ELETTRICITÀ FUTURA
imprese elettriche italiane

Technology Watch

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Technology Watch is the Elettricità Futura initiative to monitor global technology trends having the power sector at their heart. In our quarterly newsletter you will find an article with our analysis on a specific technology trends, a contribution by one of our partners and technology news from all over the world selected by Elettricità Futura.

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- **The Insight** – Wind Energy: history and technology trends
- **The Special Issue** – WindEurope: Research & Innovation driving the clean energy transition
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The Insight

Wind Energy: history and technology trends

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History

The use of wind energy has been known for thousands of years. People used wind energy to propel boats along the Nile River as early as 5,000 BC. By 200 BC, simple wind-powered water pumps were used in China, and windmills with woven-reed blades were grinding grain in Persia and the Middle East [1].

New ways to use wind energy eventually spread around the world. By the 11th century, people in the Middle East were using wind pumps and windmills extensively for food production. Merchants and the Crusaders brought wind technology to Europe. The Dutch developed large wind pumps to drain lakes and marshes in the Rhine River Delta. Immigrants from Europe eventually took wind energy technology to the Western Hemisphere [1].

The traditional windmills are still recognisable landmarks in The Netherlands and in many other areas around the world [2].

Figure 1 - Windmill in Utrecht, The Netherlands [2]

Focussing our attention to the modern wind energy industry in Europe [3], this started in the early 80’s with one of the first wind turbines produced and demonstrated in 1982, a 22 kW Bonus model. The first European wind farm (5 x 20 kW turbines) was installed and operated on the Greek island of Kythnos the same year. Wind turbines power and industrial capacity started to ramp up and in the following few years in Europe [3]. In 1991, the world’s first offshore wind farm was built in Denmark [3].

Figure 2 - One of the first wind turbines made in Europe – a 22 kW Bonus model, 1982 [3]

Figure 3 – Vindeby in Denmark as the world’s first offshore wind farm, 1991 [3]

Technology development went on at a very fast pace in the following years. A major milestone for offshore wind technologies was the entry into service of the world’s first full-scale floating wind turbine in the North Sea i.e. Hywind (2.3 MW).

Today, nominal power of wind turbines and their dimensions are increasing, with power exceeding 10 MW and blade length exceeding 100 m. For instance, LM Wind produced 107 m blades as part of the rotor of GE’s

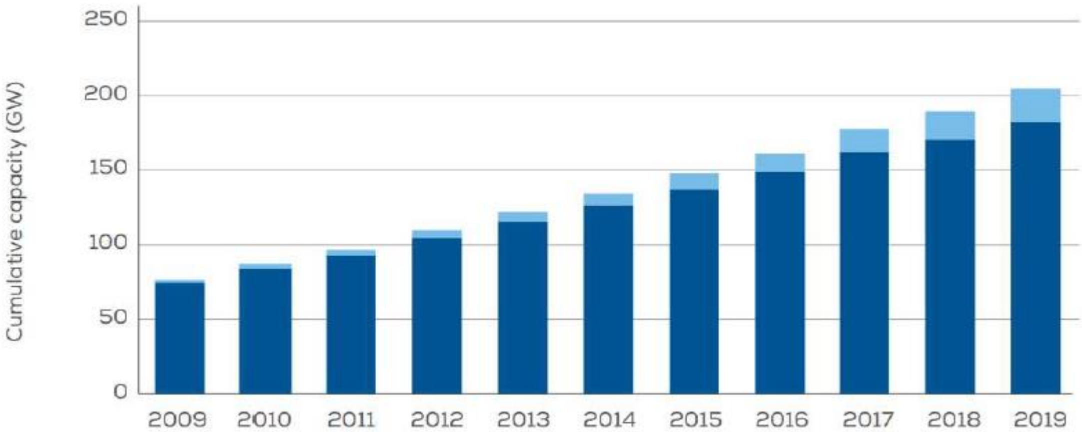
Haliade-X 12 MW turbine, updating the record for the world's largest and most powerful offshore wind turbine, capable of powering 16,000 European homes [4].

Figure 4 – 107 m long LM Wind blade for GE's Haliade-X 12 MW turbine, 2019 [4]

Wind Energy in Figures

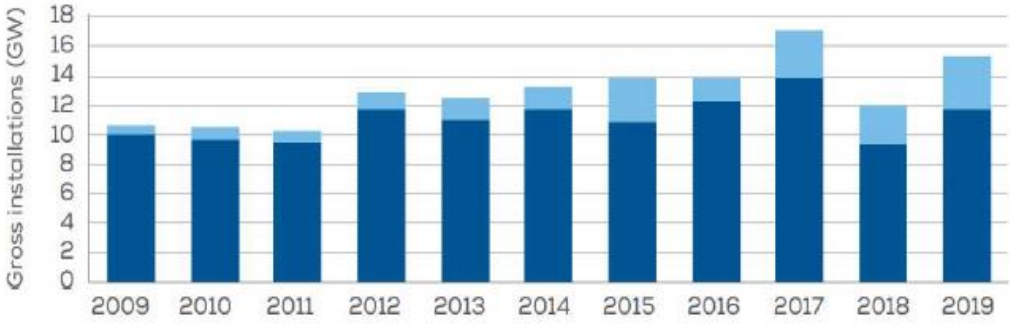
According to IRENA, wind power is one of the fastest-growing renewable energy technologies. Usage is on the rise worldwide, in part because costs are falling. Global installed wind-generation capacity onshore and offshore has increased by a factor of almost 75 in the past two decades, jumping from 7.5 gigawatts (GW) in 1997 to some 564 GW by 2018. In 2019, the overall capacity exceeded 600 GW.

In Europe, the cumulative wind capacity in 2019 was 205 GW (so almost one third of the global wind capacity), with 89% being onshore. Year 2019 was also the second-best year in terms of installations with 15.4 GW (11.7 GW onshore) after the record year 2017.



	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Offshore	2	3	4	5	7	8	11	13	16	18	22
Onshore	75	84	93	105	115	127	137	149	162	171	183
Total	**77**	**87**	**97**	**110**	**122**	**135**	**148**	**162**	**178**	**189**	**205**

Figure 5 – Cumulative Wind Capacity installed in Europe updated to 2019 [6]

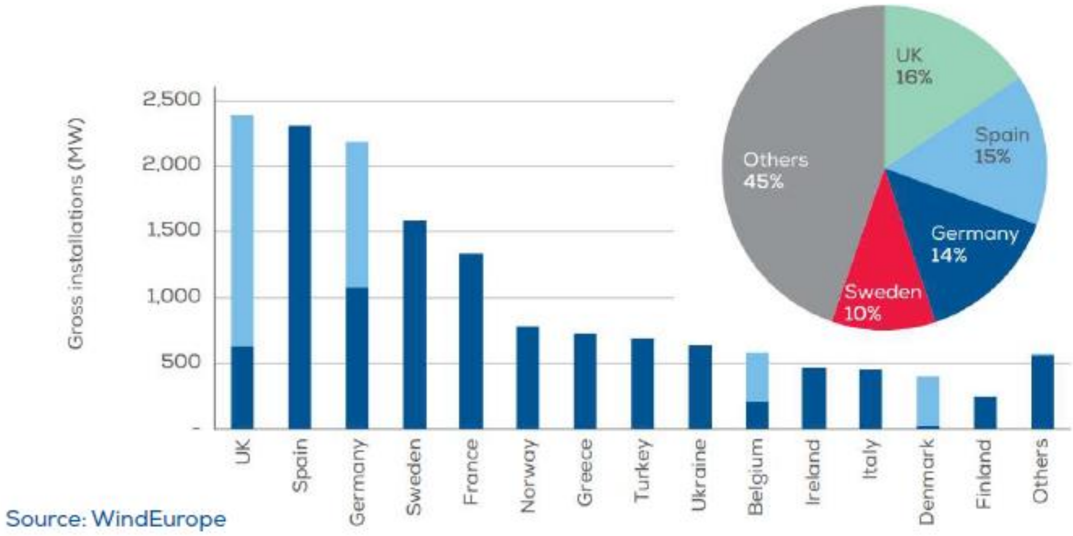


	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Offshore	0.6	0.9	0.8	1.2	1.5	1.5	3.0	1.6	3.2	2.7	3.6
Onshore	10.0	9.6	9.5	11.7	11.0	11.7	10.9	12.3	13.9	9.4	11.7
Total	**10.7**	**10.5**	**10.3**	**12.9**	**12.5**	**13.3**	**13.9**	**13.8**	**17.1**	**12.1**	**15.4**

Source: WindEurope

Figure 6 – Wind Capacity installed in Europe yearly updated to 2019 [6]

Over one half of the installed capacity in Europe in 2019 came from 4 countries (UK, Spain, Germany and Sweden) [6]. On average, 15% of the electricity demand in Europe in 2019 was covered by wind [6]



MW	UK	Spain	Germany	Sweden	France	Norway	Greece	Turkey	Ukraine	Belgium	Ireland	Italy	Denmark	Finland	Others
Offshore	1,764	-	1,111	-	-	-	-	-	-	370	-	-	374	-	8
Onshore	629	2,319	1,078	1,588	1,336	780	727	686	637	207	463	456	28	243	563
Total	**2,393**	**2,319**	**2,189**	**1,588**	**1,336**	**780**	**727**	**686**	**637**	**577**	**463**	**456**	**402**	**243**	**571**

Figure 7 – Wind Capacity installed in Europe yearly updated to 2019 [6]

Concerning Italy, wind energy has seen a significant increase going from 874 MW in 2003 to 10.8 GW in 2019 according to Elettricità Futura's elaborations based on Terna and GSE data. Most of the wind capacity is in Southern Italy, also due to the favourable wind characteristics.

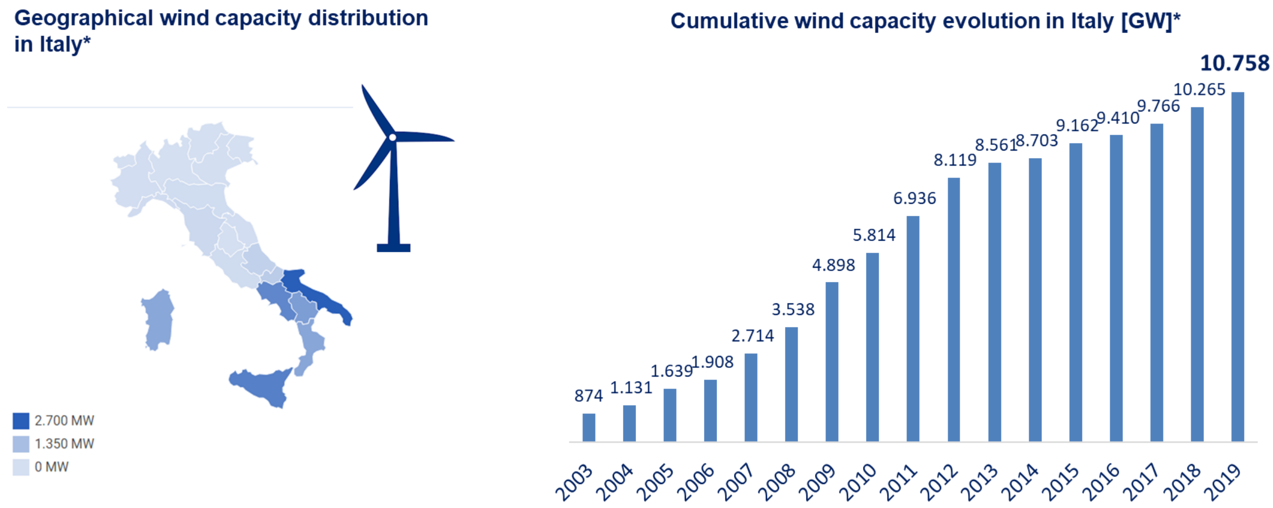


Figure 8 – Cumulative Wind Capacity installed in Italy updated to 2019 [6]

Looking at the future, Europe could install 90 GW of new wind energy capacity between 2019 and 2023 if governments adopt clear and ambitious National Energy & Climate Plans (NECPs), resolve their current issues around wind farm permitting and continue investing in grid infrastructure according to WindEurope [7]. However, if the NECPs are unambitious and permitting issues remain unresolved, then Europe will install much less new wind power: only 67 GW, 26% less than in WindEurope's Central Scenario.

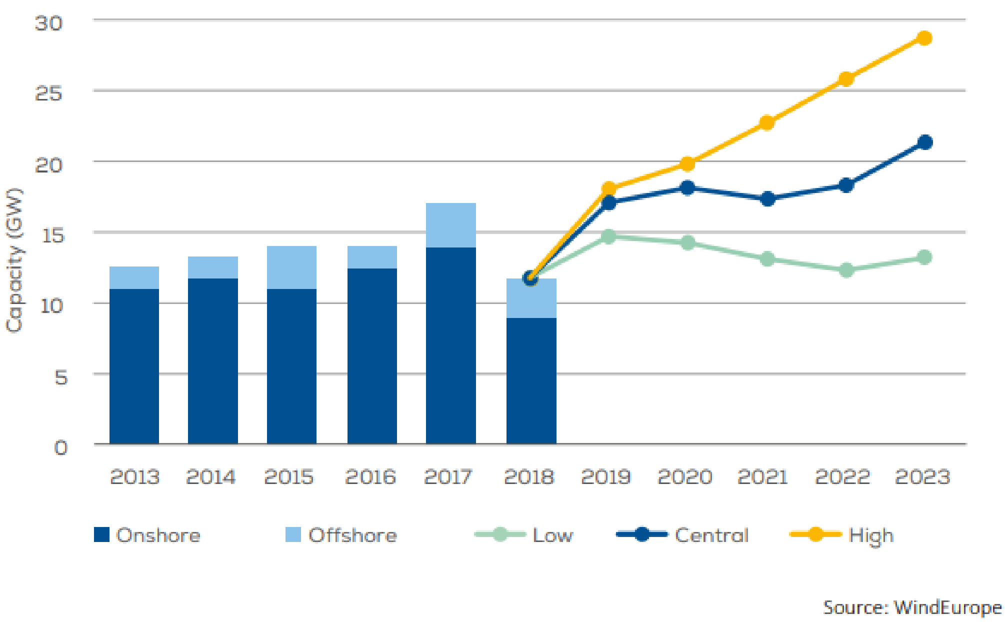


Figure 9 – Expected wind capacity growth in Europe to 2023 according to WindEurope [7]

Italy is expecting a significant growth of wind capacity by 2030, going to an overall 19.3 GW with an increase of about 90% compared to the 2018 capacity, according to the Italian National Energy and Climate Plan (NECP). Energy production is expected to increase by about 140%.

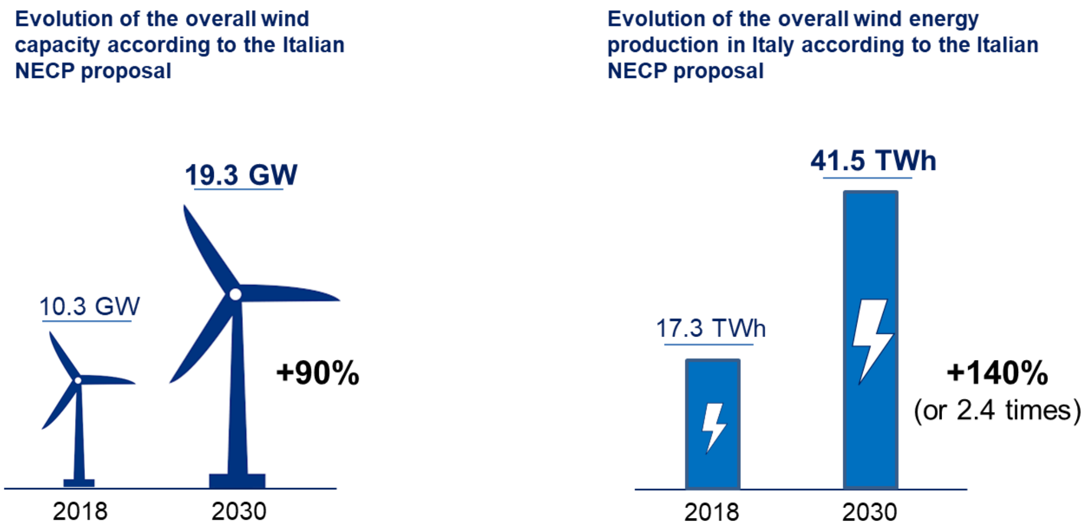
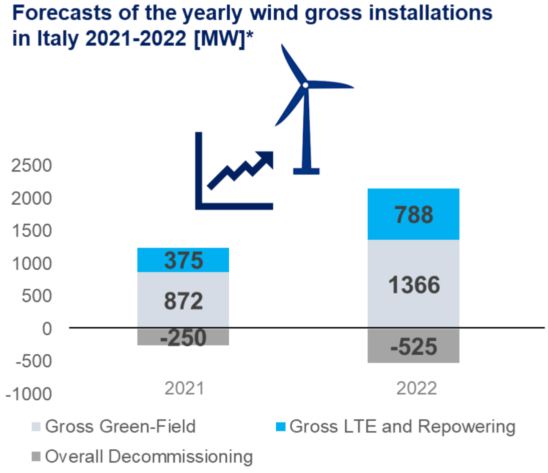


Figure 10 – Wind capacity expected in 2030 according to the National Energy and Climate Plan

Both green field and lifetime extension of existing assets and repowering will play a central role to achieve the 2030 Italian NECP targets. In fact, the expected repowering gross potential in 2021 and 2022 is about 1.1 GW and the overall potential to 2030 is about 4 GW according to EF and ANEV estimations.



The Italian wind farm is gradually getting older

- Average age at 2020: **10 years**
- Average age at 2030: **21 years**

LTE and Repowering key benefits:

- **Increasing the electricity generation** from existing sites and **providing advanced grid services** by installing state-of-the-art units
- **Exploiting the full potential** of the best wind sites
- **Improving social acceptance** e.g. by using less land

Figure 11 – Lifetime extension for wind power assets in Italy based on EF and ANEV's estimations

Technology Trends

In the past decades, the power sector has gone through a deep transformation process, with renewable energy sources playing an increasingly important role. Economic, social, and environmental forces stimulated this process, which is now accelerating at an unprecedented pace. Technology has always helped the sector to not only keep up with the present needs, but sometimes to anticipate them. Today, similarly to other industrial sectors, the power industry is facing a fundamental challenge: how to operate a transition towards a fully sustainable system. In this context, the wind sector is certainly one of the key players.

Several emerging technologies are having or are likely to have a profound impact on the development of the wind and power sector in general. Hereby a non-exhaustive list:

- **Smart material**
- **Artificial intelligence**
- Data science applications
- Wearable technologies
- **Robotics and autonomous systems**
- Internet of Things
- **Advanced design and manufacturing concepts**
- Augmented and Virtual Reality
- Information and Communication Technologies (such as blockchain)
- Long duration energy storage

Describing in detail all the technologies mentioned above is beyond the scope of this article. However, it is worthwhile listing hereby a few key examples. We selected the areas: **Smart materials**, **Artificial Intelligence**, **Robotics/Autonomous Systems**, and **Advanced design and manufacturing concepts**.

Smart materials, called also intelligent or responsive materials are designed materials that have one or more properties that can be significantly changed in a controlled fashion by external stimuli, such as stress, moisture, electric or magnetic fields, light, temperature, pH, or chemical compounds. Smart materials are the basis of many applications, including sensors and actuators, or artificial muscles, particularly as electroactive polymers. Due to the wide range of applications, they can be used in several ways in the power sector, including for harvesting or generating electricity and in the frame of reusing materials themselves. Several R&D activities are carried out around smart materials, such the ones described in [8] and [9].

An example is the use of “smart composites” embedding optical fibre sensors in wind turbine blades to monitor structural performance (by measuring parameters such as stress and vibrations), optimise performance and maintenance and potentially extend the operating life of the turbine itself [10], [11].

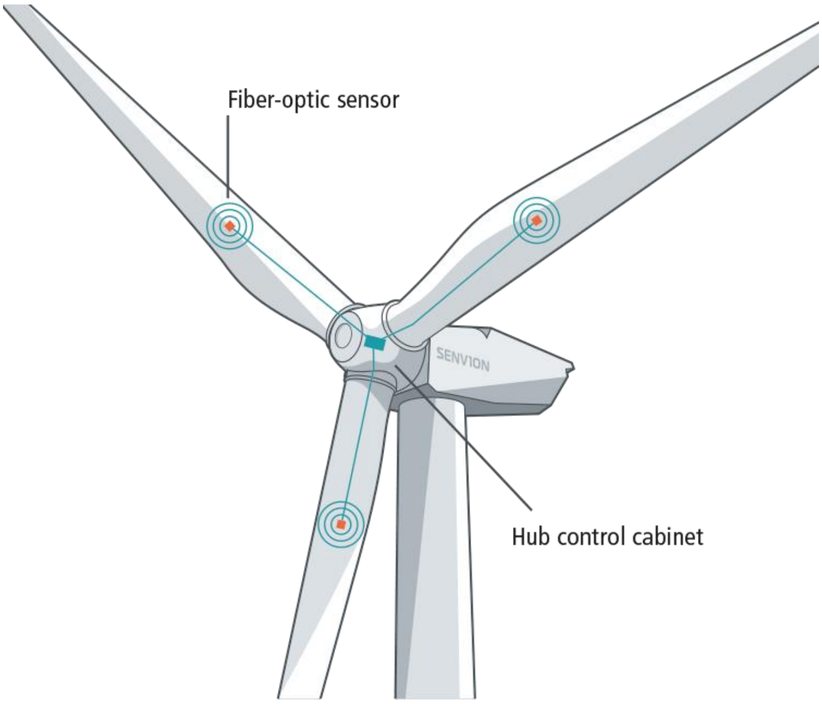


Figure 12: example of integration of optical fibre sensors onto composite turbine blades [10]

In computer science, **Artificial Intelligence** (AI), sometimes called machine intelligence, is intelligence demonstrated by machines, in contrast to the natural intelligence displayed by humans and animals. Leading AI textbooks define the field as the study of "intelligent agents": any device that perceives its environment and takes actions that maximize its chance of successfully achieving its goals. Colloquially, the term "artificial intelligence" is often used to describe machines (or computers) that mimic "cognitive" functions that humans associate with the human mind, such as "learning" and "problem solving" [12].

In the power sector, AI has wide ranging applications. One example is the optimisation of wind production by using Machine Learning. DeepMind, a Google company, has developed an algorithm based on neural networks with a database of weather data and historical data on wind turbines to provide a forecast of the output of a 700 MW wind farm 36 hours in advance and allow the optimization of dispatching and delivery to the grid 24 hours in advance. According to DeepMind, this has increased the value of electricity produced by wind farms by 20% [13].

AI has also been deployed to predict virus spread and help containing the contagion [14]. This might be useful as well for the power sector to help keeping the workforce safe, both in the office and on the field.

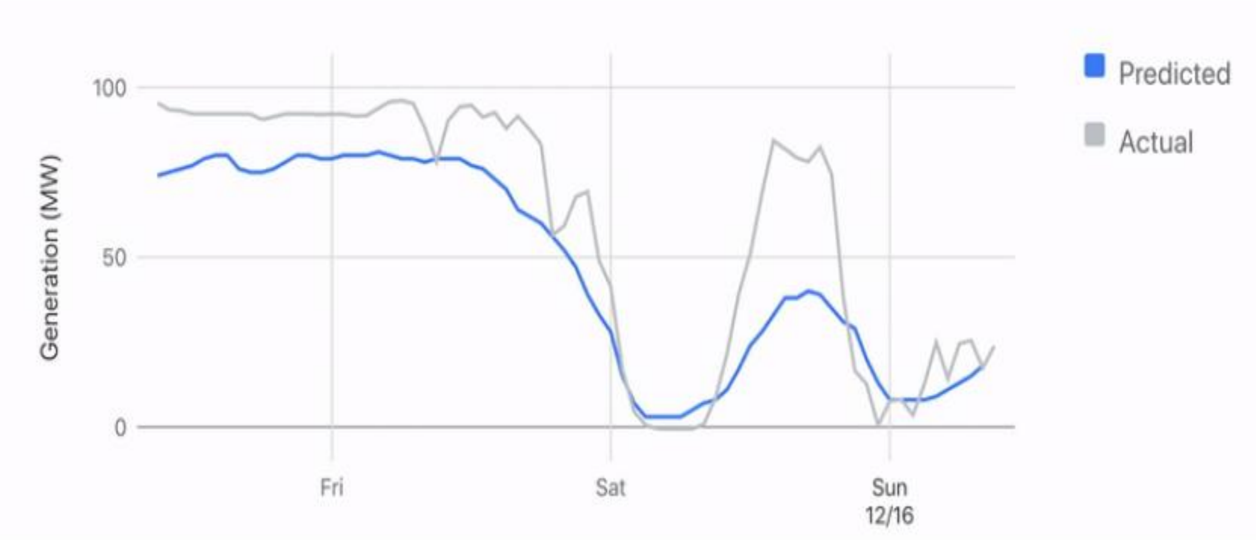


Figure 13: Predicted vs actual generation of a 700 MW Wind Farm based on Machine Learning applications [13]

The combination of **robotics** and Artificial Intelligence (AI) might disrupt the way maintenance and inspections are done in the power sector, for instance by avoiding human intervention in labour-intensive and dangerous tasks. As an example, Orca Hub [15] is a large research and development programme being carried out in the UK whose primary goal is to use robotic systems and Artificial Intelligence to revolutionise Asset Integrity Management for the offshore energy sector through the provision of game-changing, remote solutions which are readily integratable with existing and future assets and sensors, and that can operate and interact safely in autonomous or semi-autonomous modes in complex and cluttered environments. In this view, a range of autonomous drones will be certified for offshore applications, including walking, crawling, flying and swimming robots.

Autonomous robots can be also used in a context where social distancing and stringent health measures are put in place to reduce spread of the virus. In fact, the use of such systems could reduce the need of human presence on site to carry out specific Operations and Maintenance activities.

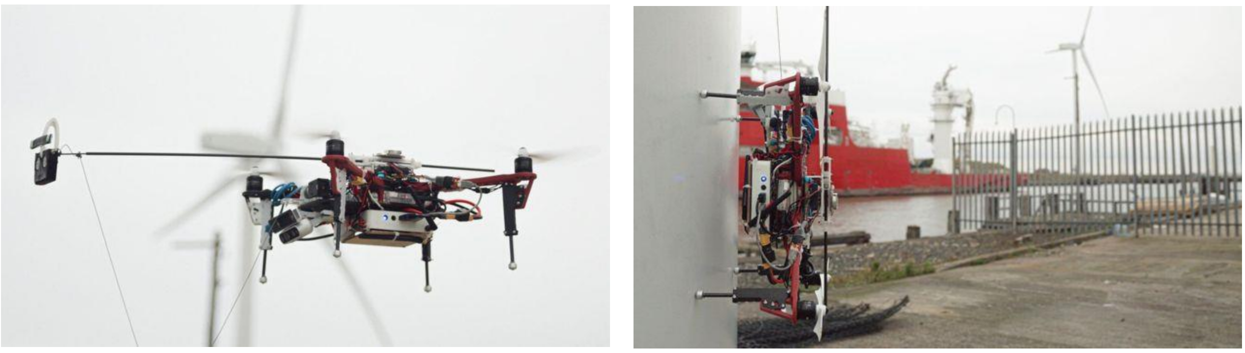


Figure 14: Example of autonomous drones being developed within the Orca Hub project [15]

Finally, concerning **advanced design and manufacturing concepts**, it is worthwhile mentioning offshore floating wind. This is not a novel technology, but a wide adoption could further boost offshore wind installations. The main innovation of floating wind concepts, compared with mainstream offshore fixed structure mounted turbines, lies with the floating support system. These floating structures have no foundation on the sea-floor, but are instead based on either semi-submersible, tension leg or spar platforms, kept in place by different mooring and anchoring systems [16].

Floating-turbine design allows for lower transportation and installation costs and lower assembly costs since for some concepts the whole setup (both platform and wind turbine) can be assembled on land and transferred offshore. The difference with existing technology is that at present, assembly is at sea, risking unstable and logistically complex conditions and costly weather downtime. The turbine and foundation for offshore structures comprise approximately 50% of the initial capital expenditure, according to [16].

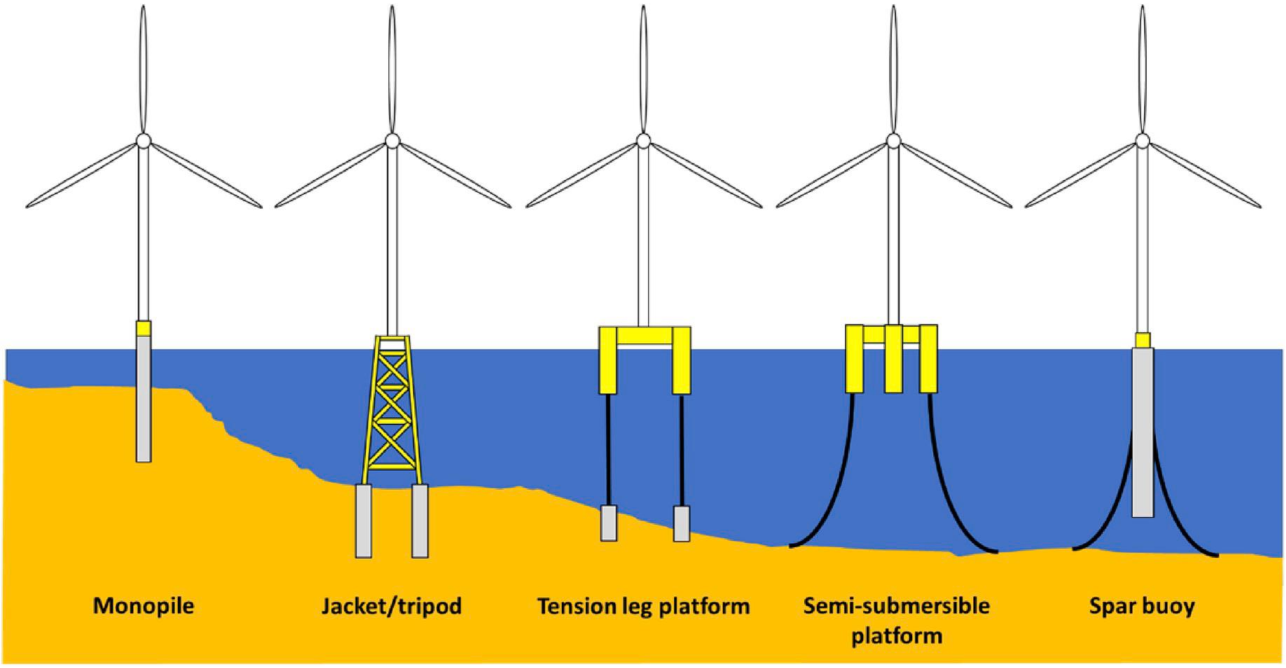


Figure 15: Offshore platforms concepts [16]

References:

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[4] GE Renewables, "Extreme Measures: At 107 Meters, The World's Largest Wind Turbine Blade Is Longer Than A Football Field", 2019 (link)

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Note: weblinks last accessed in July 2020

The Special Issue

Research & Innovation driving the clean energy transition

Author: WindEurope

Wind EUROPE

Europe will embark on a just and clean energy transition in a bid to become climate neutral by 2050. Renewables-based electrification will be the cornerstone of this transition and wind and solar will become the backbone of Europe's economy.

Wind and solar are emerging as strategic industries that can deliver both the clean energy and local jobs Europeans want and need. To achieve it, Europe needs strong and fit-for-purpose industrial policies that capitalise on Europe's technology leadership in renewables and keep these strategic sectors competitive in the global market.

A modern Research & Innovation policy is critical to the success of this transition. The EU has tended to focus R&I funding for renewables on emerging technologies only. But so-called "mature" renewable technologies such as onshore need support too to remain competitive. Horizon Europe and other EU funding programmes should focus on further incremental improvements and not just the big breakthroughs on new technology

For wind this means looking at new materials and components, innovative installation and transportation techniques, and technologies to facilitate system integration. It also means investing in recycling technologies for composite materials and ways to scale up the manufacturing lines.

In 2019 the European Technology and Innovation Platform on Wind Energy (ETIPWind)[1] produced a Roadmap that spells out the targeted Research & Innovation priorities that will accelerate the large-scale deployment of cost-competitive wind energy and support the existing European supply chain. Following the ETIPWind recommendations will also facilitate system integration, ease operations and maintenance of wind farms and bring floating offshore wind technology to full maturity.

[1] *The European Technology & Innovation Platform on Wind Energy (ETIPWind) was established in 2016 to inform Research & Innovation policy at European and national level and supports the implementation of the Integrated SET-Plan. For more information: www.etipwind.eu*

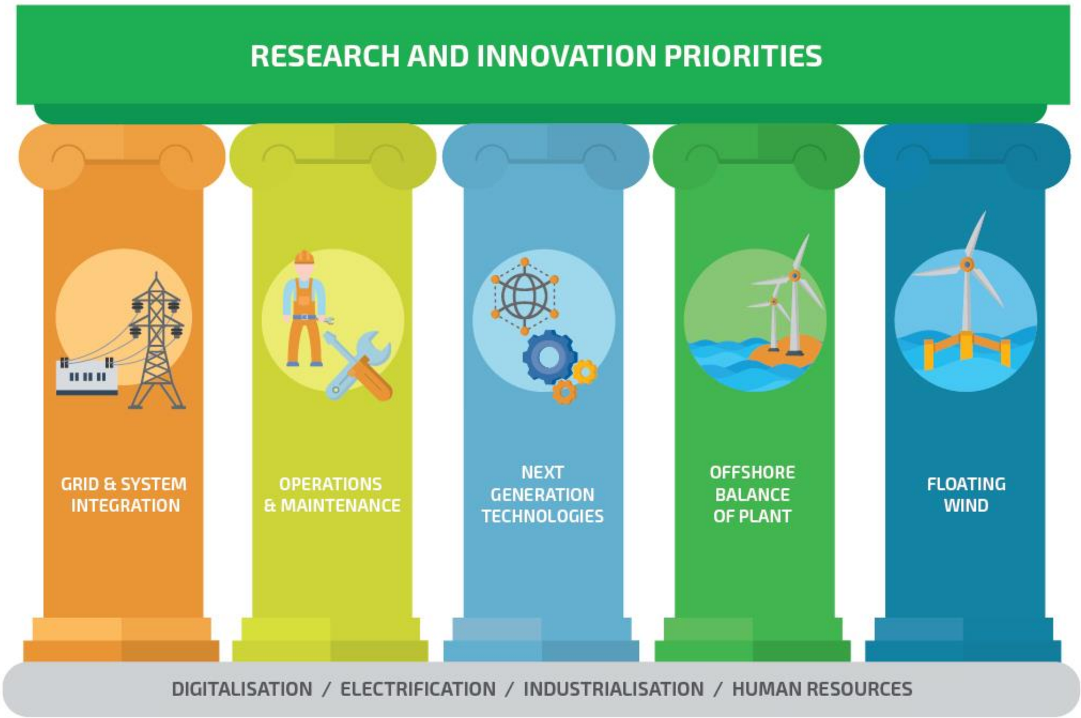

Figure 1: The five pillars of wind energy Research & Innovation

More recently the platform produced a brochure on floating offshore wind. Floating offshore wind will unlock 80% of global offshore wind resources located in deep waters (> 50m). Europe could need 150 GW of floating offshore wind by 2050, up from 45 MW installed today.

To unleash the full potential of floating offshore wind we need to start large-scale deployment. On the one hand, this requires governments to clearly state their ambitions and put in place a supportive regulatory framework. On the other hand, support to industrialise the manufacturing process and build up a balanced portfolio of floating wind concepts is needed too.

See the factsheet [Floating offshore wind: delivering climate neutrality]

Technology News Worldwide

HIGHLIGHT:

11th EDITION OF THE "BUSINESS INNOVATION AWARD (IxI)" PROMOTED BY CONFINDUSTRIA

Confindustria participates in the National Innovation Award for the Industry and Services category which will be awarded to the first 9 companies that have won the IxI Award (6 for the small and medium-sized enterprises category, 3 for the large enterprises category).

The IxI Award (created in collaboration with the Giuseppina Mai Foundation, Confindustria Bergamo with the support of BNP Paribas and Warrant Hub and with the technical support of the Italian Quality Award Association - APQI) is open to all companies producing goods and services with operational headquarters in Italy and intends to assign an official recognition to Italian companies that want to emerge and strengthen their competitive capabilities, leveraging on innovation

For more information (in Italian) visit the following link

- **#Climate Change:** Amazon has launched a $2 billion venture fund to invest in companies developing ways to cut greenhouse-gas emissions. It said the fund would focus on startups that could help it achieve “net zero” emissions by 2040.
  Link

- **#Wind:** researchers at Stanford University have devised a model to describe how, in the process of establishing wind farms, interactions between developers and landowners affect energy production costs.
  Link

- **#Solar and Hydrogen:** Solar hydrogen production. Splitting water with UV is now at almost 100% quantum efficiency. Scientists at Shinshu University have successfully split water into hydrogen and oxygen using light and meticulously designed catalysts, and they did so at the maximum efficiency meaning there was almost no loss and undesired side reactions.
  Link

- **#Storage:** A new lithium-based electrolyte invented by Stanford University scientists could pave the way for the next generation of battery-powered electric vehicles. In a study published in June in Nature Energy, Stanford researchers demonstrate how their novel electrolyte design boosts the performance of lithium metal batteries, a promising technology for powering electric vehicles, laptops and other devices.
  Link

- **#Bioenergy:** Efficient laser technique can convert cellulose into biofuel. The plant product cellulose is the most abundant form of biomass globally and can be converted into useful products such as biofuels. However, the processing of this biopolymer is cumbersome, owing to its rigid, water-insoluble structure. To overcome this, scientists from the Tokyo University of Science recently developed a novel laser-based technique that makes cellulose degradation easier. Because this reaction does not require harsh conditions, it can lead to efficient application of cellulose across various industries, especially environmental technology.
  Link

Note: weblinks last accessed in July 2020

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Elettricità Futura is the leading Italian association representing the national electricity industry. It encompasses generators of electrical energy from Renewable Energy Sources as well as traditional sources, distributors, traders, retailers and service providers. It represents and stands up for its members' interests in Italy and in Europe, contributing to making today's electrical market more efficient, enhancing the sector and exploiting the potential of the energy transition. Elettricità Futura is member of:

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