to act.

unique position to convene and support all stakeholders in this area. It aims to leverage its experience and connections to support and complement the work of other organisations including the World Bank and the International Renewable Energy Agency (IRENA), as well as partner governments and the offshore sector itself.

The OEP's strategic approach is to focus on countries with significant carbon footprints, at risk of fossil-fuel lock-in, and with significant wind resources while also responding pragmatically to country-specific ambitions, evolving politics and economics. Priority countries include Vietnam, Indonesia, the Philippines, Thailand, India, South Korea, Taiwan, Colombia, Brazil, Japan and South Africa.



Policy heat map



Egypt

- 42% renewable energy by 2035 with support of Green Corridor Initiative
- Installations projected to rise from 1.7 GW to 8 GW by 2030
- Multi-GW scale projects in early stages of development

China

- 50 GW of planned installations during the 14th Five-Year Period (2021–2025)
- Projected annual installations of 70–80 GW until 2030
- Local industry ready to support annual installations of approximately 15 GW

South Korea

- Wind energy target increase from 2 to 34%, as part of a 30% renewables target by 2036
- Projected 34 GW of installed wind energy by 2036
- New government implementing a 'One Stop Shop Bill' to fast-track project development



Brazil

- Cross-party support for wind energy as a driver of economic growth and job creation
- ABEEólica expects annual additions in the region of 3 GW for onshore wind over the next decade
- Offshore wind and green hydrogen expected as additional drivers for wind energy development

India

- Annual target of 8 GW onshore wind tender every year between 2023 and 2030 based on a single-stage two-envelope bid system.
- MNRE published a strategy paper outlining a tender trajectory of 37 GW of offshore wind by 2030
- Indian government and industry seizing supply chain opportunities



● Strong installed capacity increase, new ambitious targets and/or policy improvement
● Adequate targets and policies, but not matched by expected progress
● Lack of progress or regression

MARKETS TO WATCH





Brazil's government to bet on hydrogen and offshore as wind revolution gathers momentum

There are reasons to be optimistic about the prospects for wind energy in Brazil, following years of solid industry performance and positive policy developments. In 2022, onshore capacity surpassed 24GW¹ after another strong year for installations, while excitement over the prospects for offshore wind reached unprecedented heights.

Under the Paris Agreement, Brazil has committed to reducing greenhouse gas emissions by 37% from 2005 levels by 2025 and 50% by 2030. At the COP26 climate summit in November 2021, Brazil also announced a zero illegal deforestation target by 2030 alongside a national hydrogen strategy.²

Newly elected President Luiz Inácio 'Lula' da Silva said during his electoral campaign that his government would place climate

change and the energy transition at the core of its policies, and some concrete signs in this direction have already been sent. Brazil's new federal administration is expected to provide incentives for the energy transition while balancing energy sector priorities with a broad environmental agenda.

This represents a crucial strategic opportunity for the country, according to Brazil's wind energy and new technologies association ABEEólica, provided the right regulatory and economic infrastructure is put in place rapidly to trigger wind industry investment in Brazil in preference to other countries. As expected, under Brazil's new political leadership, state-owned energy giant Petrobras has already announced that it will fully re-enter the renewables sector, with offshore wind and green hydrogen being particularly important priorities. Signalling the company's renewed ambition, on 7 March, new Petrobras CEO Jean-Paul Prates – a long-term advocate for wind

energy and renewables – announced plans to consider developing seven offshore wind projects with a total capacity of 14.5 GW in collaboration with Norway's Equinor.

Brazil's GDP is estimated to grow by 2.8% in 2022, which alongside a continued drive towards electrification is focusing minds on the need to redouble efforts to promote renewable energy developments. Brazil has an enviable renewable energy matrix, with wind power playing a very important role in securing the country's energy supply while offering low prices for consumers and contributing to decarbonisation.

Official data confirmed that wind energy sits in second place behind hydro by share of electricity generation in Brazil, while also providing an impressive list of socioeconomic benefits. An ABEEólica report analysing the impact of wind energy on the Brazilian economy found that, for every Brazilian Real (BRL) invested

1. https://ABEEólica.org.br/wp-content/uploads/2023/01/2023_01_InfoVento29.pdf

2. <https://www.iea.org/countries/brazil>

3. <https://www.oecd.org/economy/brazil-economic-snapshot/>

in wind farms, there is a 2.9 BRL uplift on GDP.⁴

The wind energy sector in Brazil is consolidating its growth under the free electricity market environment and saw a further shift away from regulated auctions towards corporate PPAs in 2022, giving it added resilience.

ABEEólica expects annual additions in the region of 3 GW for onshore wind over the next decade – but hopes this will prove to be a conservative estimate. It is particularly optimistic about the prospects for a new and very promising offshore wind energy market as the regulatory foundations for its success are being laid.

Offshore wind: great expectations

Even before the cabinet of President Lula took office on 1 January 2023, the Director of Energy Development at the Ministry of Mines and Energy (MME), Marina Rossi, had been talking up the role of offshore wind in the country's economic development, emphasising the importance of streamlined rules to facilitate deployment.⁵

With around 8,000 kilometres of coastline blessed with strong oceanic winds, Brazil has the potential to install more than 1,200 GW of offshore wind, according to a study by the World Bank.⁶ This dwarfs the already impressive 500 GW that ABBEólica estimates could be installed onshore.

The past year saw a flurry of regulatory activity around offshore wind power generation. Since Federal Decree 10,946/2022 –

The bill was drafted by former Rio Grande do Norte Senator Jean Paul Prates – now the newly appointed CEO of state energy incumbent Petrobras. An offshore wind enthusiast, he has raised expectations that the company will review its strategic plan for 2023-27 to boost investment in renewable energy and offshore wind specifically. A significant shift may take time, but with its strong wind supply chain and well-established offshore engineering expertise,

With its strong wind supply chain and well-established offshore engineering expertise, Brazil could position itself as a regional leader

setting guidelines on the use of maritime space and the exploitation of natural resources – came into force in June 2022, a draft bill on offshore energy regulation (PL 576/2021) started making its way through parliament and two ordinances provided guidelines on the use of maritime areas and the creation of a one-stop-shop for project licensing.

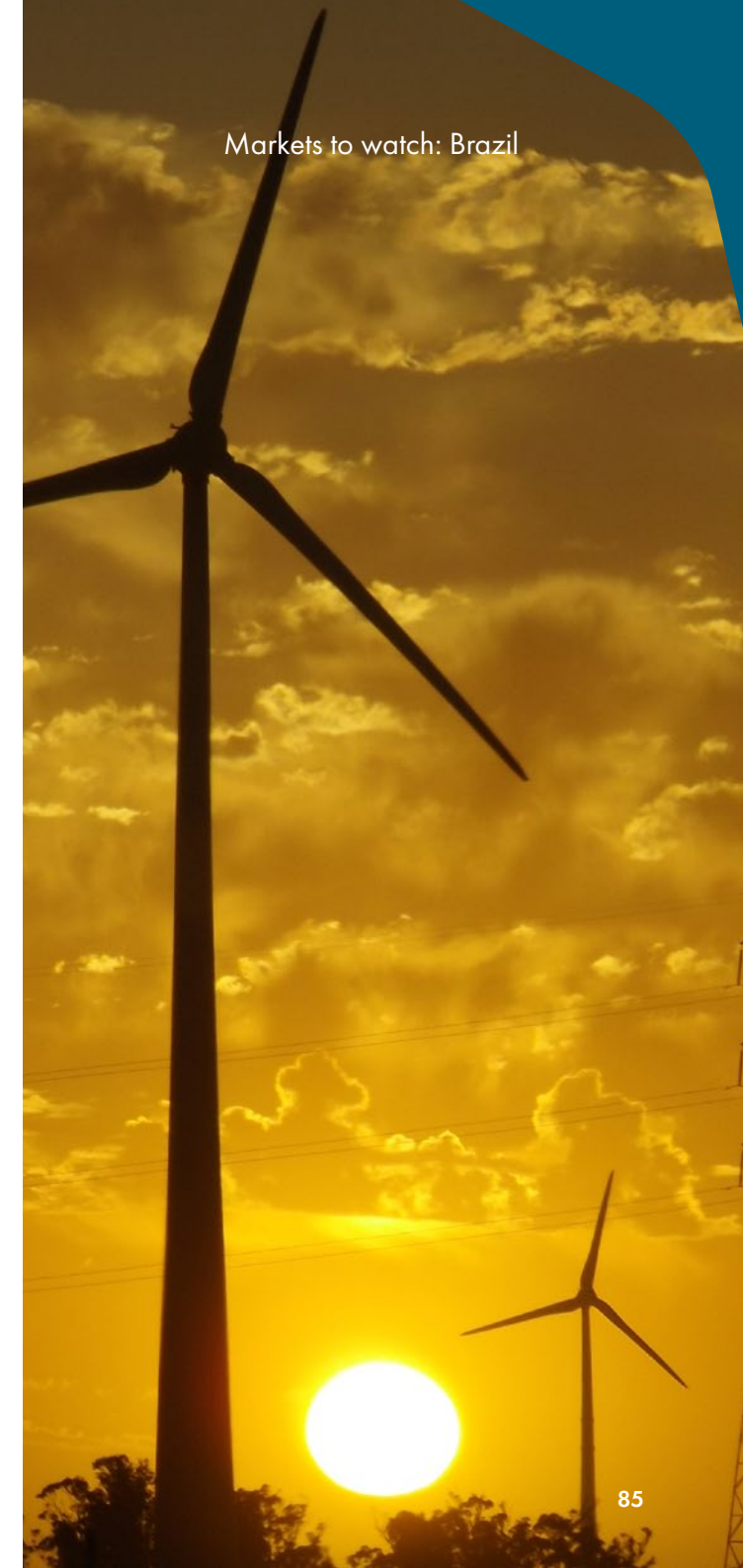
Brazil could position itself as a regional leader in an area with several countries poised to invest heavily in offshore wind energy.

For 2023, ABEEólica plans to continue to work towards the establishment of a sound and consistent regulatory framework for offshore wind, with the support of GWEC and an industry keen to invest in the country. Another major boost for the sector could come from green hydrogen, which has the

4. https://ABEEolica.org.br/wp-content/uploads/2022/02/Estudo-Braulio_final.pdf

5. <https://www.folhade.com.br/economia/ventos-fortes-nas-usinas-eolicas-contra-o-aquecimento-global/250189/>

6. <https://www.worldbank.org/en/news/feature/2020/05/27/energia-eolica-offshore-brasil-esmap>





potential to propel demand to the levels required by hard-to-decarbonise energy-intensive industries. Although OECD projections see slower growth of 1.2% in 2023 and 1.4% in 2024 for Brazil's GDP,⁷ green hydrogen could become a catalyst for boosting renewable energy demand – and the country's economic fortunes with it.

ABEEólica supports an industrial policy focusing on the synergies between green hydrogen and wind energy, and expects to engage positively with the new government to fast-track its progress. Meanwhile, it expects the first offshore wind tender in 2023 and was encouraged to see the technology gain a mention in the Brazilian Electricity Regulatory Agency's (ANEEL's) strategic plan for 2023-24.⁸ But it insists that the country needs a breakthrough in detailed offshore wind power regulation to become an attractive environment for investors and enable the technology to take off in its waters.

Investors have shown plenty of appetite for this market, with tens

of project applications for a total of more than 170 GW of offshore wind power capacity already filed with the Brazilian Institute of the Environment and Renewable Natural Resources (IBAMA).

Under its latest Ten-Year Energy Expansion Plan (PDE), Brazilian energy planning agency EPE foresees renewable energy representing 48% of the country's energy matrix by 2031. Brazil's offshore wind sector may only be in its infancy by that date, but it has the potential to make a major mark over the following decade.⁹

Having become Latin America's undisputed wind energy market leader over the past decade, with more than 50% of the region's installed wind capacity, Brazil confirmed its position in 2022. 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 conditions for industry to invest so that Brazil can lead the way to a just energy transition in the region.

7. <https://www.oecd.org/economy/brazil-economic-snapshot/>

8. <https://www.gov.br/aneel/pt-br/assuntos/noticias/2022/aprovada-agenda-regulatoria-com-15-temas-estrategicos-para-o-bienio-2023-2024>

9. <https://www.epe.gov.br/en/press-room/news/mme-launches-english-version-of-the-ten-year-energy-expansion-plan-pde-2031>

India eyes global wind energy supply chain opportunities as it targets growth in capacity additions

In the midst of global uncertainty caused by the global COVID pandemic, the Russia-Ukraine war and recessionary pressures, India's continued political stability has provided strong support for the country's climate commitments. India has prioritised renewable energy, including wind power, in its long-term vision for transformation lifting expectations for a wind sector that experienced a slowdown in capacity additions in the recent past.¹

India's Central Electricity Authority (CEA) projects Ex-Bus electricity demand to grow 75% by 2031-32 from 2021-22 levels, and 170% by 2041-42. Demand is projected to increase by more than 90% in four out of the eight windiest states by the start of the next decade. The World Energy Outlook 2022 estimates demand to triple between 2021 and 2050.

India aspires to be a 5 trillion USD dollar economy by 2025 and aims to grow manufacturing GDP 15-fold between 2021 and

2047. It is also committed to achieving net zero by 2070. Renewable energy (excluding large hydro) already represents nearly 30% of India's installed power generation capacity, at 410 GW, with 10% of this capacity being wind energy.

The combined impact of economic growth, net-zero goals and burgeoning electricity demand will result in a rapid increase in the share of renewable energy in the power generation mix. For wind power, India's target is to achieve a cumulative 140 GW of capacity by 2030.

How policy reforms will accelerate growth

In 2022, India awarded 2.25² GW of standalone and 2.45 GW of hybrid wind capacity through auctions. It commissioned a total of 1.8 GW of onshore wind power capacity.³ Recent policy reforms are likely to further boost demand for wind power and accelerate capacity additions over the coming years.

Through its Electricity (Late Payment Surcharge and Related Matters) Rules, 2022, the government aims to curb the issue of delayed payments hampering the financial health of green power generators. It has also laid down the Electricity (Promoting Renewable Energy through Green Energy open Access) Rules, 2022 to support the uptake of green power and the Draft National Repowering Policy for Wind Power Projects, 2022 to tap opportunities for repowering.

The Ministry of New and Renewable Energy (MNRE) has outlined a wind-specific renewable purchase obligation (RPO) trajectory to 2030, with an annual target of an 8 GW onshore wind tender every year between 2023 and 2030 based on a single-stage two-envelope bid system.

The plan is to harness the massive wind energy potential of eight windy states: Andhra Pradesh, Gujarat, Karnataka, Madhya Pradesh, Maharashtra, Rajasthan, Tamil Nadu and Telangana.

To support the development of power evacuation and transmission infrastructure, the CEA has published its transmission planning report for the integration of renewable energy, including 58 GW of wind energy – of which 10 GW is offshore Tamil Nadu and Gujarat – to the Inter-State-Transmission-System (ISTS) by 2030. However, the planned infrastructure may not be sufficient to accommodate MNRE's target of 8 GW per year.

Creating a market for offshore wind

In 2022, the MNRE published a strategy paper outlining a tender trajectory of 37 GW of offshore wind by 2030. Together with the Danish



1. https://eparlib.nic.in/bitstream/123456789/931974/1/17_Energy_27.pdf

2. As per IEA's Advanced Pledges Scenario

3. <https://powermin.gov.in/en/content/power-sector-glance-all-India>



Energy Agency, it also published a conceptual plan with a pipeline of 15 offshore wind projects. Additionally, the Center of Excellence on Offshore Wind and Renewable Energy, jointly set up by the Danish government and the MNRE, published reports on maritime spatial planning that build on earlier FOWIND⁴ and FOWPI⁵ projects.

Creating a market for offshore wind in India demands a strong partnership between the government, development finance institutions, commercial banks, the offshore wind industry, and local communities. Developing India as an attractive offshore wind market further requires the introduction of appropriate standards, such as environmental impact assessment (EIA) guidelines, and support for energy offtake while ensuring the competitiveness of offshore wind.

Seizing supply chain opportunities

Recent increases in commodity prices, coupled with the emerging impacts of shrinking supply chains in Europe, are pointing to a huge opportunity for India in the global wind energy supply chain.

4. <https://gwec.net/members-area-market-intelligence/fowind/>

5. <https://www.fowpi.in/>

6. <http://timesofindia.indiatimes.com/articleshow/93574111>

India's domestic annual manufacturing capacity stands at 10-12 GW for wind turbine generators. India is also the world's second-largest market for gearbox manufacturing and the second-largest supplier of blades and generators in the APAC region.

To further strengthen its leadership in the wind manufacturing sector, India must put in place a roadmap for a resilient supply chain of raw materials – including rare earth metals and non-standard steel – and for specific jobs such as casting and forging. Existing import duty relief on equipment and components such as balsa wood and pultruded carbon fibre, which cannot be produced or manufactured in India, must continue.

Micro, small and medium enterprises (MSMEs) play a pivotal role in the Indian wind manufacturing sector. Going forward, the government should consider targeted production-linked incentives for companies currently engaged in the onshore wind sector, and for those wishing to get involved in offshore wind manufacturing.

In 2022, GWEC India convened a supply chain stakeholder roundtable, which outlined

high-impact opportunities for catalysing wind power generation and manufacturing in the state of Tamil Nadu. GWEC also presented a similar scenario to the government of Gujarat, alongside recommendations on repowering, offshore wind, robust monitoring of utility-scale wind farms and transmission projects to various central government agencies.

India is in a unique position to leverage growing export and international service opportunities in the APAC and European regions. A strategic supply chain impetus is pivotal to scaling up India's wind manufacturing sector.

Prime Minister Narendra Modi has called for India to become a developed economy by 2047.⁶ In the so-called Amrit Kaal – the 25-year period between the 75th and 100th anniversaries of India's independence, which was gained in 1947 – India must leverage all channels, including Vision for 2047 and the Sovereign Green Bonds (SGrB) framework, to support its wind sector, thus achieving the government's vision of green growth and a renewable energy-led future for the country.

Egypt uses COP27 springboard to propel itself into multi-GW scale

Egypt became one of the pioneering countries for wind energy in Africa and the Middle East (ME) when the government's New & Renewable Energy Authority (NREA) built a pilot wind energy project in Hurghada in 1988. Fast forward to today, Egypt is poised to regain its status as a leading wind energy market following tremendous ambition announced on the sidelines of COP27, which was hosted in November 2022 on Egyptian soil for the first time.

Following two decades of modest wind and renewable energy targets, the Egyptian government as COP27 host made a number of gigawatt-scale announcements. If the projects are constructed, they will propel the country's wind energy industry into the upper echelon of emerging markets worldwide.

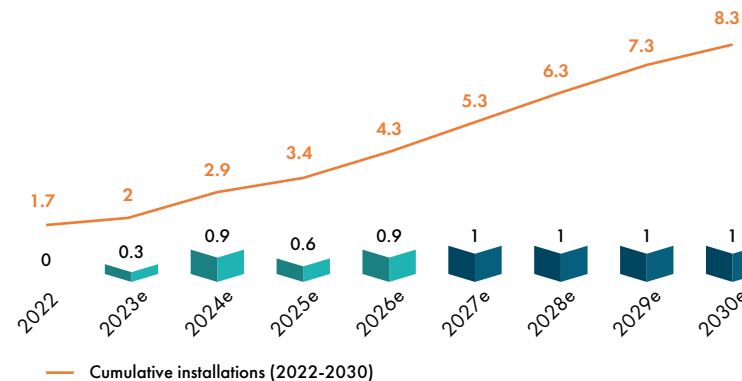
Key to unlocking this ambition is the Egyptian government announcement of the Green Corridor Initiative, a separate

electricity grid aimed at ensuring renewable energy makes up 42% of the country's energy mix by 2035. This features projects such as two 10 GW onshore wind farms planned by Masdar and ACWA Power.

The Egyptian government has 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 on future EU imports of renewable hydrogen and its derivatives; support Egypt's decarbonisation and energy transition activities;

Projected wind capacity additions in Egypt



Source: GWEC, 2023





develop the production, use and export of renewable hydrogen and its derivatives.¹

Egypt's current installed capacity sits at 1,702 MW following grid connection of Lekela Power's 252MW West Bakr wind farm. It will rise by 1.6 GW once the AMEA Power-led 500 MW Amunet project, Engie-led 500 MW Gulf of Suez 2 and ACWA Power's 1.1 GW wind farm – Africa's largest – are completed.

Wind installations are estimated to achieve 4.3 GW in 2026, if the projects currently in the pipeline go online as expected. From 2027, the several projects covered by MOUs could add an estimated 1 GW per year, culminating in more than 8 GW 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.

¹ https://energy.ec.europa.eu/memorandum-understanding-strategic-partnership-renewable-hydrogen-between-european-union-and-arab_en

Projects in MOUs between industry and the Egyptian government

- ACWA Power – 10 GW onshore wind farm
- Masdar, Infinity Power, Hassan Allam Utilities Consortium – 10 GW onshore wind farm
- Masdar, Infinity Power, Hassan Allam Utilities Consortium – 2 GW green hydrogen project in the Suez Canal Economic Zone (SCEZ)
- AMEA Power – 1 GW green hydrogen project
- Alfanar – 500,000 t/y of green ammonia and 100,000 t/y of green hydrogen
- Total Energies – 300,000 t/y green ammonia project in the Sokhna region
- Egypt Green, a joint venture between Scatec, Fertiglobe (an OCI-ADNOC joint venture), Orascom Construction and The Sovereign Fund of Egypt – 100 MW electrolyser capacity, powered by 260 MW of solar and wind power
- Green Fuel Alliance consortium, led by EDF Renewables and Zero Waste – green hydrogen and ammonia project in the SCEZ powered by 2 GW of wind and solar
- Globeleg – 3.6 GW of electrolysers powered by up to 9 GW of solar and wind energy
- Fortescue Future Industries (FFI) – 9.2 GW solar and wind energy to produce green hydrogen and ammonia

MARKET STATUS

Overview

Globally, 77.6 GW of new wind power capacity was connected to power grids in 2022, bringing total installed wind capacity to 906 GW¹, a growth of 9% compared with 2021.

Although new onshore installations declined 5% YoY in 2022, it was still the third highest year in history for additions. Following a record 2021 with more than 21 GW grid-connected, new offshore wind capacity commissioned last year dropped to 8.8 GW, making 2022 the second highest year.

Asia-Pacific lost 3% in market share last year compared with 2021, but the region remains the world's largest wind market, with China contributing 87% of its 2022 additions.

As the second largest market, Europe saw record onshore wind installations in 2022, which helped boost the region's market share from 19% in 2021 to 25%.

North America retained third place but lost 2% in market share due to slower growth in the US. Driven by a record year for installations in Brazil, Latin America (LATAM) increased its market share in 2022 by 1%.

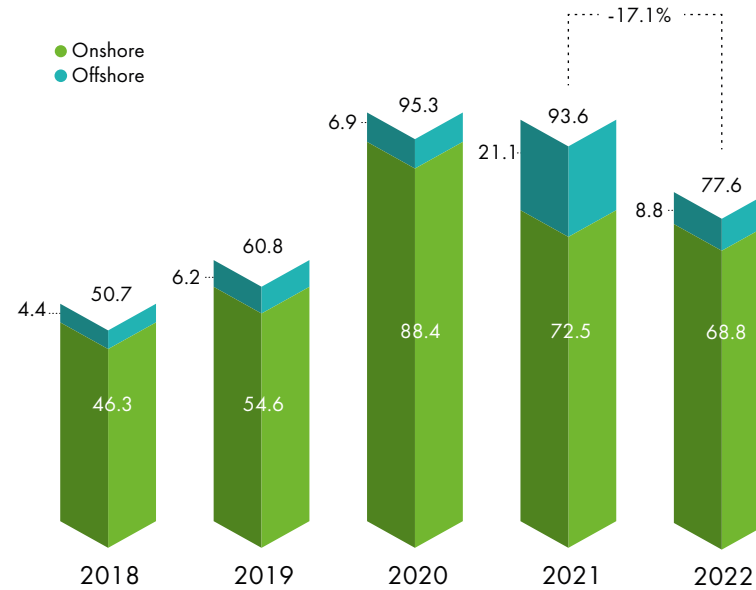
After a record year in new installations in 2021, Africa & ME connected 453 MW of wind power in 2022, the lowest since 2013.

The world's top five markets for new installations in 2022 were China, the US, Brazil, Germany and Sweden. Altogether, they made up 71% of global installations last year, collectively 3.7% lower than 2021. This was primarily due to the world's two largest markets, China and the US, losing a combined 5% market share compared with the previous year – the second consecutive year that both countries have lost market share.

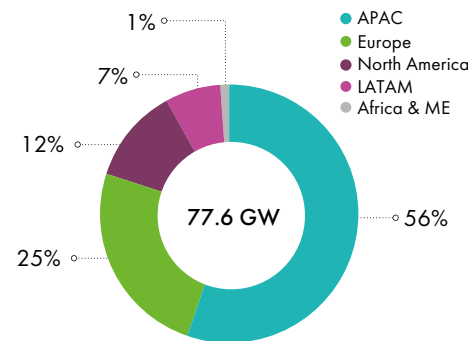
In terms of cumulative installations, the top five markets as of the end of 2022 remained unchanged. China, the US, Germany, India and Spain together accounted for 72% of the world's total installed wind power capacity, as in 2021.

GWEC reports installed and fully commissioned capacity additions and total installations. According to GWEC Global Supply Side data, globally 90.6 GW of new wind power was mechanically installed in 2022, but only 77.6 GW was commissioned primarily because 13 GW of new installations in China and Vietnam were not grid-connected. Cumulatively, 940 GW of wind power was mechanically installed worldwide by the end 2022, but only 906 GW was commissioned due to grid connection delays. All charts in the Market Status and Market Outlook sections are based on GWEC data.

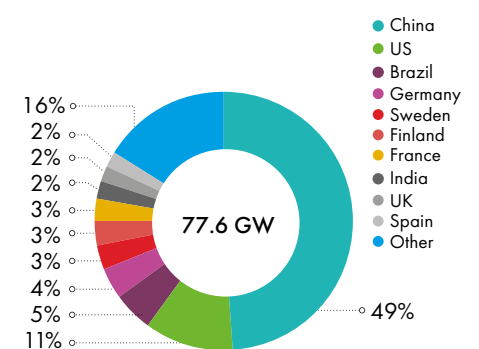
New installations
GW



New wind power capacity in 2022 by region (%)



New wind power capacity in 2022 and share of top 10 markets (%)



The status of onshore wind in 2022

New grid-connected onshore wind capacity in 2022 amounted to 68.8 GW, bringing cumulative global onshore capacity to 842 GW, with YoY growth of 8.8%.

Thanks to record installations in Sweden, Finland and Poland, and recovering installations in Germany, Europe performed well in a volatile 2022, adding a record 16.7 GW of onshore wind capacity.

Global additions in 2022 were 5% lower than in the previous year. The slowdown in LATAM, Africa & ME is partly responsible for the decline, but the primary reason is the slowdown of onshore installations in the US.

China's onshore wind installations plunged in 2021 when the world's largest onshore wind market entered the era of 'grid parity', meaning that electricity generated by onshore wind would be remunerated with the same regulated price as coal power in every province. GWEC Market Intelligence forecast, in its Q1 2022 Outlook, that Chinese onshore installations would bounce back, reaching 46 GW of new

installations in 2022. The 50.6 GW of new onshore wind capacity approved under the 'grid parity' scheme in 2021 shows that the country is on track to reach its ambitious renewable energy targets included in the 14th Five-Year Plan (2021-2025). The Chinese Wind Energy Association (CWEA) reported that 44.7 GW of onshore wind capacity was installed in 2022, but the latest statistics released by the National Energy Administration (NEA) show that only 32.6 GW of new onshore wind capacity was grid-connected last year.

In the US, our Q1 2022 Outlook forecast relatively stable onshore wind growth for 2022. The Internal Revenue Service (IRS) in June 2021 provided a further one-year extension for projects that started construction in 2016 or 2017, allowing project developers to qualify for the full Production Tax Credit (PTC) rate if their projects can meet a commercial operation date (COD) of end-2022. However, many projects were delayed by developers as they awaited full clarity on the rules of the Inflation Reduction Act (IRA).

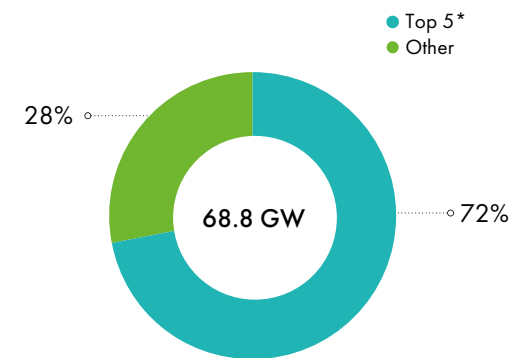
Despite finishing the year with a strong final quarter, the US wind industry commissioned only 8.6 GW of onshore wind capacity in 2022, the slowest year since 2018, according to American Clean Power (ACP). Due to supply chain constraints and grid interconnection issues, more than 10 GW of onshore wind capacity has had delays, slowing the rate of installations. GWEC expects the US market to accelerate sharply now that the IRA is in place and is fully understood by investors.

In addition to China and the US, the other onshore wind markets in the top five in 2022 were Brazil (4.1 GW), Sweden (2.4 GW) and Finland (2.4 GW).

'Grid parity', auction/tenders and the PTC remained the top three market support mechanisms behind onshore wind capacity added in 2022. Collectively, they account for a combined 91% market share, the same as the previous year.

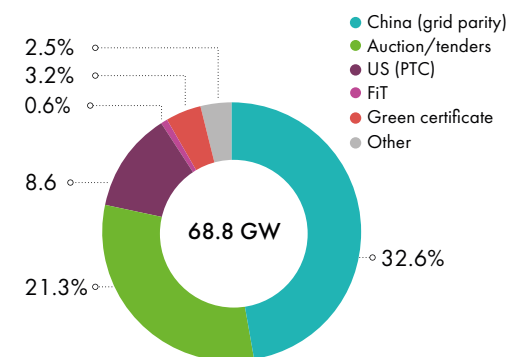
Excluding China, 13.7 GW of onshore wind capacity was awarded worldwide last year

New onshore wind power capacity in 2022 and market share by country (%)



* China, US, Brazil, Sweden and Finland

New onshore wind power capacity in 2022 by market support mechanism (%)





through wind-specific, technology-neutral, renewable and hybrid auctions, which is 30% lower than in 2021. Even though Europe accounted for more than half of this volume, it still saw awarded onshore wind capacity drop by 29% compared with 2021. Triggered by Russia's invasion of Ukraine, governments in the EU have set ambitious renewable energy targets to ensure security of supply. However, onshore wind tenders launched in 2022 were undersubscribed in several key European onshore wind markets including Germany, France, Spain and Italy. Longstanding permitting issues and increased project risk – associated with global inflation and supply chain disruption – combined with unhelpful market interventions by EU governments to undermine investors' confidence.

China approved 11 GW of onshore wind capacity under the 'grid parity' mechanism in 2022, only one-fifth of the volume reported for 2021. As of January 2023, however, provincial governments had announced more than 50 GW of onshore wind capacity under the same support mechanism, putting China on track to reach its '30-60' targets.

The status of offshore wind in 2022

8.8 GW of new offshore wind was fed into the grid last year, bringing total global offshore wind capacity to 64.3 GW by the end of 2022. The new additions are 58% lower than the bumper year of 2021 but still make 2022 the second highest year in offshore wind history.

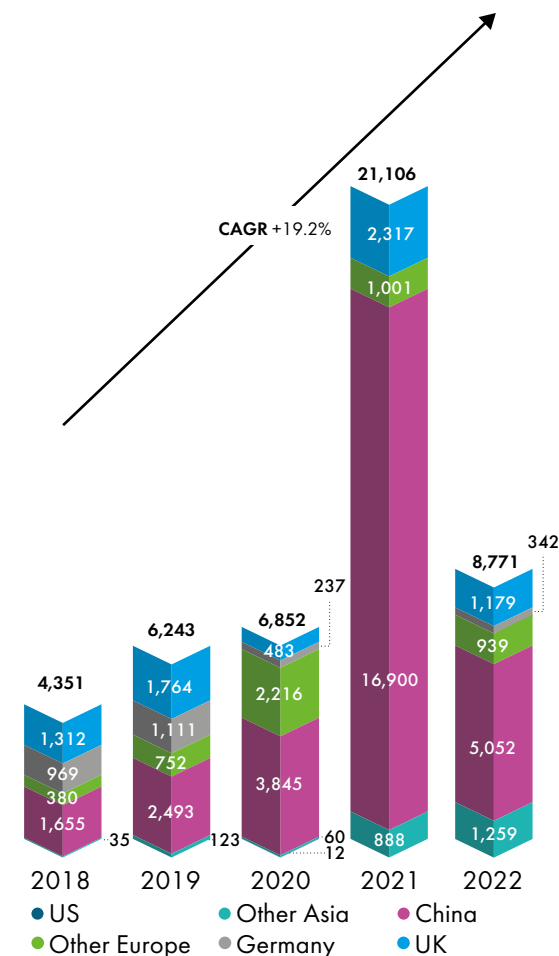
- China continued to lead global offshore wind development, although new installations in 2022 were 70% lower than in 2021 – a record year driven by the end of the feed-in tariff (FiT). Starting from 1 January 2022, China's offshore wind market has also entered the era of 'grid parity' with the end of national FiTs. Although financial support at the provincial level is still available in Guangdong, Jiangsu and Shandong, the incentive is much lower than the FiT previously offered by the central government. Commissioning more than 5 GW of new offshore wind in 2022 demonstrates the resilience of China's offshore wind industry. By the end of 2022, cumulative offshore wind installations in China exceeded 30 GW, a milestone that took

Europe more than three decades to achieve.

- With 2.5 GW offshore wind capacity across six countries connected to the grid in 2022, Europe accounted for the majority of the remaining new capacity, as in the previous year.
- The UK further consolidated its leading position in the European offshore wind market in 2022. In addition to completing the commissioning of the remaining wind turbines (924 MW) at the 1.4 GW Hornsea Project 2, which is now the world's biggest operational offshore wind farm, the UK has grid-connected 27 wind turbines (255 MW) at the 1.1 GW Seagreen Project.
- Having fully commissioned its first commercial offshore wind project, the 480 MW Saint-Nazaire wind farm, last November, France became Europe's second largest offshore wind market in new additions in 2022, followed by the Netherlands (369 MW) and Germany (342 MW).

- Italy also commissioned its first commercial offshore wind project last year. The 30 MW Beleolico offshore wind farm, which features 10 MySE3.0-135 wind turbines from Mingyang, not only represents the first installation of Chinese wind turbines in European waters, but also the first offshore wind project commissioned in the Mediterranean Sea.
- In Norway, the 94.6 MW Hywind Tampen floating wind project, featuring 11 units of SG-8.6 MW-167 wind turbines from Siemens Gamesa and a concrete SPAR-type floating foundation, was scheduled to be completed by the end of 2022, but due to supply chain issues only seven wind turbines (60.2 MW) have come into operation.
- Altogether, a total of 66.4 MW of floating wind capacity was commissioned in 2022, including 60.2 MW at Norway's Hywind Tampen project and one 6.2 MW floating wind turbine supplied by Chinese CSSC Haizhuang, installed in China on a floater prototype called 'Fuyao'.

New offshore installations (MW)



The offshore wind market has grown from 4.4 GW in 2018 to 8.8 GW in 2022, bringing its market share in global new installations from 9% to 11%. This is 11 percentage points lower than 2021, primarily due to new installations slowing down in China after an incentive-driven installation rush. GWEC Market Intelligence expects the global offshore wind market to continue to grow at an accelerated pace (for details, see Market Outlook).



- Outside of China and Europe, two other markets reported new offshore wind installations in 2022: Taiwan (1,175 MW) and Japan (84 MW). In February 2022, the Ministry of Economic Affairs' Bureau of Energy predicted a total of 2,016 MW offshore wind capacity would be added in Taiwan in 2022. However, only 145 offshore wind turbines across four projects were connected last year. This is due in part to the COVID-19 pandemic and typhoon-related disruptions. In Japan, the 140 MW Akita Noshiro Port wind farm was scheduled to achieve full commissioning by the end of 2022. All the turbines were installed by early December, but only the 84 MW Noshiro Port offshore wind farm was commissioned in 2022.
- No intertidal offshore wind project in Vietnam reached commercial operation last year, although more than 300 MW of intertidal project capacity missed their COD deadline in 2021 and more turbines were installed at a few intertidal projects in 2022. This is because the ceiling price used by Vietnam Electricity (EVN) as the

cap to negotiate PPAs with investors for their renewable energy projects was missing until January 2023.

- The US is the only market with offshore wind in operation in the Americas, but no offshore turbine or project was commissioned in 2022, as in the previous year.

was in Europe and 3 GW in Taiwan. In Europe, the UK awarded the most offshore wind capacity (7 GW) through the Contracts for Difference (CfD) Allocation Round 4, followed by the Netherlands (1.5 GW) and Germany (980 MW). The two 'subsidy-free' tenders (760 MW each) that were launched and awarded in

After overtaking the UK as the world's top offshore wind market in 2021, China further consolidated its market share in 2022

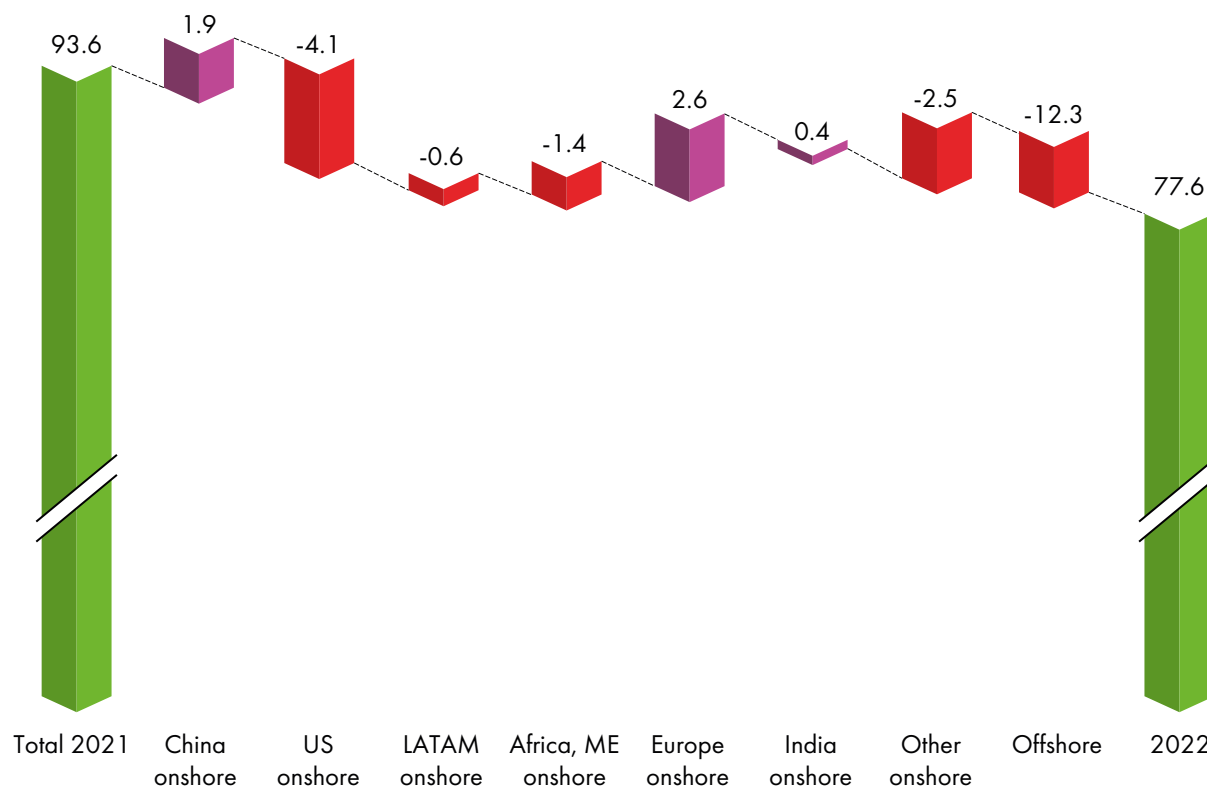
- In terms of cumulative installations, China overtook the UK as the top market in 2021, and further consolidated its market share in 2022. Germany, the Netherlands and Denmark are the other three markets that make up the top five.
- Excluding China, where 19.7 GW of offshore wind projects were approved under the 'grid-parity' mechanism, a total of 12.5 GW of offshore wind capacity was awarded worldwide last year through auctioning, of which 9.5 GW

the Netherlands were Europe's latest offshore wind auctions using non-price criteria to select winners.

- The US awarded no offshore wind project capacity last year, but collectively more than 13 GW of capacity was allocated through the New York Bight, Carolina Long Bay and California lease sales. The California auction was the first offshore wind lease sale on the US Pacific Coast and the first to support commercial-scale floating wind development.

New installations decline in all regions, except Europe

Changes in new onshore and offshore installations, 2021-2022 (GW)



The annual wind market (onshore and offshore combined) declined in all regions except Europe in 2022, with a YoY fall of 17.1%.

- Onshore wind: despite a challenging economic environment and vexing supply chain issues, Europe had a record year in 2022 with YoY growth of 18.2%, primarily driven by record installations in Sweden, Finland and Poland, as well as recovering installations in Germany. Compared with 2021, however, new onshore wind capacity added in North America, Africa & ME and LATAM last year fell by 28% (3.8 GW), 75% (1.4 GW) and 10% (0.6 GW) respectively, while new additions in APAC remained constant. The decline in North America, Africa & ME and LATAM is mainly due to lower onshore installations the US, no turbines were grid connected in Africa's two largest wind markets, South Africa and Egypt, and there was a sharp drop in new installations in Argentina and Mexico.
- Offshore wind: new offshore wind installations decreased by 58% (12.3 GW) compared with 2021, mainly due to annual growth returning to normal after China's policy-driven installation rush came to an end.

Market Status 2022

Actuals 2022 vs GWEC forecast

China onshore

Chinese onshore wind installations were expected to bounce back in 2022 to reach 46 GW, as more than 50.6 GW of onshore wind capacity was approved under the 'grid parity' scheme in 2021, demonstrating that the country is on track to reach its ambitious renewable energy targets. According to China's NEA, 32.6 GW of onshore capacity was grid-connected last year, but CWEA statistics show that 44.7 GW of onshore wind capacity was mechanically installed in 2022.

USA onshore

The rationale behind our forecast for the US is that the IRS in June 2021 provided a further one-year extension for projects that started construction in 2016 or 2017, allowing project developers to qualify for the full PTC rate if their projects can reach their COD by end of 2022. Although only 4.1 GW of onshore wind had been commissioned by the third quarter of 2022, a big installation push was still expected for Q4 2022. ACP statistics show that Q4 was the strongest quarter of the year, but due to supply chain constraints and grid interconnections, quarterly installations were still down 35% compared with 2021.

India onshore

India commissioned 1.58 GW of wind power in the first three quarters of 2022, continuing the trend of recovering installation rates. However, total additions in 2022 were still lower than our Q3 2022 projection, which is primarily driven by the cancellation of projects rendered unviable by high inflation and delays on account of grid unavailability and timeline extensions in their Scheduled Commissioning Date (SCD).

Germany onshore

To reduce reliance on fossil fuels imported from Russia, Germany's new federal government increased its 2030 renewables target while introducing a new 'Onshore Wind Law' (WindLandG) in July 2022 to accelerate installations as part of its 'Easter Package'. Actual onshore wind installations in 2022 were slightly lower than expected, but still made Germany Europe's largest wind market for additions in 2022.

Brazil onshore

Wind power development in Brazil has demonstrated the industry's resilience over the past three years, especially during the COVID-19 pandemic and the country's political turbulence. 2022 was a record year, with more than 4 GW of onshore wind installations. The strong growth is linked to projects being developed through both the regulated scheme of public auctions and the free market of private PPAs.

Vietnam onshore

Since more than 1 GW of registered onshore wind projects missed their COD deadline in 2021, we expected some of them to start commercial operation in 2022, provided offtake agreements could be made. However, no onshore wind projects achieved commercial operation last year due to the ceiling price used by EVN as the cap to negotiate PPAs with investors for renewable projects not being in place until January 2023.

UK offshore

In 2022, GWEC Market Intelligence expected the remaining offshore turbines (totalling 924 MW) at the 1.4 GW Hornsea Project 2 to reach commercial operation, and half of the turbines at the 1,075 MW Seagreen Project (114 wind turbines) in Scotland to come into operation. Although all the turbines were fully commissioned at the Hornsea Project 2, only 27 wind turbines (255 MW) were grid-connected at the Scottish project.

Germany offshore

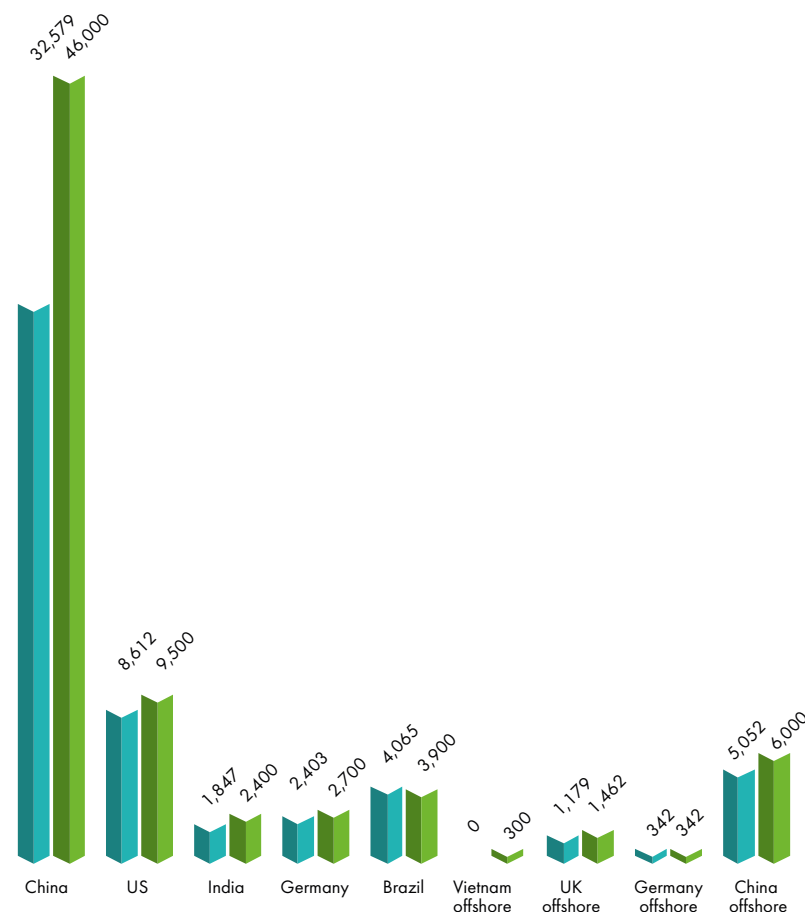
The 342 MW Kaskasi offshore wind farm reached commercial operation in the German North Sea in 2022, in line with our projection. New offshore wind installations have been low since 2020, primarily due to unfavourable offshore wind policies and a small short-term offshore wind project pipeline.

China offshore

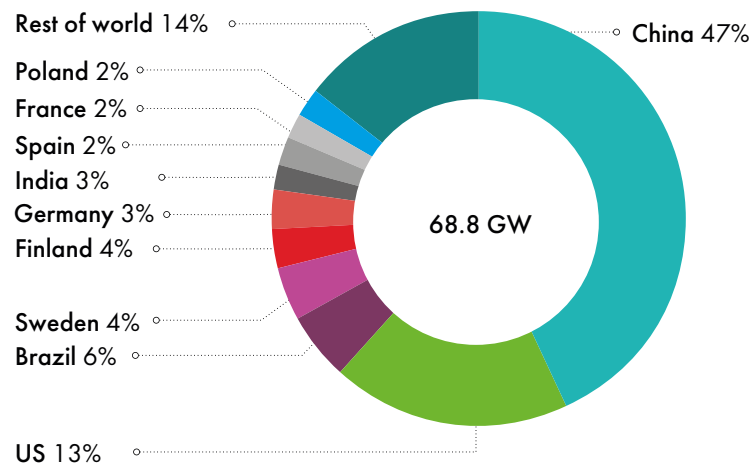
After a record year in 2021, with nearly 17 GW of offshore wind grid-connected, new installations were predicted to drop dramatically following the introduction of 'grid parity' in the Chinese offshore wind market from 2022. GWEC Market Intelligence predicted 6 GW of offshore wind to be commissioned in 2022, which was primarily based on the fact that more than 7 GW of offshore wind projects had started construction by Q1 2022.

Actuals for 2022 vs GWEC forecast

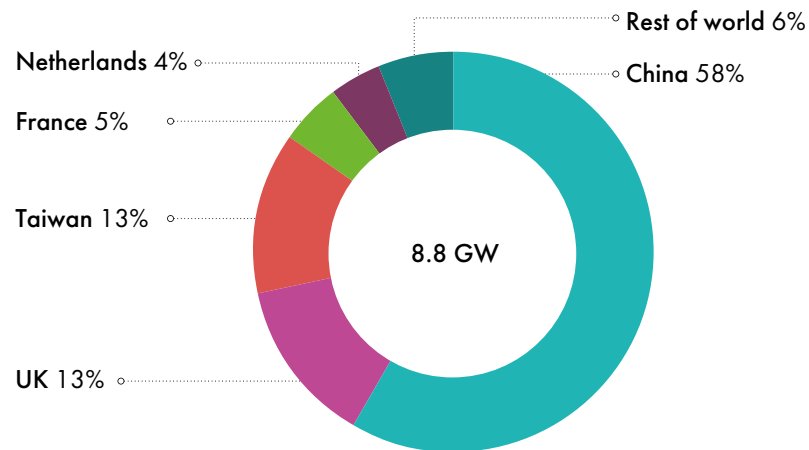
● Actuals 2022
● Forecast Q3 2022



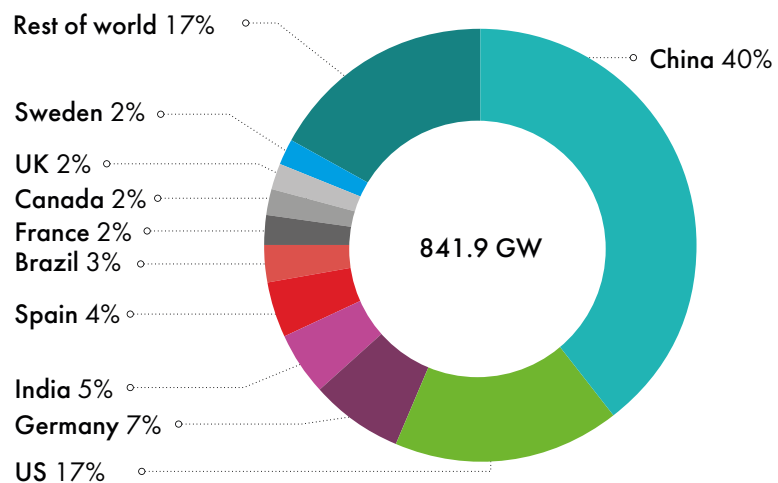
New installations onshore (%)



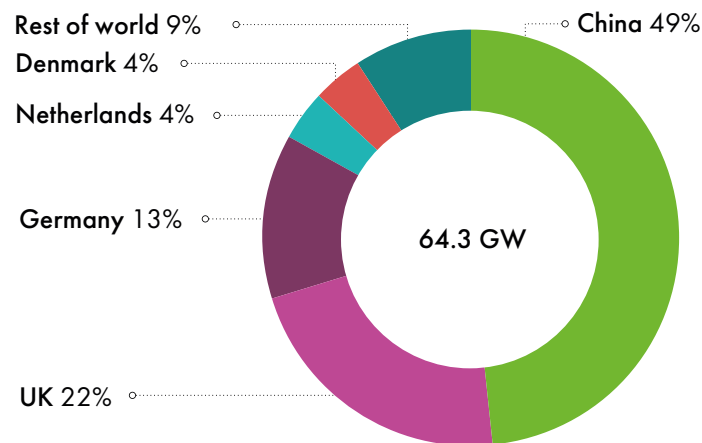
New installations offshore (%)



Total installations onshore (%)

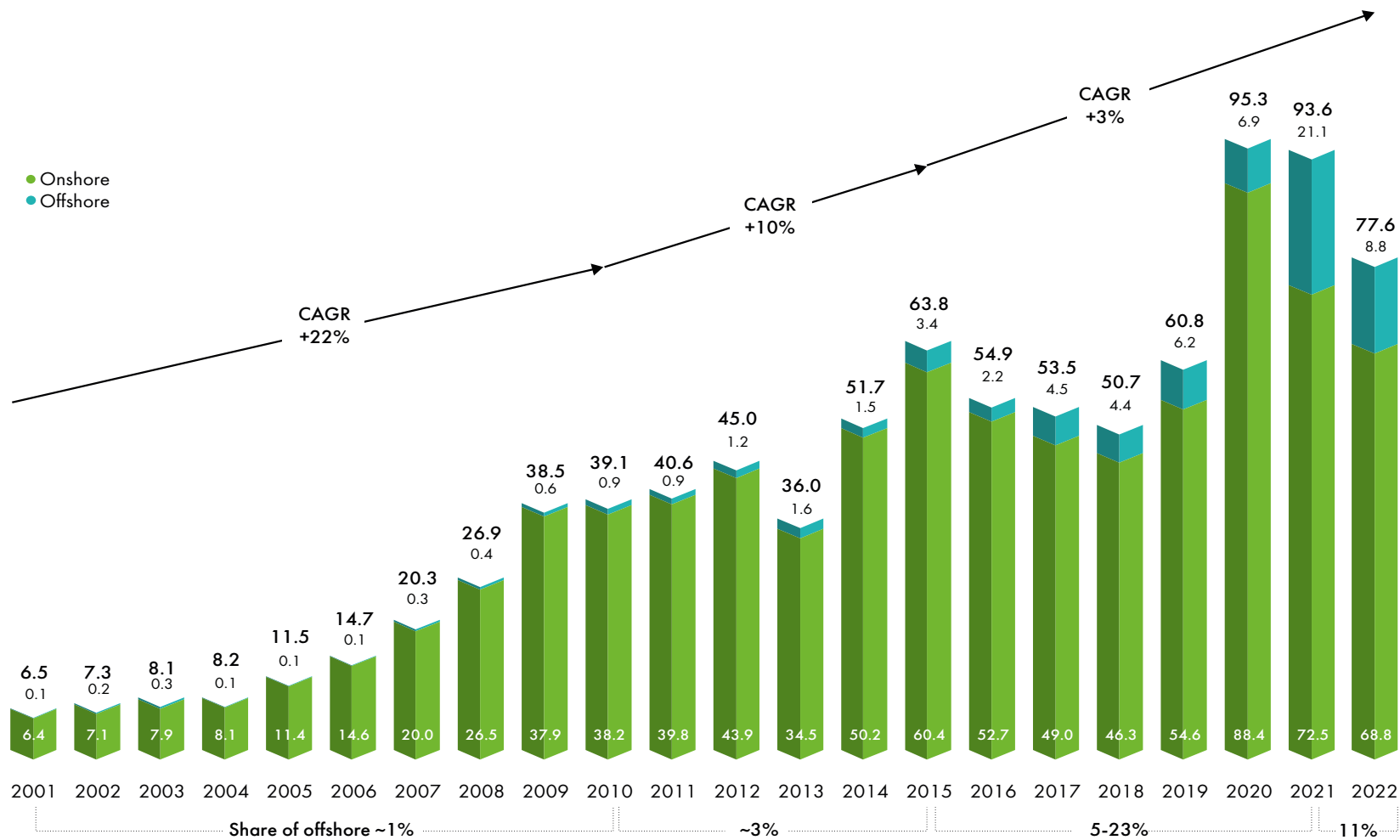


Total installations offshore (%)

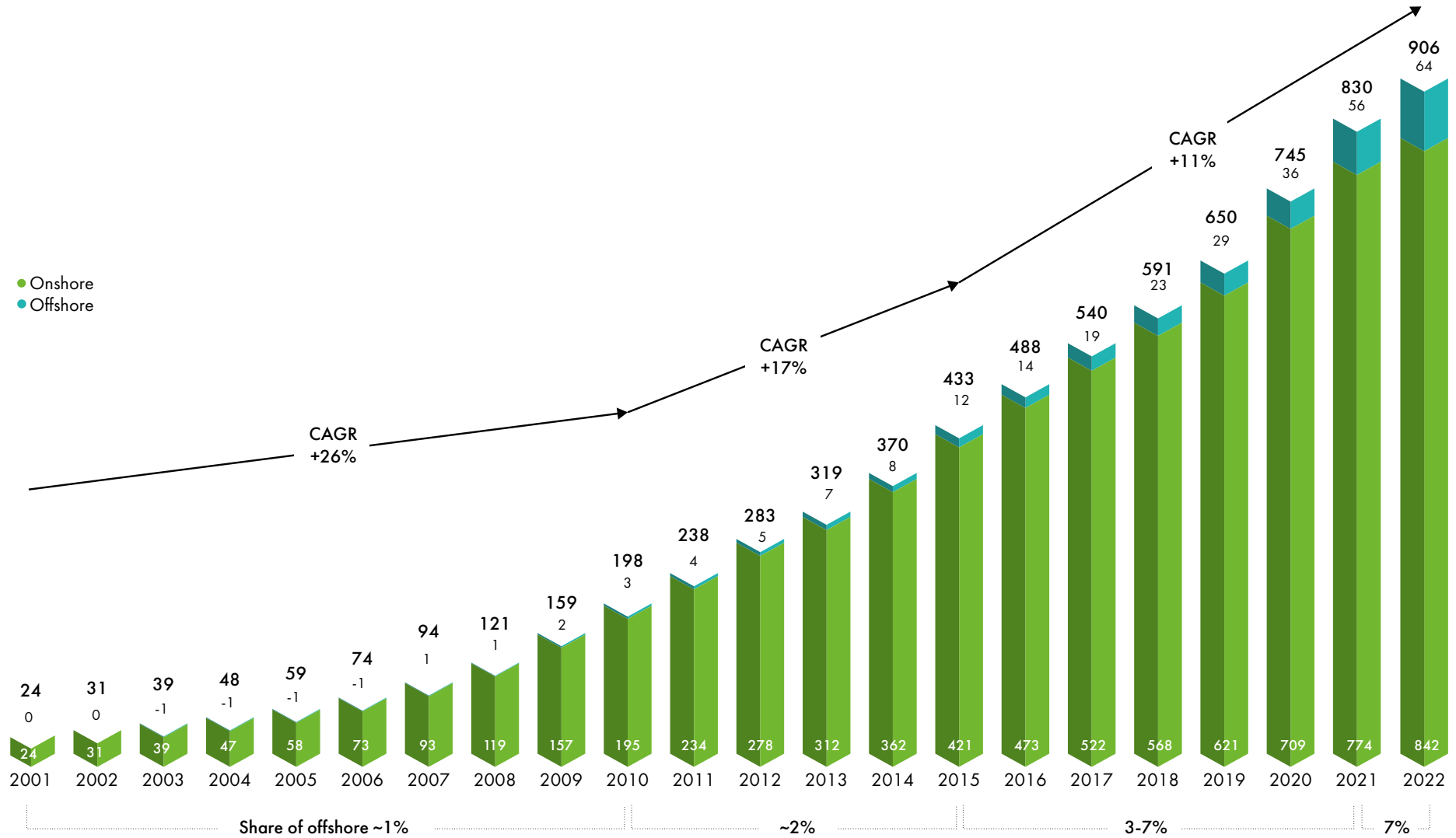


Detailed data sheet available in GWEC's member-only area. For definition of region see Appendix - Methodology and Terminology

Historic development of new installations (GW)



Historic development of total installations (GW)



GWEC adjusted 2021 total installations compared with the Global Wind Report 2022 based on the latest available statistics. For details see Appendix – Methodology and Terminology

Market Status 2022

Historic development of new and total grid-connected installations

MW, onshore	New installations 2021	Total installations 2021	New installations 2022	Total installations 2022
Total onshore	72499	773818	68816	841898
Americas	19243	189582	14829	204134
USA	12747	135848	8612	144184
Canada	677	14255	1006	15261
Brazil	3830	21567	4065	25632
Mexico	473	7159	158	7317
Argentina	669	3291	18	3309
Chile	615	3444	824	4268
Other Americas	232	4018	146	4165
Africa, Middle East	1809	9359	349	9708
Egypt	237	1702	0	1702
Kenya	102	435	0	435
South Africa	668	3442	0	3442
Morocco	197	1512	276	1788
Saudi Arabia	416	422	0	422
Other Africa	189	1846	73	1919
Asia-Pacific	37352	365887	36970	402852
China	30670	301419	32579	333998
India	1459	40083	1847	41930
Australia	1746	9125	1412	10537
Pakistan	229	1516	301	1817
Japan	211	4523	149	4668
South Korea	64	1562	96	1658
Vietnam	2717	3102	0	3102
Philippines	0	443	0	443
Kazakhstan	88	337	418	755
Other APAC	168	3776	169	3945
Europe	14095	208991	16667	225204
Germany	1925	56814	2403	58951
France	1192	19079	1590	20653
Sweden	2104	11952	2441	14393
United Kingdom	328	14074	502	14575
Spain	750	28134	1659	29793
Finland	671	3186	2430	5607
Netherlands	952	5370	933	6223
Turkey	1400	11102	867	11969
Other Europe	4773	59280	3842	63040
MW, offshore	New installations 2021	Total installations 2021	New installations 2022	Total installations 2022
Total offshore	21106	55549	8771	64320
Americas	0	42	0	42
USA	0	42	0	42
Asia-Pacific	17788	27695	6311	34006
China	16900	26390	5052	31442
Japan	0	52	84	136
South Korea	0	142	0	142
Vietnam	779	874	0	874
Taiwan	109	237	1175	1412
Europe	3317	27812	2460	30272
United Kingdom	2317	12739	1179	13918
Germany	0	7713	342	8055
France	0	2	480	482
Netherlands	392	2460	369	2829
Denmark	605	2308	0	2308
Belgium	0	2262	0	2262
Other Europe	4	328	90	418

GWEC adjusted 2021 new and total installations compared with the Global Wind Report 2022 based on the latest available statistics.

MARKET OUTLOOK

Global wind energy market expected to grow by 15% on average per year

GWEC Market Intelligence expects that new wind power installations will exceed 100 GW in 2023 and that 680 GW of new capacity will be added in the next five years under current policies. This equals more than 136 GW of new installations per year until 2027.

The compound annual growth rate (CAGR) for the next five years is 15%.

Achieving double-digit growth is a very positive development. There are five pillars that will underpin this level of success in the next five years:

- Europe's renewed urgency to replace fossil fuels with renewables to achieve energy security in the aftermath of the Russian invasion of Ukraine.
- A strong uplift for renewable energy in the US over the next

ten years, primarily driven by the Inflation Reduction Act (IRA).

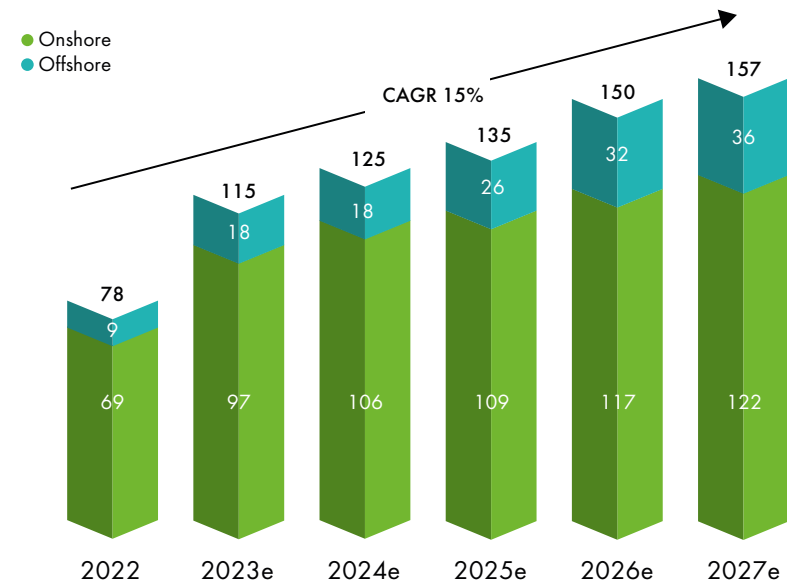
- China's commitment to further expanding the role of renewables in its energy mix, aiming for renewable energy to contribute more than 80% of total new electricity consumption by the end of the 14th Five-Year Period (2021–2025).

- Governments fully waking up to the opportunities that offshore wind can provide, making offshore wind truly global and increasing ambition in mature and developing markets.

- Strong growth in large emerging markets both onshore and offshore from the middle of this decade.

Global wind power growth in 2023–2027 will continue to rely

New installations outlook 2023–2027 (GW)



GWEC's Market Outlook represents the industry perspective for expected installations of new capacity for the next five years. The outlook is based on input from regional wind associations, government targets, tender results, announced auction plans, available project pipeline, and input from industry experts and GWEC members. An update will be released in Q3 2023. A detailed data sheet is available in the member-only area of the GWEC Intelligence website.

primarily on three market support mechanisms:

- 'Grid parity' (China)
- Tax credit (PTC, ITC and technology-neutral tax credits in the US)
- Wind-specific, technology-neutral, renewable and hybrid

auctions (Europe, LATAM, Africa & ME and South East Asia).

In addition to addressing challenges such as permitting and market design, governments will have to implement new policy solutions to ensure that the global supply chain can meet increasing demand from both established and emerging markets.

Global onshore outlook

The CAGR for onshore wind in the next five years is 12%. Expected average annual installations are 110 GW, with a total of 550 GW likely to be built in 2023–2027.

Growth in China, Europe and the US will be the backbone of global onshore wind development in the next five years. Altogether they are expected to make up more

Global offshore outlook

After a YoY fall of 58% in 2022, annual offshore wind installations are expected to bounce back reaching 18 GW in 2023. The CAGR for offshore wind in the next five years is 32%. With such a promising growth rate, new installations are likely to double by 2027 from 2023 levels.

China and Europe will be the two key contributors to near-term

Growth in China, Europe and the US will be the backbone of global onshore wind development in the next five years

than 80% of total additional capacity in 2023–2027. GWEC Market Intelligence believes that China will be the engine of near-term growth, accounting for 62% of new installations in 2023. But installations will accelerate in Europe, the US and emerging markets in Southeast Asia and Africa & ME from 2025. Global onshore wind markets will become more diversified by 2027 with half of the annual growth coming from markets outside of China.

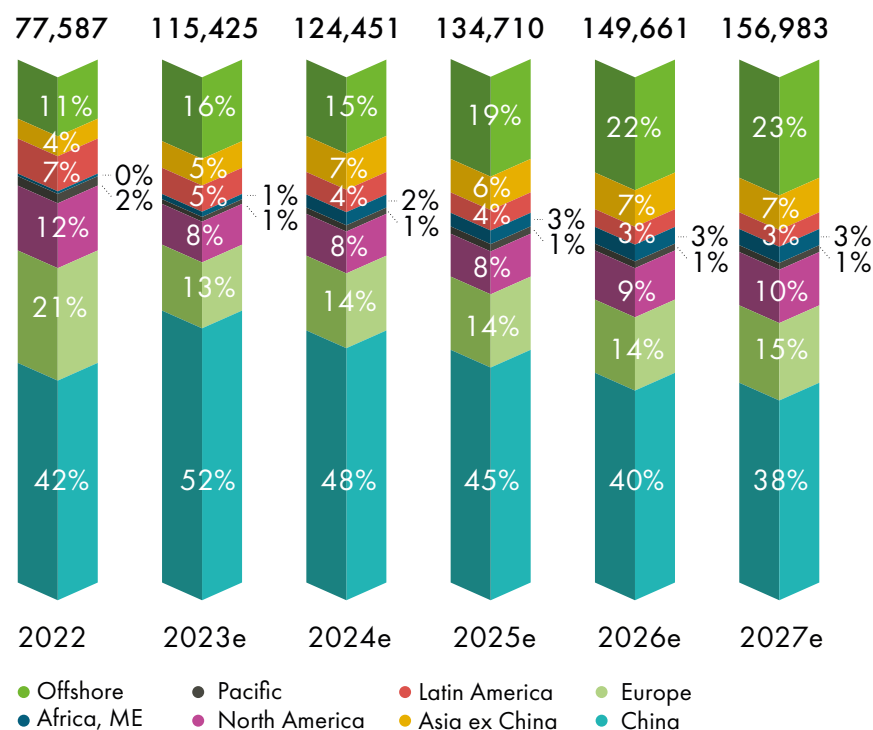
growth, making up more than 80% of new additions in 2023 and 2024. The US and emerging markets in APAC will start gaining sizeable market share from 2025 with 7-8 GW of new offshore wind expected to be added every year over the rest of the forecast period.

In total, 130 GW of offshore wind is expected to be added worldwide in 2023–2027, with expected average annual installations of nearly 26 GW.



Onshore wind in APAC, Europe and the US is expected to accelerate while offshore wind keeps going strong

New onshore and offshore installations outlook by region (MW, %)



Offshore wind

The global offshore market is expected to grow from 8.8 GW in 2022 to 35.5 GW in 2027, bringing its share of total new global installations from today's 11% to 23% by 2027.

In Asia, China will remain the largest contributor with 64 GW to be added in the next five years, followed by Taiwan (6.9 GW), South Korea (2.3 GW), Vietnam (2.2 GW, primarily intertidal projects) and Japan (0.9 GW).

In Europe, more than 37 GW of offshore wind capacity is expected to be built in 2023–2027, of which 41% is likely to be installed in the UK - primarily driven by the commissioning of CfD Allocation Round 3 and 4 projects, 16% in Germany, 9% in the Netherlands, 8% in Poland, 8% in France and 6% in Denmark.

With the first utility-scale offshore wind project expected to be partially connected in 2023, 15 GW of offshore wind capacity is predicted to be commissioned in the US in the next five years, making it the largest

offshore wind market after China and the UK in terms of new additions. This projection is based on the assumption that the supply chain will be established in time to address the growth from the East Coast of the US.

China

Strict COVID-19 restrictions and the impact of a sudden 'reopening' of the country made 2022 a difficult year. Achieving grid connection of 33 GW (mechanical installation of 45 GW) of onshore wind capacity has demonstrated the resilience of the Chinese wind industry. In early 2023, the NEA predicted that generation from wind and solar power will double by 2025 from 2020 levels. To reach the target, 250–300 GW of wind power capacity needs to be added between 2021 and 2025. Since more than 80 GW of wind turbine orders have already been awarded in 2022 and the Chinese government committed to non-fossil fuels achieving 25% of the country's primary energy mix by 2030, GWEC Market Intelligence has further upgraded its onshore wind installations forecast and now predicts 300 GW of new capacity to

GWEC's Market Outlook represents the industry perspective for expected installations of new capacity for the next five years. The outlook is based on input from regional wind associations, government targets, available project information as well as input from industry experts and GWEC members. An update will be released in Q3 2023. A detailed data sheet is available in the member-only area of the GWEC Intelligence website.

be added to the grid in China in the next five years.

Asia excl. China

Excluding China, India is the largest wind market in Asia. We expect the country's onshore wind market to continue to recover, with new additions peaking in 2025–2026 given the expiry of the 100% interstate transmission charge waiver (ISTS) in June 2025. Towards 2030, annual growth has the potential to reach 5-6 GW under the new 8 GW/year tender trajectory. However, the tapering down from 50% to zero of ISTS charge waivers between 2026 and 2028 is likely to limit installations to 4.5–5.0 GW. In total, 21 GW of onshore wind capacity is likely to be added in India in 2023–2027, accounting for half of the predicted additions for the region. No onshore wind projects achieved commercial operation in Vietnam last year, but we expect new capacity to be commissioned in 2023 and 2024 now that a ceiling price used by EVN to negotiate PPAs with investors for their renewable projects has been set by the Ministry of Industry and Trade. Elsewhere in the region, growth is expected to come from Japan, Pakistan and emerging markets of southeast Asia, as well as in Central Asia. Southeast Asia (mainly the Philippines, Laos,

Thailand and Sri Lanka) and Central Asia (primarily Kazakhstan and Uzbekistan) are likely to make up 22% and 12%, respectively, of the new capacity expected for this region in 2023–2027.

Pacific

No projects were commissioned in New Zealand in 2022, although two projects totalling 260 MW were under construction last year. With construction work ongoing at another two projects expected to be online by December, 2023 will be a record year for this market. However, growth in New Zealand is likely to stop if no project is added to the pipeline in the next two years. In Australia, the total capacity of shovel-ready onshore wind projects at the start of 2023 was close to 4 GW. Although the installation rate in 2023 is predicted to be the lowest since 2019 – based on announced project CODs – annual installations will surge again from 2024 and more than 3 GW of onshore wind is expected to be connected before 2026. Growth momentum is likely to continue beyond 2025 because:

- More states have rolled out renewable tenders and renewable energy zones as more renewables and storage are urgently needed to replace coal plants due to retire.





- The corporate PPA market remains strong, driven by sustainability goals.
- There are commitments from mining and heavy industries on captive renewables and green hydrogen.
- Several transmission projects, such as Project EnergyConnect, VNI West and Marinus Link, are either approved or under construction.

Europe

Our forecast for the next five years is in line with WindEurope's Central Scenario¹, which is based on the latest developments in EU regulation, national policies, signed PPAs, project development timelines and the ability of wind to secure further capacity in upcoming auctions and tenders. After a record year of installations, onshore wind additions in Europe in 2023 are likely to fall by 13% compared with last year, which is due to an expected slowdown in the Nordic countries. Local opposition and laws enabling local communities to block any project are having a particularly negative effect in Norway. With strong growth coming back in established European markets such as Germany, Spain, the UK, France, Italy and Turkey, the European onshore market will take off again from 2024. Driven by the REPowerEU target and

2030 renewable targets for non-EU countries, record onshore wind installations are expected for Europe every year over the rest of the forecast period.

North America

The US onshore wind market has been a tax credit-driven market. With the IRA signed into law by the Biden administration last August, the situation is likely to continue for the next ten years. The IRA extended and increased investment and production tax credits (ITC and PTC) through 2024 for wind energy projects that begin construction before 1 January 2025. In 2025, the tax credits for wind will be replaced with technology-neutral credits for low-carbon electricity generation, which in turn are slated for phaseout in 2032, or when greenhouse gas emissions from the US power sector fall to 25% of 2022 levels, whichever is later². Additionally, under the IRA, projects can receive stackable bonus credits if certain local component requirements are met. GWEC expects the US onshore wind market to accelerate now that guidance from ISR on the IRA implementation is in place. With the tax benefits and incentives being fully understood by investors and suppliers, new investment plans have already been announced

1. <https://windeurope.org/intelligence-platform/product/wind-energy-in-europe-2022-statistics-and-the-outlook-for-2023-2027/>

2. <https://www.energy.gov/eere/wind/articles/us-wind-industry-federal-incentives-funding-and-partnership-opportunities-fact>

across the country. In total, 60 GW of onshore wind capacity is expected to be added in the next five years in North America, of which 92% will be built in the US and the rest in Canada. Growth momentum is unlikely to stop in this region beyond 2027, as more capacity is predicted to be added in the US in 2028–2032, primarily driven by technology-neutral tax credits.

Latin America

Growth in LATAM remained stable in 2022 with new installations reaching 5.2 GW, the second highest in history. The growth was primarily driven by Brazil, which had a record year and made up nearly 80% of the region's additional capacity. Brazil performed well in the past two years: its strong growth was linked to projects being developed through both the regulated scheme of public auctions and the free market of private PPAs. Despite pipeline growth having been interrupted by an unhelpful policy environment in Mexico and economic instability in Argentina, new LATAM installations of 5 GW are likely in 2023–2027, primarily driven by ongoing growth in Brazil and Chile, as well as the completion of long-awaited projects in Colombia. GWEC Market Intelligence expects 26.5 GW of onshore wind to be added in this

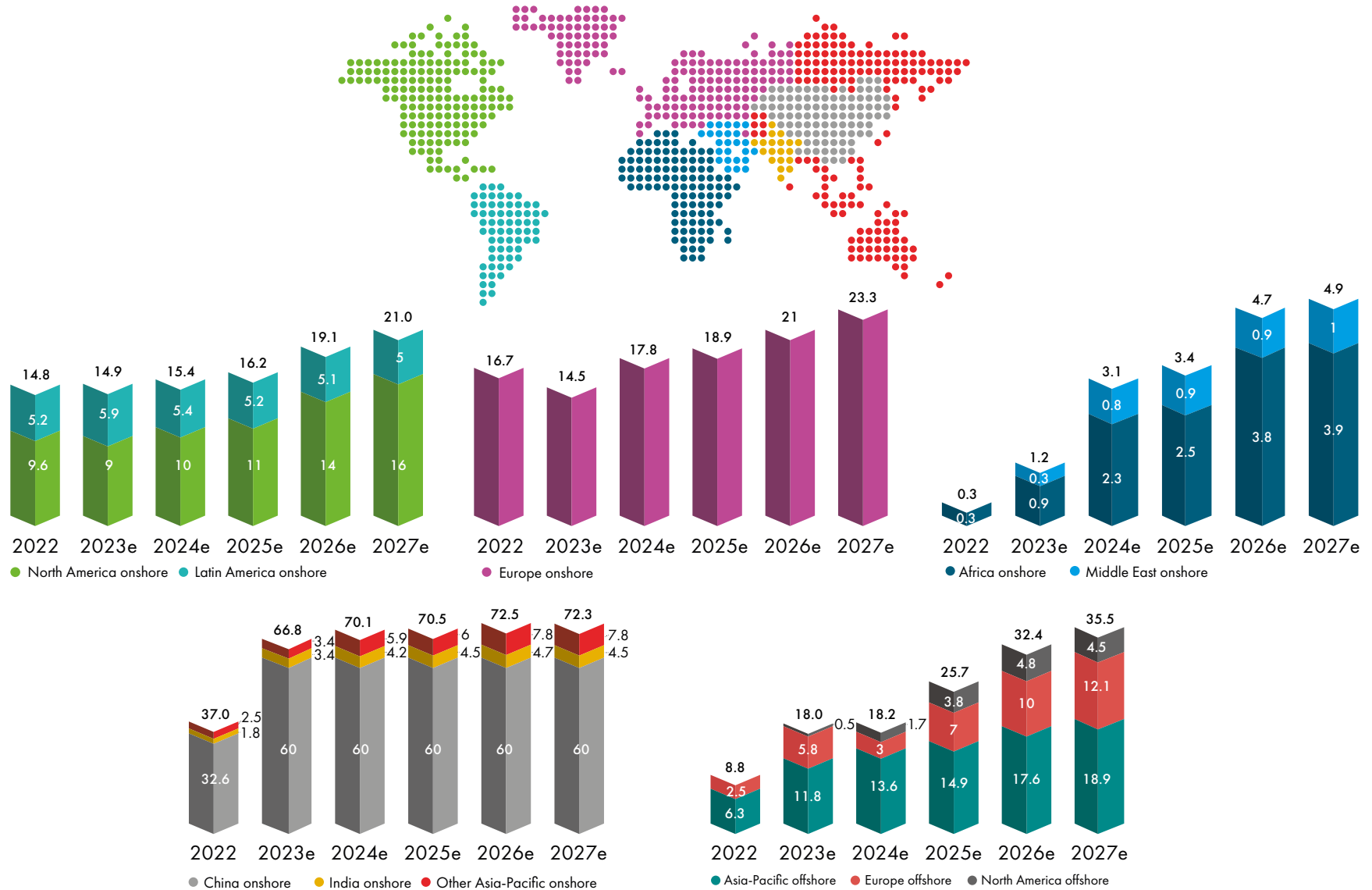
region in the next five years with Brazil, Chile and Colombia contributing 78% of the additions.

Africa/Middle East

After a record year in new installations in 2021, Africa & ME connected 453 MW of wind power last year, the lowest since 2013. Compared with GWEC Market Intelligence's Q3 2022 Outlook, new onshore wind additions for this region in the next five years have been downgraded by 16% (2.6 GW). This is the result of most of the awarded onshore wind projects from the REIPPP Bid Window 5 auction being delayed in South Africa and no wind capacity being awarded from the REIPPP Bid Window 6 auction, launched in 2022, due to the unavailability of grid capacity in the provinces of Eastern Cape and Western Cape. With GW-level projects expected to be built in North Africa and Saudi Arabia – and projects from the REIPPP Bid Window 5 auction coming online – annual growth is likely to bounce back in this region reaching 5 GW in 2026–2027. In total, 17 GW of new capacity is expected to be added in the next five years (2023–2027), of which 5.3 GW will come from South Africa, 3.6 GW from Egypt, 2.4 GW from Saudi Arabia and 2.2 GW from Morocco.



Regional onshore and offshore wind outlook for new installations (GW)



APPENDIX



Global Wind Report 2023 - Methodology and Terminology

Data definitions and adjustments

GWEC reports installed and fully commissioned capacity additions and total installations. New installations are gross figures not deducting decommissioned capacity. Total installations are net figures, adjusted for decommissioned capacity.

Historic installation data has been adjusted based on the input GWEC

received. GWEC made the adjustments to both new and cumulative installations in 2021 for all the markets where updated statistics are available.

Definition of regions

GWEC adjusted its definition of regions for the 2018 Global Wind Report and maintains these in the 2023 edition, specifically for Latin America and Europe.

Latin America: South, Central America and Mexico

Europe: Geographic Europe including Norway, Russia, Switzerland, Turkey and Ukraine

Sources for the report

GWEC collects installation data from regional and country wind associations, alternatively from industry

experts and wind turbine manufacturers.

Used terminology

GWEC uses terminology to the best of our knowledge. With the wind industry evolving, certain terminology is not yet fixed or can have several connotations. GWEC is continuously adapting and adjusting to these developments.

Common industry acronyms

APAC	Asia-Pacific	EEZ	Exclusive Economic Zone	IPCC	Intergovernmental Panel on Climate Change	NEA	China's National Energy Administration
BNEF	Bloomberg New Energy Finance	EIA	Environmental Impact Assessment	IPP	Independent Power Producers	NFTs	Non-Fungible Tokens
BOEM	Bureau of Ocean Energy Management (BOEM)	EMDEs	Emerging Markets and Developing Economies	IRA	The US Inflation Reduction Act	NSEC	North Seas Energy Cooperation
C&I	Commercial And Industrial	EMS	Energy Management System	IRENA	International Renewable Energy Agency	O&M	Operation And Maintenance
CAGR	Compound Annual Growth Rate	EPC	Engineering Procurement Construction	IRP	Integrated Resource Plan	OEMs	Original Equipment Manufacturers
CAISO	California Independent System Operator	ESG	Environmental, Social, and Corporate Governance	ISO	Independent System Operator	OSS	One Stop Shop
CAPEX	Capital Expenditure	EU	European Union	ITC	Investment Tax Credit	OPEX	Operational Expenditure
CBAM	Carbon Border Adjustment Mechanism	EV	Electric Vehicle	kt	Kilo Tonnes	OWSC	Offshore Wind Service Contracts
CCER	China Certified Emission Reduction	EVOSS	Energy Virtual One-Stop Shop	kWh	Kilowatt Hour	PDP	Power Development Plan of Vietnam
CCGT	Combined Cycle Gas Turbine	FDI	Foreign Direct Investments	LATAM	Latin America	PEA	Provincial Electricity Authority of Thailand
CCUS	Carbon Capture, Utilisation, And Storage	FID	Final Investment Decision	LCOE	Levelised Cost of Energy	PPA	Power Purchase Agreement
CfD	Contract for Difference	FIT	Feed-In Tariff	LNG	Liquefied Natural Gas	PV	Photovoltaic
CO₂/		FTE	Full-Time Equivalent	MEA	Metropolitan Electricity Authority of Thailand	PTC	Production Tax Credit
CO₂e	Carbon Dioxide/ Equivalent	GDP	Gross Domestic Product	MNRE	Ministry Of New and Renewable Energy	R&D	Research And Development
COD	Commercial Operation Date	GHG	Greenhouse Gases	MOIT	Ministry of Industry and Trade of Vietnam	RECs	Renewable Energy Certificates
COP	Conference of the Parties	GST	Goods and Services Tax	MOU	Memorandum of Understanding	REE	Rare Earth Element
DFI	Development Finance Institution	GW	Gigawatt	Mt	Metric Tonnes	ROI	Return on Investment
DNSH	Do No Significant Harm	HSSE	Health, Safety, Security, And Environment	MW	Megawatt	RPS	Renewables Portfolio Standards
DSR	Demand-Side Response	HVDC	High-Voltage Direct Current	MWh	Megawatt Hour	RTO	Regional Transmission Organisation
ECA	Export Credit Agency	IEA	International Energy Agency	NDCs	Nationally Determined Contributions	STEM	Science, Technology, Engineering and Mathematics
EGAT	Electricity Generating Authority of Thailand	IFC	International Finance Corporation			TW	Terawatt
		IoT	Internet of Things			TWh	Terawatt Hour

About GWEC Market Intelligence

GWEC Market Intelligence provides a series of insights and data-based analysis on the development of the global wind industry. This includes a market outlook, country profiles, policy updates, deep-dives on the offshore market among many other exclusive insights.

GWEC Market Intelligence derives its insights from its own comprehensive databases, local knowledge and leading industry experts.

The market intelligence team consists of several strong experts with long-standing industry experience across the world.

GWEC Market Intelligence collaborates with regional and national wind associations as well as its corporate members.

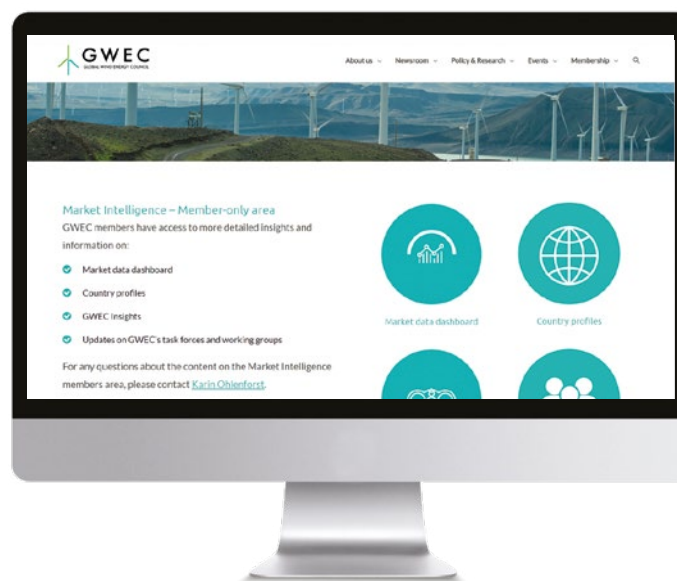
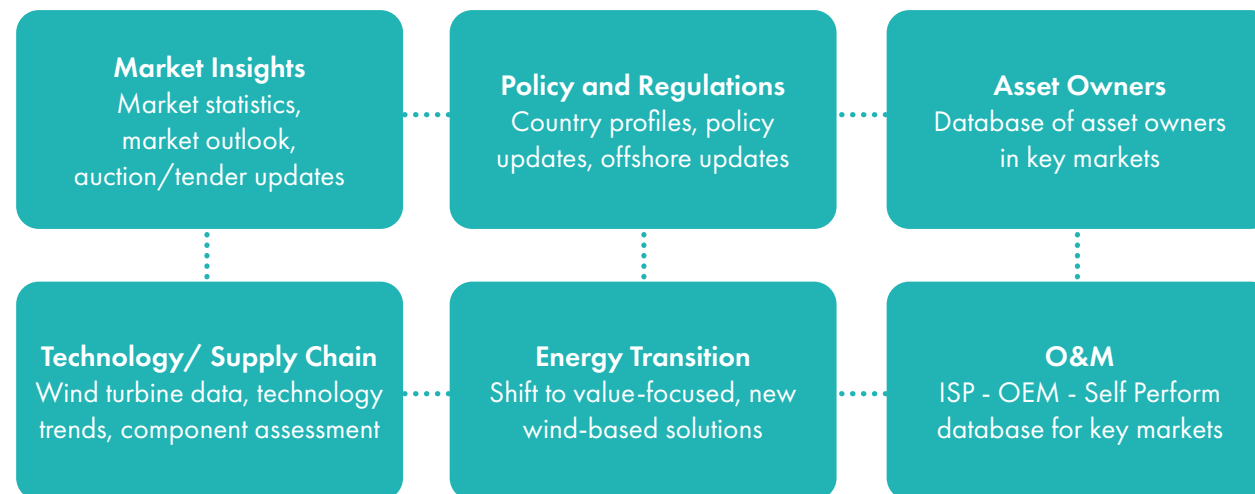
How to access GWEC Market Intelligence Corporate GWEC Members

- Wind energy associations
- Market Intelligence subscription

Contact

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GWEC Market Intelligence Areas



GWEC Market Intelligence created a Member-only area to provide more in-depth market intelligence to GWEC's members and their employees.

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GWEC Market Intelligence Products in 2023

Product	Frequency
1. Wind Energy Stats/Market Data	
Wind Stats 2022 (historic annual, accumulative, decommission data)	Annual
Global Wind Report 2023	Annual
Wind Energy Statistics (wind energy penetration rate, jobs)	Annual
2. Country Profiles/Policy Updates	
Country Profiles Onshores/Country Profiles Offshore	Annual
Ad-hoc Policy Updates	Ad-hoc
3. Market Outlook	
Global Wind Market Outlook 2023-2027 (Q1 and Q3) Database + Report	Semi-Annual
India Market Outlook Report 2023-2027	Annual
Global Wind Workforce Outlook 2023-2027	Annual
4. Supply Side Data	
Global Wind Turbine Supply Side Data Report 2022 (by OEM, by technology, by turbine ratings, models and drive train, etc)	Annual
5. Auctions/Tenders	
Global Wind Auction Database Annual/Auction Trends and Learnings	Quarterly
6. Offshore Wind Market	
Global Offshore Wind Report 2023 / Market Entry Opportunities Database	Annual/Quarterly
Global Offshore Project Pipeline (database, in operation and under construction)	Annual/Quarterly
Global Offshore Turbine Installation Vessel Database and Report	Annual/Quarterly
7. Components Assessment	
Blade (Q4 2023), Generator (Q4 2021), Gearbox (Q4 2022), followed by other components	Special Report
8. Wind Asset Owners/Operators	
Asset Owners and Operators Database (Onshore & Offshore Ranking)	Annual
Asset Owners and Operators Status Report (including strategical trends)	Annual
9. O&M	
O&M Service Provider Database (ISP - OEM - Self-perform)	Annual
O&M Service Provider Status Report (including regional trends)	Annual
10. Energy transition, Digitalisation, New Technologies	
Position papers / studies - permitting, Corporate PPAs / New solutions, GWEC policy recommendations	Special Report

GWEC Global Leaders

The Global Wind Energy Council's Global Leaders are an exclusive leadership group of decision-makers and top-tier members who form the basis of the Association's Executive Committee, which drives the work programme and plays a major role in shaping GWEC's priorities for its efforts in the short and long-term strategy.



Siemens Gamesa

Siemens Gamesa unlocks the power of wind. For more than 40 years, we have been a pioneer and leader of the wind industry, and today our team of more than 26,000 colleagues work at the center of the global energy revolution to tackle the most significant challenge of our generation – the climate crisis. With a leading position in onshore, offshore, and service, we engineer, build and deliver powerful and reliable wind energy solutions in strong partnership with our customers. A global business with local impact, we have installed more than 120 GW and provide access to clean, affordable and sustainable energy that keeps the lights on across the world, while supporting the communities where we operate.



Shell

Shell is building a global integrated power business spanning electricity generation, trading and supply. Shell entered the offshore wind business in 2000 as part of a consortium that installed the first offshore wind turbine in UK waters. Today, we have deployed, or are developing, over eight gigawatts (GW) of wind across North America, Europe, the UK, and Asia. We see offshore wind as a critical way of generating renewable electricity for our customers and moving Shell towards its target of being a net-zero emissions energy business by 2050 or sooner, in step with society.



Ørsted

The Ørsted vision is a world that runs entirely on green energy. Ørsted develops, constructs, and operates offshore and onshore wind farms, solar farms, energy storage facilities, renewable hydrogen and green fuels facilities, and bioenergy plants. Moreover, Ørsted provides energy products to its customers. Ørsted is the only energy company in the world with a science-based net-zero emissions target as validated by the Science Based Targets initiative (SBTi). Ørsted ranks as the world's most sustainable energy company in Corporate Knights' 2022 index of the Global 100 most sustainable corporations in the world and is recognised on the CDP Climate Change A List as a global leader on climate action.



Mainstream Renewable Power

Mainstream Renewable Power is a leading pure-play renewable energy company, with wind and solar assets across global markets, including in Latin America, Africa, and Asia-Pacific. Mainstream is one of the most successful developers of gigawatt-scale renewables platforms, across onshore wind, offshore wind, and solar power generation. It has successfully delivered 6.5 GW of wind and solar generation assets to financial close-ready. In May 2021, Aker Horizons acquired a 75% equity stake in the company, accelerating its plans to deliver its high-quality pipeline of over 16 gigawatts of clean energy. Mainstream has raised more than EUR3.0bn in project finance to date and employs more than 420 people across five continents.

Global Leaders



GE Renewable Energy

GE Renewable Energy

GE Renewable Energy harnesses the earth's most abundant resources – the strength of the wind, the heat of the sun and the force of water; delivering green electrons to power the world's biggest economies and the most remote communities. With an innovative spirit and an entrepreneurial mindset, we engineer energy products, grid solutions and digital services that create industry-leading value for our customers around the world.



Corio

Corio Generation is a specialist offshore wind business dedicated to harnessing renewable energy worldwide. Our 20+ GW development portfolio is one of the largest in the world, spanning established and emerging markets, as well as floating and fixed-bottom technologies.

With our leading industrial expertise and deep access to long-term capital, we work closely with our partners in the creation and management of projects from origination, development and construction, and into operations.

Corio Generation is a Green Investment Group (GIG) portfolio company, operating on a standalone basis. GIG is a specialist green investor within Macquarie Asset Management, part of Macquarie Group.



Iberdrola

With over 170 years of history behind us, Iberdrola is now a global energy leader, the number one producer of wind power, and one of the world's biggest electricity utilities in terms of market capitalisation. We have brought the energy transition forward two decades to combat climate change and provide a clean, reliable and smart business model, to continue building together each day a healthier, more accessible energy model, based on electricity



Copenhagen Infrastructure Partners

CIP

Founded in 2012, Copenhagen Infrastructure Partners P/S (CIP) today is the world's largest dedicated fund manager within greenfield renewable energy investments and a global leader in offshore wind. The funds managed by CIP focuses on investments in offshore and onshore wind, solar PV, biomass and energy-from-waste, transmission and distribution, reserve capacity, storage, advanced bioenergy, and Power-to-X.

CIP manages ten funds and has to date raised approximately EUR 19 billion for investments in energy and associated infrastructure from more than 140 international institutional investors. CIP has approximately 400 employees and 11 offices around the world.



Vestas

Vestas is the energy industry's global partner on sustainable energy solutions. We design, manufacture, install, and service wind turbines across the globe, and with +151 GW of wind turbines in 86 countries, we have installed more wind power than anyone else.

Through our industry-leading smart data capabilities and +129 GW of wind turbines under service, we use data to interpret, forecast, and exploit wind resources and deliver best-in-class wind power solutions. Together with our customers, Vestas' more than 29,000 employees are bringing the world sustainable energy solutions to power a bright future.



SSE

SSE Renewables is a leading developer and operator of renewable energy, headquartered in the UK and Ireland, with a growing presence internationally. Its strategy is to lead the transition to a net zero future through the world-class development, construction and operation of renewable power assets and it is building more offshore wind energy than any other company in the world. Part of the FTSE-listed SSE plc, SSE Renewables is taking action to double its installed renewable energy capacity to 8GW by 2026 as part of its Net Zero Acceleration Programme, and increase renewables output fivefold to over 50TWh annually by 2031.



Equinor

We are looking for new ways to utilise our expertise in the energy industry, exploring opportunities in new energy and driving innovation in oil and gas around the world. We know that the future has to be low carbon. Our ambition is to be the world's most carbon-efficient oil and gas producer, as well as driving innovation in offshore wind and renewables. We plan to reach an installed net capacity of 12-16 GW from renewables by 2030, two-thirds of this will be from offshore wind. With five decades of ocean engineering and project management expertise, focus on safe and efficient operations, in depth knowledge of the energy markets, skilled personnel and a network of competent partners and suppliers, Equinor is uniquely positioned to take a leading role in the offshore wind industry. From building the world's first floating wind farm to building the world's biggest offshore wind farm we are well underway to deliver profitable growth in renewables to be a leading company in the energy transition.



ReNew

ReNew is the leading decarbonisation solutions company listed on Nasdaq (Nasdaq: RNW, RNWVWW). ReNew's clean energy portfolio of ~13.4 GWs on a gross basis as of December 31, 2022, is one of the largest globally. In addition to being a major independent power producer in India, we provide end-to-end solutions in a just and inclusive manner in the areas of clean energy, green hydrogen, value-added energy offerings through digitalization, storage, and carbon markets that increasingly are integral to addressing climate change.

Leading Sponsor



Supporting Sponsor



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