1. Wind energy's role on the road to net zero

Like a high-resolution satellite image, 2020 offered a sharpened reality of the state of our planet. The COVID-19 pandemic brought greater recognition to the consequences of human development on the natural world, and of the cascading knock-on effects an event can wield on our economies, livelihoods and security.

As policymakers chart the way out of the pandemic, and emissions show signs of returning to pre-pandemic levels in the world's fastest growing economies, there is unprecedented agreement that climate change is the true global emergency. The concept of a runaway threat crippling the entire world is now not only credible, but relatable. This has prompted the UN to underscore the call for urgent action to reach net zero greenhouse gas (GHG) emissions by 2050 – a call which has since been echoed by more than 120 countries representing over half of global GDP, alongside thousands of businesses, investors, cities, regions and universities.[1]

It is worth looking back at a long year in which the global wind industry demonstrated its resilience and its role in green recovery. But the events of 2020 also defined the outlines of what lies ahead: the role of wind energy in a carbon-neutral world.

The pandemic accelerates shifts in the global energy matrix

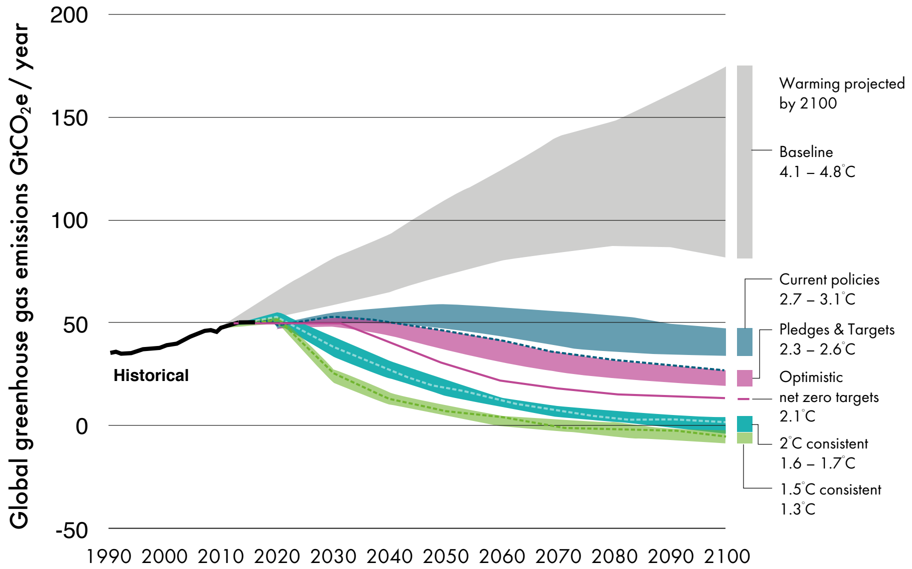
The pandemic cast a long shadow across the world, posing a challenge to economies and to the global wind industry as never before. Its impacts reverberated throughout the wind supply chain, disrupting manufacturing and export flows. From the US to South Africa, projects were hit by delays.

While some impacts were temporary, the pandemic also accelerated energy shifts already in motion. Global energy demand declined by roughly 5% in 2020, according to the IEA, including falls of 8% and 7% for oil and coal demand, respectively.[2] Credit agencies are now expecting global oil demand to continue declining steadily over the next decade; in its most conservative outlook, BP forecasts peak oil demand as soon as 2025.[3] Last year, capex committed to offshore wind overtook investment in offshore oil and gas for the first time.[4]

From the EU to large Japanese trading houses to the world's largest investment funds and development finance institutions, there are calls to phase out coal and the financing of new coal plants. Although coal reduction still lags in parts of Eastern Europe, in 2020 renewables

2100 Warming projections

Emissions and expected warming based on pledges and current policies



Source: Climate Action Tracker, December 2020.

1. https://unfccc.int/climate-action/race-to-zero-campaign; https://eciu.net/analysis/briefings/net-zero/net-zero-the-scorecard#:~:text=Net%20zero%20economies,(World%20Bank%2C%202018)
2. https://www.iea.org/reports/world-energy-outlook-2020
3. https://www.carbonbrief.org/analysis-world-has-already-passed-peak-oil-bp-figures-reveal
4. https://www.tradewindsnews.com/offshore/-51bn-in-wind-farm-capital-spending-outstrips-oil-and-gas-for-first-time/2-1-955552

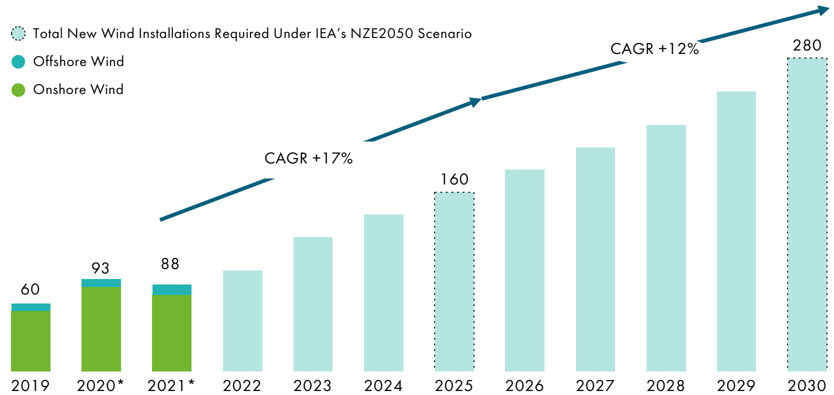
generated more electricity in the EU than fossil fuels for the first time, powered by 14.7GW of new wind plants reaching grid connection.

2020 also saw milestone commitments to carbon neutrality, with the EU, Japan, South Korea, Canada and South Africa each pledging to reach net zero by 2050. Combined with China's net zero by 2060 target and the US intention to reach net zero by 2050 under the Biden administration, countries which have adopted or considered net zero targets now represent two-thirds of the global economy and 63% of global GHG emissions.[5]

These are no longer just market trends, at least in the sense of cyclical movements. It is clearer than ever that the era of fossil fuels is over, and the global energy transition is here to stay. 2020 presented a once-in-a-generation opportunity to reset human development. **The question is whether we can turn the newfound sense of optimism and urgency into accelerated implementation and deliver the transition in time.** 2021 must be the time to turn long-horizon net zero roadmaps into actions, via concrete policy interventions, interim target-setting and robust delivery plans. Otherwise, even in the most optimistic scenarios, we will miss our Paris targets.

Annual wind installations must increase dramatically to reach net zero by 2050

New global wind installations (GW)



Source: GWEC Market Intelligence; IEA World Energy Outlook (2020), volume in 2022-2024 and 2026-2029 are estimates

Wind energy's role in achieving net zero

One year on from the beginning of the pandemic, the wind industry has demonstrated incredible resilience. In Q2 2020, GWEC Market Intelligence was predicting a 20-30% reduction to the end-of-year forecast. But the industry more than bounced back to deliver a record year of growth with 93 GW, largely spurred by installations in China. Investment in offshore wind surpassed 2019 levels to reach US$303 billion in 2020, partly due to the sector's longer project development timelines which are more resilient to the pandemic impacts.[6]

While jobs have been lost and projects delayed, the global wind industry defied expectations and is set to continue growing at a steady pace. Before 2025, the industry will exceed 1TW in global cumulative installations of onshore and offshore wind, according to GWEC Market Intelligence.

Cost reduction from larger turbines, innovations in installation/O&M and reduced investor risk will further drive deployment: Out to 2030, IRENA expects average LCOE of onshore wind to continue declining by 25% from 2018 levels, while offshore wind LCOE will shrink 55% from 2018.[7]

But accelerated growth of wind and renewable energy is required to "bend the curve" and put us on a trajectory which can limit global warming to "well below" 2°C, as set out in the Paris Agreement. Current policies are propelling us towards a 2.9°C pathway by 2100. If all pledges and NDCs as of December 2020 were implemented, we might reach 2.1°C and will miss a net zero by 2050 target.

With a few exceptions, the energy sector, which makes up around three-quarters of global GHG emissions, is characterised by long investment and development timelines – an accelerated pace for change must be set now. Every year we fall short of the dramatic action needed to change our pathway

5. http://www3.weforum.org/docs/WEF_Net_Zero_Challenge_The_Supply_Chain_Opportunity_2021.pdf; https://climateactiontracker.org/publications/global-update-paris-agreement-turning-point/
6. https://webcache.googleusercontent.com/search?q=cache:SJo8SyYNV5cJ:https://www.windpowermonthly.com/article/1704954/offshore-wind-spending-reaches-record-high-2020+&cd=1&hl=en&ct=clnk&gl=uk
7. https://www.irena.org/publications/2020/Apr/Global-Renewables-Outlook-2020

deepens the decarbonisation cuts required in years to come,

and locks in the devastating burdens of climate change for future generations.

To have a chance of meeting the Paris targets, fossil fuel-based capacity needs to be phased out concurrent to an increasingly steep expansion of renewables and related infrastructure. For wind, annual deployment must surge to around 180 GW, according to IRENA's Transforming Energy Scenario. Under the IEA's Net Zero by 2050 scenario, annual run rates for wind would need to be even steeper, reaching 160 GW by 2025 and then 280 GW by 2030 – 3 times the volume built in 2020.

Over the next 10 years, international institutions are calling for profound system transformation to take place. The UN Race for Zero has pegged the tipping point in the clean power sector as reaching a 60% renewable energy share in the global power mix, including 30% from wind and solar power. Total annual global investment in clean power and enabling system infrastructure needs to rise from US$380 billion in 2020 to $1.6 trillion by 2030, according to the IEA.

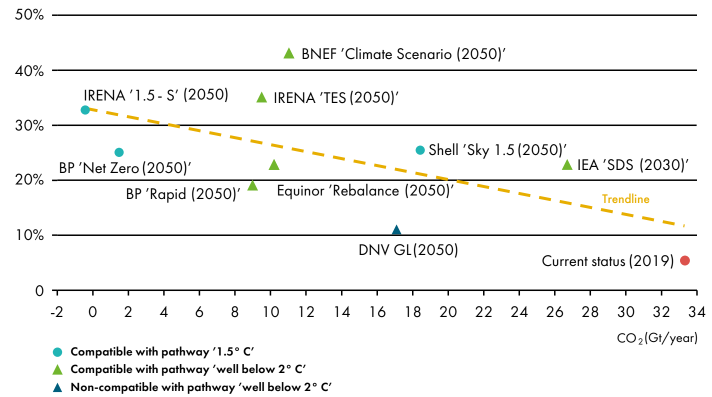
Wind energy in long-term energy scenarios

GWEC Market Intelligence analysed different long term energy scenarios (LTES) to map the role of wind energy in the global energy transition and, eventually, carbon neutrality. Selection of LTES was based on compatibility with Paris Agreement targets for a 1.5°C pathway by end-of-century and the recent UN goal to reach net zero emissions by 2050. Not all scenarios extended to 2050 (year of the forecast is indicated in parentheses on the graphs), and each depends on a unique set of system transformations, technology innovations and behavioural changes.

Institutional and commercial LTES call for higher shares of wind energy in the total power mix due to its stable generation profile – 43% in the case of BNEF's scenario and 35% in the case of IRENA's Transforming Energy Scenario – paired with widescale electrification measures for system-wide decarbonisation. The general trendline reflects that wind energy must rise from today's roughly 6% share of the global power mix to more than 30% by 2050, to achieve proximity to a pathway well below 2°C.

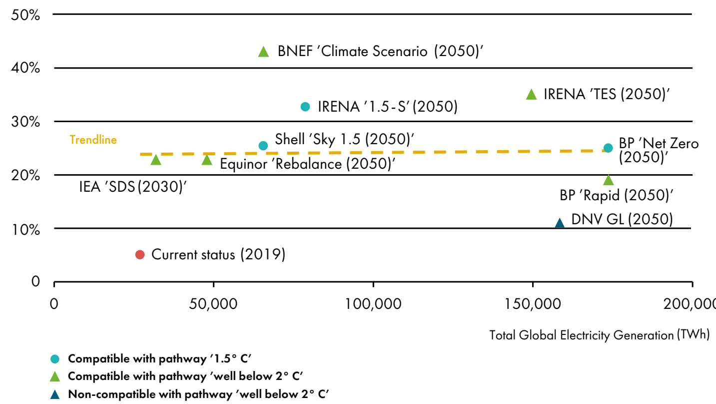
LTES diverge when it comes to the scale of electrification for a Paris-compliant pathway. The scenarios with higher rates of global electricity generation (BNEF, IRENA and BP) emphasise both higher shares of wind and renewable energy

Share of wind energy (%) in total global electricity mix versus global energy-related CO2 emissions



Note: (20XX) indicates the year of projected scenario
Sources: BNEF New Energy Outlook 2020; IRENA Global Renewables Outlook 2020; IEA World Energy Outlook 2020 (Sustainable Development Scenario); BP Energy Outlook 2020; Equinor Energy Perspective 2020; DNV GL Energy Transition Outlook 2020; IRENA World Energy Transitions Outlook preview 2021(Data of 'Wind share in total glo electricity generation' is an estimate, page no. 19); Shell-Energy Transformation Scenarios, February 2021.
Further LTES are mapped out in the report: IRENA (2020), Global Renewables Outlook: Energy transformation 2050.

Share of wind energy (%) in total global electricity mix versus total electricity generation



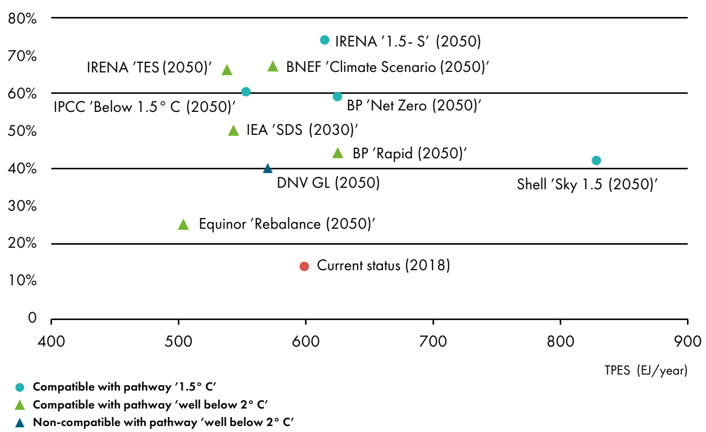
Note: (20XX) indicates the year of projected scenario
Sources: BNEF New Energy Outlook 2020; IRENA Global Renewables Outlook 2020; IEA World Energy Outlook 2020 (Sustainable Development Scenario); BP Energy Outlook 2020; Equinor Energy Perspective 2020; DNV GL Energy Transition Outlook 2020; IRENA World Energy Transitions Outlook preview 2021(Data of 'Wind share in total glo electricity generation' is an estimate, page no. 19); Shell-Energy Transformation Scenarios, February 2021.
Further LTES are mapped out in the report: IRENA (2020), Global Renewables Outlook: Energy transformation 2050.

combined with green hydrogen and Power-to-X solutions to meet final energy consumption needs.

Outside of electrification rates, LTES are aligned in calling for a rapid acceleration of wind energy deployment alongside improvements in energy efficiency, demand-side flexibility and sector coupling for a clean, resilient and secure energy system. This convergence of different policies is reflected in the graph below, where most scenarios which are 1.5°C-compatible and closer to net zero by 2050 call for at least a 60% share of renewable energy in the total primary energy supply. Scenarios are also aligning around a bandwidth of 500-650 EJ/year, requiring a degree of structural and behavioural changes to reduce energy demand.

As of the end of 2020, 127 countries covering 63% of global GHG emissions have expressed or are considering net zero goals. This balance of measures in these LTES can be instructive for national long-term energy planners, particularly as they align policies with net zero targets. The backdrop of major LTES comprises large-scale renewable energy penetration for onshore wind, offshore wind and solar energy, widescale electrification, energy efficiency measures and the deployment of technological innovations like Power-to-X and green hydrogen for storage and system flexibility.

Share of renewable energy (%) in total primary energy supply



Note: (20XX) indicates the year of projected scenario

Sources: BNEF New Energy Outlook 2020; IRENA Global Renewables Outlook 2020; IEA World Energy Outlook 2020 (Sustainable Development Scenario); BP Energy Outlook 2020; Equinor Energy Perspective 2020; DNV GL Energy Transition Outlook 2020; IRENA World Energy Transitions Outlook preview 2021(Data of 'Wind share in total glo electricity generation' is an estimate, page no. 19); Shell-Energy Transformation Scenarios, February 2021.
Further LTES are mapped out in the report: IRENA (2020), Global Renewables Outlook: Energy transformation 2050.

The backdrop of most energy transition scenarios combines large-scale renewable energy generation, widescale electrification (particularly in the power, industry and short-distance transport sectors) and energy efficiency measures. A mix of innovative technologies, from green hydrogen to digitalisation and storage solutions, will be required to enable high rates of renewables penetration, adequate security and flexibility of the power system and decarbonisation of hard-to-abate sectors. These scenarios require decarbonisation of molecules, not just electrons.

Can we more than treble the volume of wind energy projects being installed worldwide over the next 10 years? Onshore wind is already a mature and mainstream energy source which is cost-competitive with new coal/gas plants and, in many markets, undercuts the operating costs of fully depreciated conventional generation assets.[10] There is expanding recognition of the economic growth, job creation, water consumption savings and health cost savings attached to wind energy. Meanwhile, initiatives like the UN-linked Ocean Panel and Ocean Renewable Energy Action Coalition have highlighted offshore wind as a vital technology which will provide 10% of the needed carbon mitigation by 2050 for a 1.5°C pathway.[11]

But in practical terms, the scale of build envisioned by 2030 means that actions to set the global wind industry on this path need to be taken now, given the time required for policy commitments to materialise, project development, financing decisions and more. Increasing capacity for wind and renewables will also require urgent forward-planning of infrastructure and grid buildout, as well as investment in storage technologies and demand-side management.

Even a concentrated sprint of action in the run-up to COP26 in November 2021 will not be enough to win the race to net zero. To bend the curve, policymakers must adopt the principle of continuous improvement in line with the "ratchet mechanism" of the Paris Agreement, and continue to push for higher ambitions at regular intervals.

10. https://www.irena.org/publications/2020/Jun/Renewable-Power-Costs-in-2019
11. https://oceanpanel.org/sites/default/files/2019-10/HLP_Report_Ocean_Solution_Climate_Change_final.pdf

Working together to accelerate wind energy deployment
In every major institutional scenario for energy system transformation, the wind market must rapidly expand over the next decade. The industry must be resoundingly clear that this growth will not happen spontaneously and requires urgent policy interventions worldwide.

A "climate emergency" approach to act now

As with wartime-era measures, the experience in 2020 demonstrated the mandate for governments to act in a crisis and free up bandwidth for public institutions. As we freewheel forwards on an "off-track" pathway to 2050, governments should similarly react to convene resources to radically scale up the deployment of renewable energy. Among other measures, this could entail:

- Committing to ambitious capacity targets for wind energy which increase over time;
- Granting "must-run" status, priority dispatch and priority grid connection to wind and renewable projects;
- Categorising wind projects as nationally significant and critical infrastructure, with improvements to streamline permitting and simplify license applications;
- Investing in long-term grid and transmission planning and infrastructure;
- Safeguarding existing and awarded wind projects, and avoiding retroactive changes to approved remuneration schemes;
- Enabling open-access regulation for a bilateral market of renewable energy;
- Creating policy frameworks for repowering of older wind plants in mature wind markets;
- Accelerating net zero commitments, carbon budgets, carbon pricing and science-based approaches among government bodies, and sense-checking reliance on CO_2 removal technologies in net zero plans; and
- Creating frameworks for a just transition, including ending direct and indirect subsidies for fossil fuel plants, providing fair compensation for early retirement of conventional assets and redirecting subsidies into worker training funds and diversity strategies for workforce development.

Policy and regulation provide the signals to the private sector for action and investment, allowing for economical decision-making. Making benefits and consequences clear to businesses, via "pull" signals like targets and "push" signals like taxes, will allow business to reorganise in line with a carbon-neutral pathway.

The last year has demonstrated that investment in the wind industry is plentiful. **The pandemic has tipped the scales, irreversibly, for private investment in clean energy.** In the first half of 2020 alone, while overall investment in power generation slumped, offshore wind financing quadrupled compared to the same period in 2019, reaching US$35 billion.[12] Retail and institutional investors increasingly view clean energy as a safe harbour. Major utilities like Engie, Enel Green Power, Iberdrola, TEPCO and KEPCO have been future-proofing their balance sheets by increasing investment in clean energy assets and avoiding the risk of stranded assets.

The challenge will be deploying capital into bankable wind projects at a sufficient rhythm to accelerate annual installations to the near-200 GW level. In 2020, there were more credit rating downgrades for emerging markets and developing countries than in all previous economic crises over the last 40 years.[13] For emerging economies, the pandemic has raised the spectre of higher financing costs, due to increased fiscal pressure on the balance sheets of public utilities and grid operators, as well as higher regulatory, currency and counterparty risks.

Greater coordination is needed to de-risk climate and renewable energy finance in emerging economies. Temporary debt suspension by actors like the G20 and IMF will not be enough. Governments should work together with multilateral development banks (MDBs), development finance institutions (DFIs) and the financial sector to create financing mechanisms

12. https://www.theguardian.com/environment/2020/jul/13/offshore-wind-energy-investment-quadruples-despite-covid-19-slump
13. https://www.bu.edu/gdp/files/2020/11/DRGR-report-Jan-2021.pdf

Photo Credit: Equinor

which build on the strong economics of wind energy, record-low global interest rates and the availability of low-cost funding for renewables and storage capacity.[14]

Such mechanisms could be developed with an "emergency" or "rapid response" approach to quickly move to supporting emerging economies and redirect private financial flows to climate change mitigation solutions like wind energy.

Case Study: Optimising wind plant performance

Provided by: WindESCo

Optimisation is playing an increasingly important role in the growth of wind energy and enabling energy transition. WindESCo provides solutions to help owners and operators maximize their assets' performance, energy production and reliability to unlock hidden value and promote a carbon-free energy future. WindESCo's mission is ensuring that every turbine produces its maximum energy output and operates reliably beyond its intended lifetime, a critical step on the journey to Net Zero.

About the Project

WindESCo was engaged by UPC Renewables to optimize 79 MW of in-warranty turbines under an OEM full-service agreement (FSA). The Sidrap Wind Farm, located in Indonesia, is operated by UPC Renewables, the leading independent power producer (IPP) in Asia-Pacific. Globally, UPC has 4,500 MW of installed capacity.

In 2019, UPC Renewables' new 30 tower wind plant was generating less-than-expected revenues compared to pre-construction estimates. The wind plant was not meeting its P50 projection and turbines were failing their power curve tests. No solution was being offered by the OEM to address the issues and increase production.

Scalable Solutions

UPC Renewables sought a cost-effective, scalable solution that would provide immediate ROI. WindESCo offers a comprehensive wind farm AEP improvement software which leverages SCADA data to increase AEP between 1–7%. The WindESCo solution required no hardware be installed at the site and provides analytics beyond existing asset monitoring platforms. Throughout the process the two companies worked closely to determine optimised parameters, verify that they were implemented correctly, and calculate the gains in energy output.

After collecting enough data, the WindESCo team performed analytics consisting of proprietary SCADA data checks. Three checks came out as requiring further investigation. Working with UPC Renewables, WindESCo determined that addressing Static Yaw Misalignment would provide the best short-term value. Two additional recommendations were identified for further improvement.

Out of 30 turbines, WindESCo determined that 27 were experiencing greater than 2° of static yaw misalignment and needed correction. The company worked with UPC Renewables to implement recommendations, and to confirm the recommended offsets were implemented correctly.

Measurable Results

In just a few months, WindESCo was able to optimize plant output, an endeavor that would have taken over a year with other technologies. The insights gained through WindESCo's solutions directly resulted in a 2% increase in AEP for the project.

The impact to the bottom line? An increase of $5,700/MW/Yr for a total benefit of $450,000/Yr. All without invalidating UPC Renewables' FSA and Warranty with the OEM.

From hydrocarbons to electrons

The central logic of the road to net zero will be to electrify everything we can in line with a cost-optimal clean energy transition. Widescale direct electrification can leverage existing technologies, with wind and renewable energy dispatched to power homes, industry, short-distance transport and the infrastructure of our cities. With more stable generation profiles, offshore wind, hybrid projects and virtual renewable power plants can provide strong complementarity to the continuous power demands of the industry and buildings sectors.

Electrification will itself compound the demand for green power, as the market incentives to decarbonise (e.g. carbon caps and border adjustment taxes) and to electrify (e.g. electric vehicle subsidies and electrification of industrial processes, such as heat generation for petrochemical cracking) will aggregate the demand for data analytics, cloud-based storage and machine communication.

14. https://www.weforum.org/agenda/2021/01/how-to-accelerate-the-energy-transition-in-developing-economies

For the wind industry, the advancement of cyber-physical networks will enable smarter and more efficient grids, greater transparency in how we consume and stronger civic engagement. The expansion of an "Internet of Things" will mean more assets along the value chain will become connected devices to be monitored in real-time and optimised for performance.

Current applications range from intelligent factory cranes to remote monitoring of wind turbines by autonomous devices. A pilot project for predictive analytics has already enabled wind turbines to supply the Danish system operator with balancing reserves at the end of 2020, paving the way for more flexible grid systems with large-scale renewables integration.[15]

Complementary technologies for energy flexibility

With higher capacity factors compared to other renewable energy sources, **onshore and particularly offshore wind provide greater energy reliability to emerging markets where power demand is growing,** especially if aggregated over large geographical areas. IRENA forecasts global weighted average capacity factors for onshore wind will increase to 32-58% by 2050 and to 43-60% by 2050 for offshore wind.[16] The world's first floating wind farm, the Hywind Scotland project in the North Sea, already achieved 56% capacity factors in its first two years of operation.[17]

Large-scale wind penetration will require balancing and storage technologies to maintain a cost-effective and secure transition. Hybrid renewable tenders with wind, solar and battery elements are now picking up around the world, from India's Round-the-Clock tenders to Germany's "innovation auctions". **But storage technologies will need to be competitive and scalable to disincentivise support of polluting and inflexible energy systems.**

This will be particularly critical for accelerating renewables in markets with weaker grids, which already face challenges in voltage and disruptions from extreme

Case study: Advanced monitoring systems to bring down costs

Provided by: Bonfiglioli

Bonfiglioli's products are continuously optimised to improve wind turbine performance for both offshore and onshore applications, with a strong focus on size and weight optimisation. With a market share of over 35% in wind turbine yaw and pitch drives and supplies to leading worldwide wind turbine OEMs, Bonfiglioli is a leader in advanced solutions for the wind industry. Its team of experts creates, designs and produces advanced solutions to deliver tailor-made solutions, predominantly led by a constant focus on LCOE reduction from both a direct and indirect standpoint.

LCOE indirect reduction is sought after through an evolving condition monitoring system that enables customers to maximise productivity and return on investment. Product reliability is undoubtedly an important parameter, but so is the ability to constantly check the health of the system and to plan maintenance operations. Bonfiglioli provides an IOT range that includes sensors on the gearbox and motor and an edge computer capable of conveying data and information to the customer's and/or Bonfiglioli's cloud, when a wireless connection is available.

All information relating to the RUL (Residual Useful Life), the operating conditions of the main components of products and any malfunction is obtained through algorithms that take into account fundamental aspects such as speed, temperature, relative humidity, operating torque and operating vibrations along the entire spectrum of frequencies. This allows the operating conditions of critical components to be constantly monitored in real time and to prevent unexpected downtimes by optimising maintenance interventions, particularly relevant for offshore wind applications where early fault detection is critical.

Already well accustomed to working with APQP methodology, specialising in APQP4Wind represents a distinctive element for the next generation of Wind products at the highest levels of quality, with a standardised approach.

With a unique global footprint, Bonfiglioli can guarantee the manufacture of local components to ensure a flexible and reactive supply chain. Ultimately a strong and global operation set up guarantees the right focus towards adopting a common culture regarding the Lean concept at global level.

15. https://en.energinet.dk/About-our-news/News/2020/12/16/Milestone-Wind-turbines-can-balance-the-electricity-grid
16. https://irena.org/-/media/Files/IRENA/Agency/Publication/2019/Oct/IRENA_Future_of_wind_2019_summ_EN.PDF
17. https://www.equinor.com/en/news/2019-11-28-hywind-scotland-data.html

weather events. Cost-effective storage solutions will be needed for grid resilience. Batteries are increasingly affordable for short-duration application; since 2010, prices have declined by two-thirds for stationary application (such as grid management) and by 90% for lithium-ion batteries in electric vehicles.[18]

System transformation will also require long-duration storage solutions (see: Enabling technology: Power-to-X and green hydrogen). A recent study of California's grid decarbonisation found that it would require up to 55 GW of long-duration storage by 2045 - more than 150 times the state's current storage capacity.[19]

For the hard-to-abate sectors, such as steel production, chemicals, aviation, maritime shipping and other forms of long-haul transport, there are higher barriers to electrification. Investment in energy carrier technology will be required, including in an efficient, versatile and scalable storage solution like green hydrogen.

Green hydrogen is increasingly a jewel in the crown of national climate action policies, after decades of failing to take off due to barriers in production costs, transport, demand and competitiveness in the transport sector. At least 13 countries have a national hydrogen strategy in place, and dozens more are considering one or have supported hydrogen projects.

Back in 2016, the Electricity Generating Authority of Thailand announced its 22 MW Lam Takhong wind project with a 1 MW electrolyser to provide 10 hours of clean energy supply to a local building. Now, there are numerous examples of green hydrogen projects under development, from NortH2 in Europe to Saudi Arabia's Neom city.

According to IRENA, around 95% of hydrogen production today is based on methane gas and coal.[20] Future deployment of hydrogen must prioritise green hydrogen. Its production is already technically viable, and will require investment, learning curves and further deployment to reduce the costs of electrolysers and supply chain logistics. Concurrently, the scaling-up of renewable energy capacity in proximity to hydrogen plants will support hydrogen's pathway to cost-competitiveness.

Pushing carbon-intensive assets off the grid

Looking ahead to COP26, one of the key set-pieces for the international negotiations will be the agreement of an effective global carbon tax mechanism. This will provide a crucial "push" factor to fossil fuels-dependent markets, going beyond current carbon trading schemes which allow entities to pay to continue emitting carbon. It will also send a strong signal on the urgency of emissions reductions – while net emissions continue to rise annually, the UN has stated that emissions need to rapidly decline by 7.6% annually from 2020 to 2030 to meet Paris Agreement targets.[21]

Case studies provide evidence for the effectiveness of carbon pricing, from the UK's "carbon price floor" for fossil fuels generators to the

18. https://www.iea.org/news/a-rapid-rise-in-battery-innovation-is-playing-a-key-role-in-clean-energy-transitions
19. https://static1.squarespace.com/static/5b96538250a54f9cd7751faa/t/5fcf9815caa95a391e73d053/1607440419530/LDES_CA_12.08.2020.pdf
20. file:///C:/Users/joyce/Downloads/IRENA_Green_hydrogen_cost_2020.pdf
21. https://unfccc.int/news/cut-global-emissions-by-76-percent-every-year-for-next-decade-to-meet-15degc-paris-target-un-report

reformed Emissions Trading Scheme (ETS) in the EU. China's newly launched national ETS will be an important step on its road to carbon neutrality and is set to become the world's largest emissions management scheme, with more than 2,200 power generators participating.

There are several challenges around gaining consensus on a global carbon tax, relating to carbon inequities between developing and developed countries, tax at the point of consumption versus production, allocation of revenues and appropriate pricing strategies. According to the IMF, a scheme needs to begin with initially low prices (US$6-20/ton) and then rapidly increase on an annual basis to reach US$40-150/ton by 2050.[22]

At the same time, there is mounting agreement that fossil fuels are immensely under-priced when it comes to the costs of production, air pollution, global warming and environmental impact. A global carbon tax can provide a significant lever to adequately price emissions, incentivise renewables uptake and redirect revenues into green funds for societal benefit.

Potential pinch points on growth in the decade ahead

Looking beyond the urgent policy interventions needed in the next few years, there are several other challenges on the horizon.

Addressing structural barriers in the Global South

The energy transition will adopt a different rhythm and form in every country. But many countries share similar challenges in market design, where investment in wind energy is available but policy conditions undermine the viability of projects. Wind and solar energy already became the cheapest energy options for two-thirds of the global population by the end of the last decade – for these areas, the issues centre on clearing market barriers to get projects through the development pipeline to grid connection.[23]

For the rest of the world, primarily countries in the Global South, renewable energy uptake faces structural barriers, such as energy access shortfalls and affordability gaps in the power sector. Worldwide, 770 million people still lack electricity access, and this is set to shrink only moderately to 430 million people by 2030, with concentration in sub-Saharan Africa and South Asia.[24] The economics of renewable energy, especially for utility-scale wind projects, are tougher in areas with limited customers on the grid.

> A dramatic scale-up of wind energy will require international cooperation on grid infrastructure and cross-border interconnection, sustainable land and ocean management, technical standards, supply chain regulation, environmental protection and more.

While decentralised renewable solutions have been the least-cost response to date, an equitable energy transition will require systemic change. Expanding renewable energy in areas lacking power calls for long-term political economy planning, strong regulation of the power sector, innovative financing models to incentivise private investment in renewables and redirection of fossil fuels subsidies to electricity networks and clean energy assets.

An evolving global supply chain

As the wind market expands to new markets, the supply chain continues to evolve. The number of wind turbine suppliers has declined from 63 OEMs in 2013 to 33 OEMs in 2019, according to GWEC Market Intelligence. The top six turbine suppliers now control nearly three-quarters of the global market. More than half of the turbines installed in 2019 were in the Asia-Pacific region, strengthening the existing export hubs of China and India, and giving rise to new suppliers as East Asia and South East Asia markets build their offshore wind capacity.

Similar market consolidation is seen in the gearbox segment, where less than half of suppliers operational eight years ago remain active. In blades, the number of independent and SME suppliers has dwindled due to inability to compete on cost,

22. https://www.imf.org/-/media/Files/Publications/WEO/2020/October/English/ch3.ashx
23. https://www.bloomberg.com/news/articles/2019-08-27/solar-wind-provide-cheapest-power-for-two-thirds-of-globe-map
24. https://www.iea.org/reports/sdg7-data-and-projections/access-to-electricity; https://www.irena.org/newsroom/articles/2019/Dec/SDG-7-Win-Win-for-Ending-Energy-Poverty-and-Protecting-the-Climate

R&D investment and market coverage. As a result, 10 blade producers account for 80% of the total global blade supply today.

The heightened competition for terrain, rare earths and technology ahead raises the risk of price volatility and trade tensions. This can slow down cost reduction and learning curves for the wind industry, while inflating project capex. Concurrently, tariffs and protectionism are now heating up around sectors like battery manufacturing – which need to grow at pace to support the energy transition.

What does political agreement on net zero look like?

A dramatic scale-up of wind energy will require international cooperation on grid infrastructure and cross-border interconnection, sustainable land and ocean management, technical standards, supply chain regulation, environmental protection and more. While the COP process provides a framework for cooperation, much of the multilateral alignment required for the energy transition lies outside the scope of existing mechanisms.

The fuel for this cooperation will be recognition of common aims and mutual benefits. Take grid: Integrated electricity systems are not only a means for countries with low resource potential or system flexibility to gain access to clean energy; they are also a potential revenue stream for countries with significant resource, where the dividends from cross-border power trading can be re-invested for social value creation, such as in public health or education. The EU currently has at least 82 interconnectors across 22 borders, and grid integration is also strong in regions like Central America.[25] In other regions where clean energy demand is on the rise, like South East Asia, interconnection is still in the feasibility stage.

It remains to be seen whether the global expansion of renewable energy will result in greater self-sufficiency and trust-building among states or heightened vulnerabilities and competition. The former could unite a global alliance around the ideals of carbon neutrality, while the latter could yield a realpolitik of transactional cooperation which slows down the transition.

Conclusion

As a mainstream energy source in many parts of the world and in all major energy transition scenarios, wind energy has a responsibility to chart a clear path through the choppy waters ahead. This will require a unified voice on issues of global significance, from carbon pricing to market design, from just transition to circular economy. This also means strong representation in the evolving debate on the nature of energy security.

Wind energy will power the road to net zero, but to get there by mid-century requires credible and intensified efforts in the run-up to COP26 and ahead of the next deadline of NDCs in 2025. As a priority in the near term, the wind industry must work in tandem with its collaborators in the energy transition to increase national ambitions for renewables and raise awareness of their cross-cutting benefits for economies and people.

2021 has begun with lofty expectations, marking the start of the UN Decade of Action and the Decade of Ocean Science for Sustainable Development. It also marks the beginning of the decade which will determine whether we can reach net zero by 2050.

25. https://ec.europa.eu/energy/sites/ener/files/documents/2nd_report_ic_with_neighbouring_countries_b5.pdf