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windEXT

Advanced maintenance, lifetime extension and repowering of wind farms supported by advanced digital tools

Project nº 612424-EPP-1-2019-1-ES-EPPKA2-KA

R2.1 Evaluation of the operation and maintenance market

WP2

Written by

8.2 Consulting AG

Project consortium

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1 Wind Energy in the world

1.1 Total installations onshore (%)

By the end of 2019 the total installed onshore wind energy capacity in the world was 621 GW. In terms of cumulative installations, the top five markets as the end of 2019 remained unchanged. Those markets are: China, the US, Germany, India and Spain, which together accounted for 72 per cent of the world's total wind power installation.

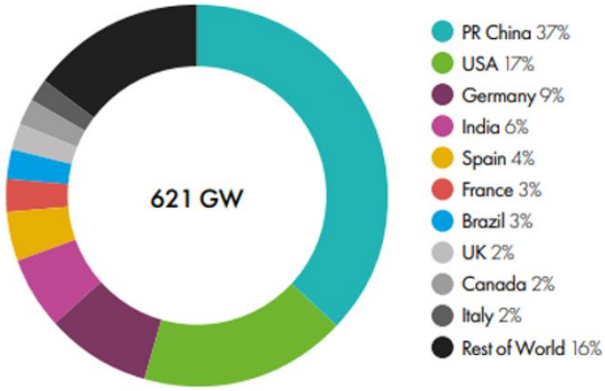

Figure 1 - Total installations onshore in the world *(Source: GWEC)*

1.2 Total installations offshore (%)

By the end of 2019 the total installed offshore wind energy capacity in the world was 29,1 GW. Approximately 70% of this capacity was installed in europe.

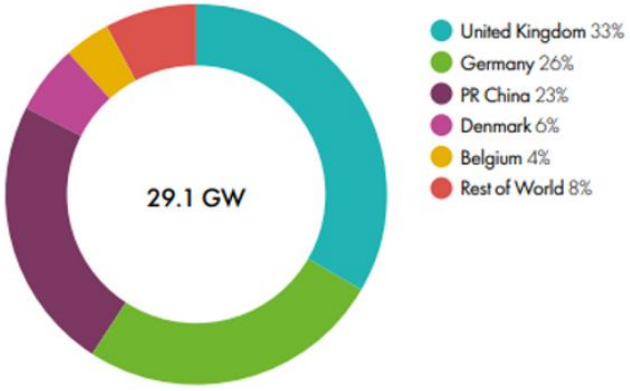

Figure 2 - Total installations offshoer in the world *(Source: GWEC)*

1.3 Historic development of total installation onshore and offshore

Table 1: Historic development of the wind energy capacity

Year	Capacity (GW) connected onshore	Capacity (GW) connected offshore	Capacity (GW) connected Total
2001	24	0	24
2002	31	0	31
2003	39	<1	39
2004	47	<1	48
2005	58	<1	59
2006	73	<1	74
2007	93	1	94
2008	119	1	121
2009	157	2	159
2010	195	3	198
2011	234	4	238
2012	278	5	283
2013	312	7	319
2014	362	8	370
2015	421	12	433
2016	473	14	488
2017	522	19	540
2018	568	23	591
2019	621	29	651

Source: GWEC

- 99% of the offshore wind energy installed in the world has been installed in the last 10 years. The remaining 1% was installed between 2001 and 2009.
- In the last 3 years an average of 5,000 MW per year has been installed offshore.
- Approximately 75% of the world's onshore wind capacity has been installed during the last 10 years
- More than 50% of the global wind energy installed last year (2019), was installed in the Asia Pacific region. Followed by Europe with approx. 25%, North America 16%, LATAM 6% and Africa/Middle East about 1,5%.
- Approx. 70% of the global installation last year was installed in five countries (China, USA, UK, India and Spain).

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2 Wind Energy in Europe

2.1 Cumulative wind power instalations in Europe

205 GW of wind power capacity was installed in Europe at the end of 2019. 89% of this capacity was installed onshore and 11% offshore.

Germany is the european country with the largest installed capacity, followed by Spain, the UK, France and Italy.

15% of the electricity consumed in europe (EU-28) last year (2019) was generated by Wind turbines. Denmark is the european country with the largest share of wind energy in its electricity demand, almost 50%.

The five countries with the largest installed wind power capacity represent 67% of the total capacity in europe: Germany (61 GW), Spain (26 GW), the UK (24 GW), France (17 GW), and Italy (11 GW).

Table 2: Total installed wind power by country

Country	Capacity (GW) connected onshore	Capacity (GW) connected offshore	Capacity (GW) connected total
Germany	54	7	61
Spain	26	-	26
UK	14	10	24
France	17	-	17
Italy	11	-	11
Sweden	9	-	9
Turkey	8	-	8
Denmark	4	2	6
Poland	6	-	6
Portugal	5	-	5
Netherlands	3	1	4
Ireland	4	-	4
Belgium	2	2	4
Greece	4	-	4
Others	16	-	16

Photo: 8.2 Group; Installation of an onshore wind turbine in Germany (height of the tower approx. 150 meters).

2.2 Cumulative wind instalations offshore in Europe

According to the EWEA, at the end of 2019 there were 5,047 offshore wind turbines installed and connected to the grid in Europe. These 5,047 turbines represents a cumulative nominal power of 22,072 MW.

The european offshore wind capacity is installed across 12 countries, but five of them – the UK, Germany, Denmark, Belgium and the Netherlands – represent 99% of the total capacity.

With 45% of all installed offshore wind capacity in Europe, the UK leads this market. Followed by Germany (34%), Denmark (8%), Belgium (7%) and the Netherlands (5%).

Including offshore wind farms with partial grid-connected turbines there were 110 offshore wind farms installed in Europe by the end of 2019.

The largest owners of the european offshore wind farms are Ørsted (16%), RWE (12%), Vattenfall (7%) and Macquarie (7%).

According to EWEA, 70% of the global floating wind capacity was installed in Europe by the end of 2019. Europe's floating wind fleet was the largest worldwide with a total of 45 MW.

Table 3: Cumulative offshore capacity in Europe

Country	Wind farms connected	Turbines connected	Cumulative capacity (MW)
UK	40	2,225	9,945
Germany	28	1,469	7,445
Denmark	14	559	1,703
Belgium	8	318	1,556
Netherlands	6	365	1,118
Sweden	5	80	192
Finland	3	19	70,7
Ireland	1	7	25,2
Spain	2	2	5
Portugal	1	1	8,4
Norway	1	1	2,3
France	1	1	2
TOTAL	**110**	**5,047**	**22,072**

Source: EWEA

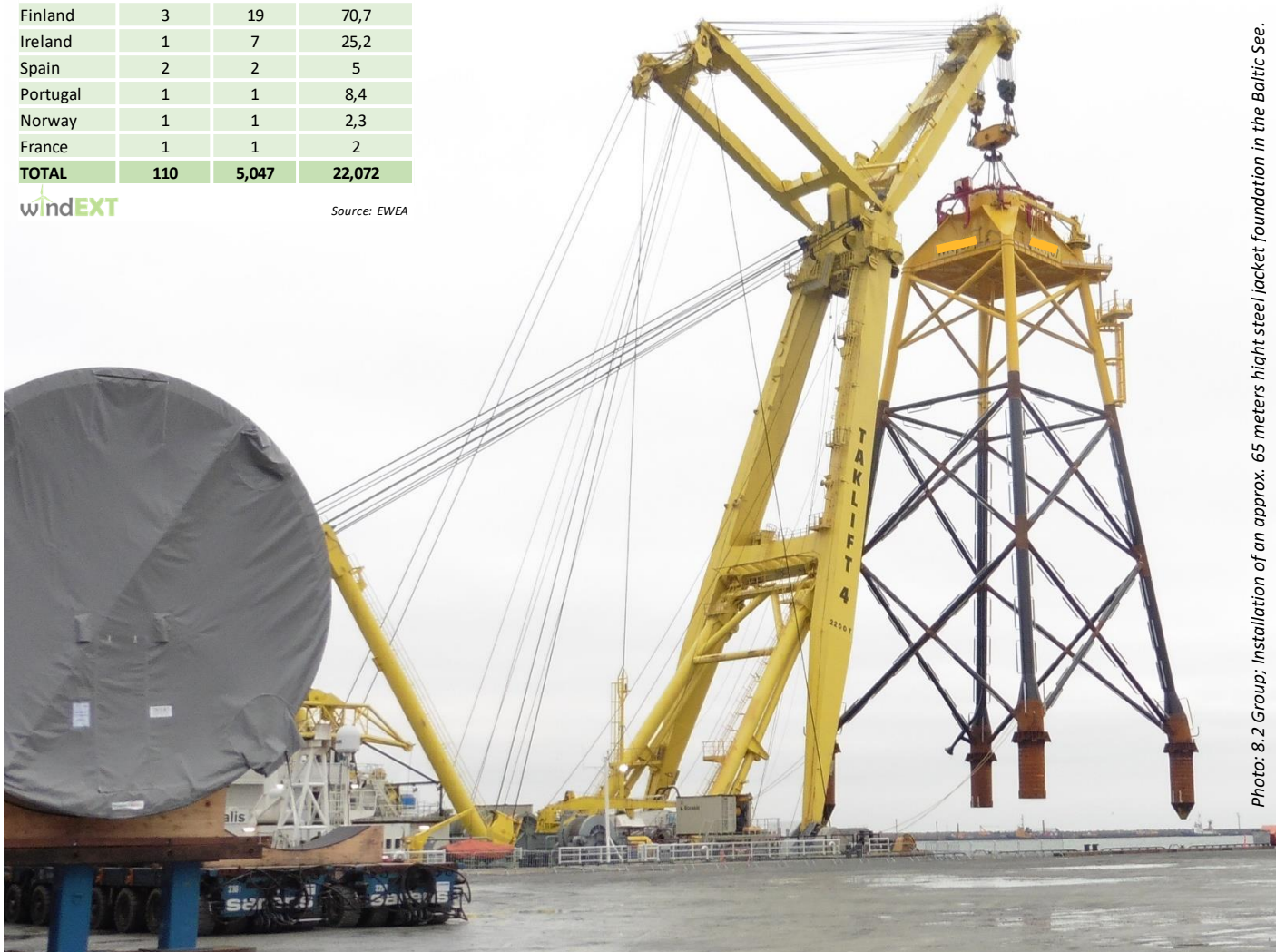


Photo: 8.2 Group; Installation of an approx. 65 meters hight steel jacket foundation in the Baltic See.

2.3 Offshore wind installations in 2019

In 2019 Europe set a record with the connection of 3,623 MW offshore. The largest amount of connected offshore wind energy in a single year to date in Europe.

The UK leaded the added supply of offshore energy with 1,764 MW (48,6%). Followed by Germany 1,111 MW (30,6%), Denmark 374 MW, Belgium 370 MW and Portugal 8 MW.

Germany

In 2019 Germany connected 1,111 MW, in other words 30.6% of the installed offshore wind energy in europe. Three offshore wind farms were connected, Merkur Offshore (252 MW), Deutsche Bucht (260.4 MW) and Hohe See (497 MW). The installed wind farm Hohe See is the largest offshore wind farm in Germany to date.

The Netherlands

In 2019, part of the foundations of a 731.5 MW wind farm were installed. This wind farm is expected to be connected to the dutch grid in 2021.

The largest prototype of a offshore wind turbine (GE Haliade-X 12 MW) was installed in the Netherlands (onshore) at the end of 2019.

Portugal

The first offshore (floating) wind farm in Portugal is under construction, in 2019 the first of three wind turbines was connected. The model installed is V164-8.4 MW. This is the largest installed floating turbine in the world.

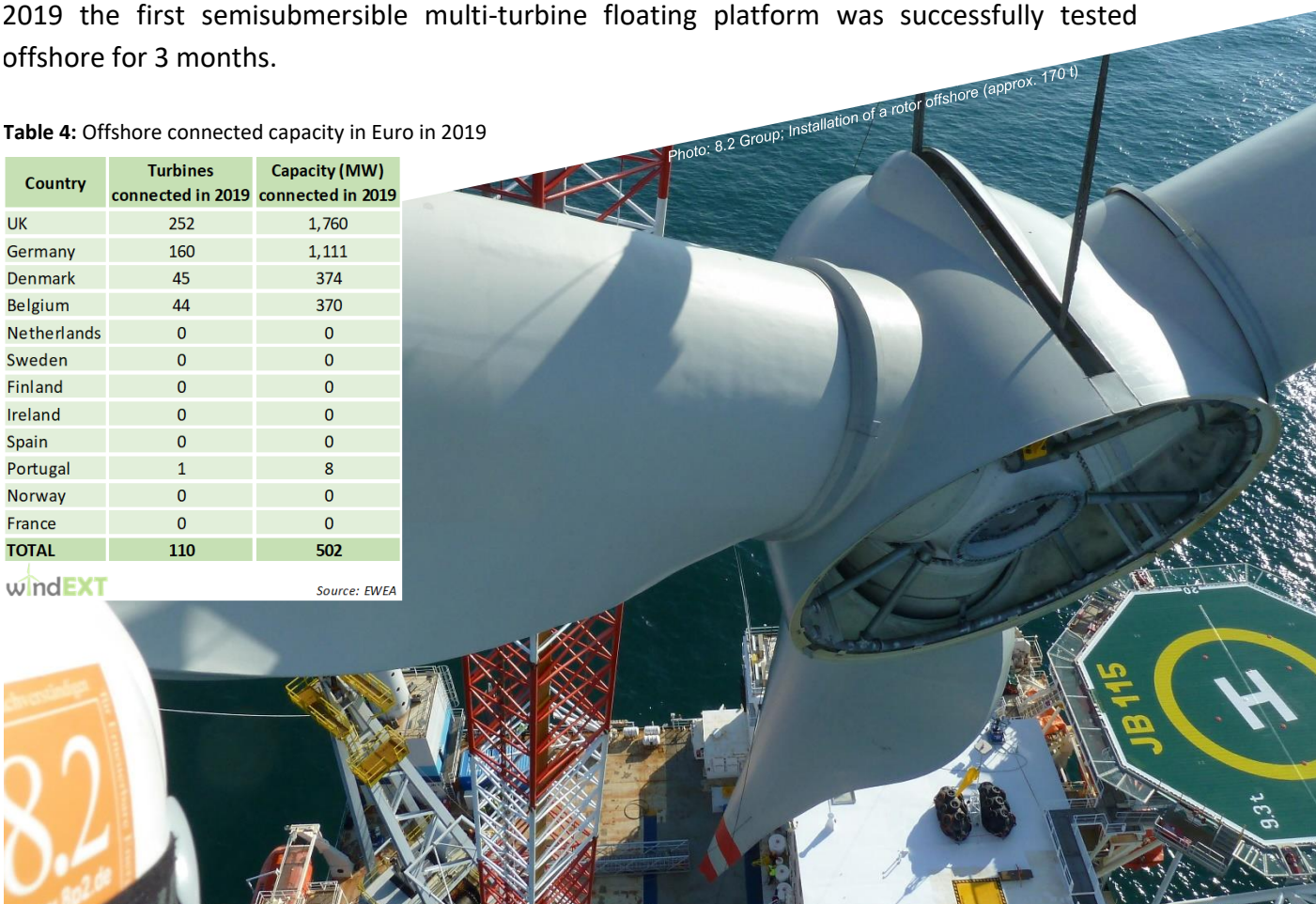
Spain

Spain has not continental platform, there are many initiatives, specially floating projects. In 2019 the first semisubmersible multi-turbine floating platform was successfully tested offshore for 3 months.

Table 4: Offshore connected capacity in Euro in 2019

Country	Turbines connected in 2019	Capacity (MW) connected in 2019
UK	252	1,760
Germany	160	1,111
Denmark	45	374
Belgium	44	370
Netherlands	0	0
Sweden	0	0
Finland	0	0
Ireland	0	0
Spain	0	0
Portugal	1	8
Norway	0	0
France	0	0
TOTAL	**110**	**502**

windEXT *Source: EWEA*



2.4 Decommissioning and repowering of wind farms

During 2019, 178 Mw was decommissioned in Europe. over 97.5% of the decommissioned capacity was onshore. Of the 11.7 GW onshore wind capacity installed in 2019, only 1,4% were repowering projects.

Lack of regulatory support, complex permitting rules and high wholesale electricity prices were the main reasons for low market activity in decommissioning and repowering.

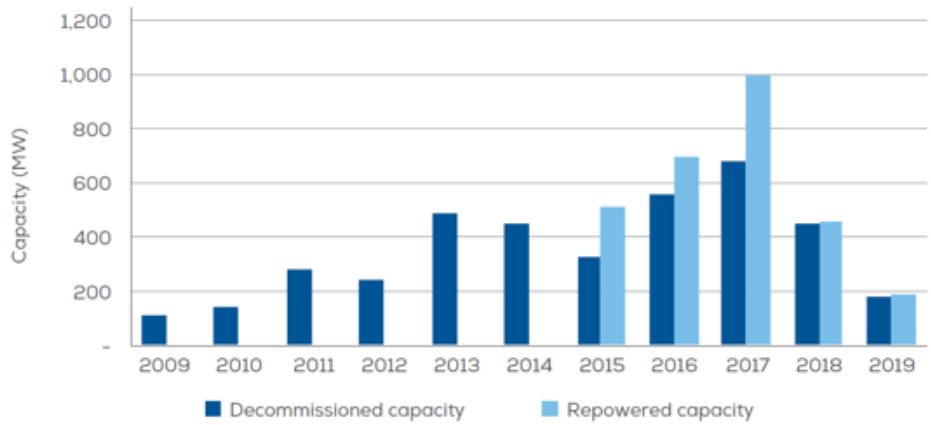


Figure 3 - Decommissioned and repowered capacity in Europe (Source: EWEA)

2.5 Wind turbine size

Wind turbines continue to get more powerful every year. In 2019 the average nominal power of the installed wind turbines was 3,2MW onshore and 7,8MW offshore in Europe.

Table 5: Number of onshore WTGs installed and their average power rating

Country	Turbines connected	Average power rating
France	511	2,6
Sweden	447	3,6
Germany	325	3,3
Greece	314	2,3
UK	230	2,7
Norway	204	3,8
Turkey	200	3,4
Ukraine	166	3,8
Ireland	163	2,8
Italy	154	3
Finland	56	4,3
Austria	49	3,1
Croatia	24	2,9
TOTAL	**2843**	**3,2**

Source: EWEA

During 2019, 2843 wind turbines were installed onshore in europe, the average nominal power was 3,2MW. The most powerful onshore wind turbines on average were installed in Finland, with an average rating of 4.3 MW (Nordex).

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Table 6: Number of offshore WTGs installed in Euro in 2019 and their average power rating

	connected	power rating
UK	252	7
Germany	160	6,9
Denmark	45	8,3
Belgium	44	8,4
Portugal	1	8,4
TOTAL	**502**	**7,8**

Source: EWEA

The average rated capacity of the offshore wind turbines installed in Europe last year (2019) was 7.8 MW, 1 MW larger than in 2018. The average power rating in Belgium and Portugal was 8.4 MW.

Officially the most powerful wind turbine at the end of 2019 was GE's Haliade-X (12 MW). The first prototype was installed onshore in the Netherlans last year, the commercialisation is planned in 2021.

2.5.1 Offshore wind turbine manufactures

According to EWEA (The European Wind Energy Association) at the end of last year (2019), 3 manufacturers represent 96% of the total offshore capacity connected in Europe.

Of the total installed capacity offshore in Europe, SGRE (Siemens Gamesa Renewable Energy) hast more than 68%.

MHI Vestas Offshore Wind is the second largest manufacturer with 23.5%. With only 4.4% Senvion is ranked third.

Due to Senbion's bankruptcy in 2019, the European offshore wind market will essentially be in the hands of just two manufacturers SGRE and MHI Vestas.

Photo: 8.2 Group; Offshore wind farm with Senvion turbines

3 Germany

3.1 Power, number of wind farms and turbines.

Wind power in Germany is a growing industry. The installed capacity was approximately 61.5 gigawatt (GW) at the end of 2019 according to the latest GWEC report, with 7.5 GW from offshore installations. In 2019, a quarter of the country's total electricity was generated using wind power, compared to an estimated 9.3% in 2010.

More than 30,000 wind turbines were located on and offshore in Germany by year end 2019, and the country has plans for further expansion. As of the end of 2019 Germany was the third largest producer of wind power in the world by installations, behind only China and the USA. Germany also has a number of turbine manufacturers, such as Enercon and Nordex and Siemens Gamesa although the latter mainly produces turbines outside of Germany.

Germany is a mature wind market and onshore wind energy has been an important industry in Germany for many years. In 1995, the total onshore wind installed capacity was already 1,530 MW. Larger onshore installations are also in the works, which could possibly see an even larger percentage of wind energy powering Germany.

Despite Germany's leading position, permitting barriers and political standstill are affecting installations numbers. For example, in 2017 a record 6.6GW was installed onshore. This figure had shrunk to just over 1GW by 2019. According to a 2019 report by consultancy FA Wind nearly 10GW of onshore wind projects are stuck in the permitting phase in Germany. Offshore the situation is brighter as the government has increased target from 15 to 20GW by 2030.

Nevertheless, the medium to long-term outlook for Germany is generally positive. For example, the guaranteed Feed-In-Tariffs (FITs) for the first generation of turbines ends in 2021 meaning there will be great potential for repowering onshore.

Photo: 8.2 Group; Port of Eemshaven - Netherlands; Load of a 5MW rotor onboard a 131m length installation vessel; Germany's first commercial offshore wind farm

3.2 Manufacturers and technologies with presence in the market.

In the German market, after the bankruptcy of Senvion in 2019, there are still three major manufacturers of wind turbines, Enercon, Nordex and Siemens Gamesa. The German market is already strongly consolidated through bankruptcies, acquisitions and mergers.

Overall, in 2018 the German market is dominated by a few manufacturers, the analysis shows. In addition to Enercon (56.3%) Vestas (120 plants, 24%) and Nordex (57 plants, 10.2%) had market shares above ten percent. This means that the three manufacturers cover more than 90 percent of the market. Enercon and Vestas were able to significantly increase their market shares compared to the same period in 2017 (Enercon +16 percentage points; Vestas +5 percentage points).

3.3 Market structure by ownership.

Private owners

Behind them are the so-called citizen wind farms. At 39 percent, they even account for the largest share of onshore wind energy, according to a recent study by trend and market research institute trend:research. Private owners usually mean companies whose shareholders are private individuals, often residents directly from the municipality where the park is built. Together they set up a limited liability company or a registered cooperative (eG), of which they are shareholders. The profits from energy production are distributed annually to the shareholders. Such projects are financed by part equity capital as well as loans from banks and funding institutions. External service providers or self-founded operating companies are commissioned with the planning, project planning and subsequent operation.

Projector

Project developers are companies that deal with the planning, project development, construction and management of wind farms. In this role, they are not the owners of the wind turbines, but are entrusted with the realization of a park project. However, since the know-how already exists, many project developers also operate their own parks and issue bonds to investors, participate as shareholders or sell them entirely to investors. Examples of project planners from Bremen are wpd AG, Energiekontor AG or Energiequelle GmbH. They account for just under a quarter (23 percent) of land owners.

Funds/Banks

Like any major investment project, wind farms must be financed by loans. Banks, however, are not only benefiting from the wind power boom through lending – they are also interfering themselves by participating in projects, especially in the very expensive offshore projects. For example, the first commercial wind farm on German sea, BARD Offshore 1, is operated by Ocean Breeze Energy GmbH & Co. KG, which in turn is wholly owned by UniCredit Bank AG from Munich.

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Energy supplier

Energy supply companies own almost 15 percent of all wind turbines on land. These, in turn, can be divided into international, supra-regional and regional energy suppliers. Utilities operate power plants, electricity grids and energy infrastructures and account for electricity generation with households or companies. Especially in offshore projects, supra-regional and international energy suppliers participate due to the high investment amounts.

"Big 4"

A separate mention in the list of wind turbine owners is worth mentioning the big four of the German energy generation landscape as the highest-selling companies: E.ON, RWE, EnBW and Vattenfall. While they have a stake in only a small proportion of land wind turbines, their shares in the offshore sector are 23 percent. This is because the high investment costs of these parks can be more easily met by high-capital companies.

Offshore, the big four as well as funds/banks have the largest shares in the ownership structure with more than 60 percent, the rest divided between international and regional ESs.

3.4 Presence of ISP (Independent Services Providers).

Independent service providers (ISPs) of wind turbines are using empirical data to make their case to the wind industry that they are a cost efficient way to improve productivity and profits. This comes at a time when many wind park owners are struggling to cope with underperforming wind projects, higher service costs and a lack of spare parts.

There are a number of business models for wind turbine service, many of which have been around for decades. Wind turbine owners often agree contracts with turbine manufacturers for service in the warranty stage, and frequently pay for an extended service agreement once the warranty runs out. Other wind turbine operators, predominantly larger owners of big fleets, operate their own in-house service teams. ISPs fill in the gaps. However, as more turbines are installed worldwide, and manufacturer warranties on more turbines expire, good operations and maintenance (O&M) often proves a challenge for turbine owners. New ISP companies are entering the market, with the goal of meeting this new demand. Often, they can provide better value than is being offered by the turbine manufacturers that have control of many markets worldwide. Irrespective of who does the service, it is agreed upon that many turbines could be performing better.

Measuring up

One of the best measures of the lucrativeness of wind turbines is their availability factor. It is critical that when good winds blow, the turbines are able to run at peak capacity. According to Klaus Kruger of Voith Industrial Services, which provides O&M to a range of industries, the wind industry has overestimated the expected energy production of wind parks, and projects often do not correctly factor in the ongoing O&M costs to keep a turbine running efficiently. Kruger says that availabilities in Europe range from below 95% at lower performing wind

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turbines up to an average of around 97% at the higher performing ones. Even at the better 97% range, the wind industry should look for higher goals, says Kruger.

While some owners are reluctant to spend more on maintenance or don't have the money for it, better maintenance can save a business money rather than increase cost. Voith's experience is a good example. It took over O&M of a medium-sized commercial wind turbine for an owner that had previously relied on the turbine manufacturer for service. The wind turbine availability factor was 94.3% before Voith did an initial audit. Two years after Voith took over service, availability had increased to 97.6% and today stands at 99%, which is uncommon for wind turbines. This resulted in an increase of turbine income of 6% compared to previously.

Matthias Brandt, CEO of Deutsche Windtechnik AG, based in Husum, Germany, provides a similar example. The company specializes in the region's abundant Vestas and NEG Micon turbines - themselves acquired by Vestas in 2004.

Deutsche Windtechnik took over O&M from the manufacturer on a wind park with 1.5 MW NEG Micon machines. The first four years of operation were under the manufacturer's warranty and the park operated at 95.5% availability. After audits, new servicing and some minor parts replacements, Windtechnik increased availability to 97.1%. This meant an additional 600,000 kWh and additional yearly revenue of EUR52,000. The turbine manufacturer's previous yearly maintenance costs had been EUR106,000, more than Windtechnik's annual charge of EUR85,000, meaning the wind park owners were EUR73,000 a year more profitable.

Brandt says: "On most turbines you will find lots of possibilities for improvements and retrofits." He echoes a point expressed by other wind service experts - that a key to cost-effective maintenance is having knowledgeable staff who know the specifics of turbine models and are able to use data to their advantage. Raw data is useless unless it is understood and applied, he says.

In spite of the drive from ISPs, the manufacturers are not permitting ISPs to take more of the maintenance market share without a fight. Manufacturers often say they should stay closely involved in the maintenance process or provide full after-warranty service as they often know the turbines and subcomponents best and have better access to spare parts and can provide high quality and technical know-how. Their close connection to the design department is also seen as an advantage to using the services of manufacturers.

As the machines age

The argument that the manufacturer knows the turbine best is relevant for new turbines but is less valid with older machines, says Strange Skriver, chief technical consultant of the Danish Wind Turbine Owners Association. Half of all wind service in Denmark is done by ISPs "The most knowledge of many machines is from the ISP even if the manufacturer is still alive," says Skriver, referring to the disappearance of some companies whose machines continue to operate over the years.

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Skriver believes that a spare parts strategy should begin early on, and developers should allocate money for supply of some spares, especially for gearboxes. This is a useful strategy against gearbox failure and the potential downtime, as replacements can take months to arrive.

The short supply of spare parts is one of the serious topics facing the wind industry, says Voith's Kruger, who adds that the average lead time for replacement gearboxes last year was one and a half years. "This is something that the owners of a wind farm and the banks cannot live with and we have to look for ways compensate for that," he says. "The downtimes lead to reduced income for the owner and in some cases we have seen bankruptcies of wind farms that were performing poorly." Kruger adds that reduced component lifecycle is also a big issue. There are cases of wind components failing after just two years in some cases, even though they were designed for a ten-year or more life cycle. Part of the problem may be that some components are operating today under different conditions then they were in the past, says Kruger. The problems are especially clear for those joining the industry from more mature sectors.

Reducing failures

"The wind industry today exhibits some early-phase characteristics, by which I mean failure rates in components and systems is too high," says Sverre Trollnes, who leads the new energy division for international energy company StatoilHydro ASA. The company recently completed a study on failure rates at multiple wind farms. "It was astonishing," says Trollnes. "If this was in our other businesses like oil and gas we would not allow our investment to go ahead, I'm sure of it. So this really needs to be addressed. When short times between failures is combined with a poor operations and maintenance strategy then you have really poor performance, and that is what we see in some of the assets."

There is discussion in the industry about moving away from purely corrective and scheduled maintenance to predictive and preventative maintenance. Certain processes will always be done to a schedule and certain actions will always be taken to deal with a problem, however Trollnes believes that most of the operations and maintenance strategy in the wind industry is based on running plants until they fail.

About 70% of maintenance at most wind turbines is either scheduled or corrective, he adds, which often fails to improve the performance of a wind turbine or to identify problems that can lead to unplanned downtime. "We should look at component failure from a new angle," says Trollnes. "We have decided that 80% of all stops should be planned and preventative in nature. It's a vast target from where we are today, but we know that it's possible because we've done it in other industries."

Trollnes points out that it is easy to blame the turbine manufacturer or the ISP however, in reality, the situation will need everyone in the wind industry to work together to make needed improvements. It will also need a wholesale adoption of preventive and predictive maintenance technologies, such as systems that automatically and remotely monitor

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deviations in component vibrations. "It's a combination," says Trollnes. "You need expert manufacturers, and you need ISPs - it's about how you put the team together."

3.5 Main critical challenges on maintenance activities:

3.5.1 Aging of maintenance labour force

The physical condition of a turbine is assessed through an on-site inspection during the practical part of the lifetime extension evaluation. Prior to the on-site testing and inspection of the turbine, the information and data already available are analyzed. Technical documentation and reports, as well as weather and performance data, are examined so that the turbine can be assessed for weaknesses and defects.

The objective of the physical assessment is to document any damage or unusual wear and tear to the turbine's components and equipment. Load-bearing and safety-relevant components are examined in detail. Maintenance records are checked plus the turbine condition is compared with the technical documentation. Inspectors focus on signs of corrosion, visible cracks and suspicious noises in the gearbox etc.. Also, a detailed investigation is carried out for weaknesses or flaws associated with a particular type of wind turbine, such as known shortcomings in the quality management during specific production periods or certain components or design flaws that lead to premature defects.

The conditions of the main elements of the turbine — e.g. the rotor blade, supporting structure and the foundation — are carefully evaluated In most cases the damage discovered is relatively minor and caused by corrosion, weathering and material fatigue. For instance, rotor blades or cables frequently need maintenance. Close attention is also paid to any changes in the surrounding environment of a wind farm. Expansions in neighboring sites must be taken into account in turbulence calculations.

3.5.2 Lifetime extension trends

To evaluate the current condition of a turbine, the lifetime extension assessment is usually performed during the last year of validity of the operating permit. If divestment of the turbine is being considered, or in the case of medium-term budget planning, it may be preferable to carry out the analysis at an earlier stage.

The assessment to determine whether a wind turbine may operate beyond its design life consists of two parts, conducted in parallel. Experts in the analytical and practical evaluation provide each other mutual assistance during the entire process. After the analytical evaluation and on-site inspection (Life Extension Inspection; LEI), a status report is drawn up specifying the requirements needed for lifetime extension.

Photo: 8.2 Group; Life Extension Inspection (LEI) of a 24-year-old wind turbine in Germany

For example, repairs or precautionary replacements of the bolted connections of the rotor blade are often necessary, as these are usually the first elements to reach their design load limits. This way an accurate financial estimate of the potential costs involved in lifetime extension can be generated. The results of the assessment provide valuable input for weighing opportunities and efforts for continued operation and are important in assisting wind farm operators in their decision-making process.

One critical factor in the safety evaluation process is establishing the structural stability of a wind turbine. The tests required to verify structural stability are mainly focused on the load-bearing components, from the rotor blades to the foundation, as well as the safety devices, brake systems and turbine control systems. The actual loads to which a turbine has been exposed during its operational lifetime need to be calculated and compared with loads resulting from design conditions. This information is obtained from computer simulations that reflect design conditions after type testing, as well as environmental operating conditions. Furthermore, an on-site inspection of the turbine is performed.

Environmental operating conditions include site-specific wind conditions. Data documenting average wind speeds, turbulence intensities and extreme wind events for the previous 20 years need to be quantifiable in order to calculate loads for the period of operation. This calculation is based on operating data and data from the anemometer on the nacelle. If this data is not known for the entire operating period, other data sets (i.e. reanalysis data) are used to perform long-term extrapolation. In the case of a wind farm with a variety of capacity additions, turbulence is calculated individually for each turbine as well as for each of the windfarm layouts during the design lifetime.

In the analytical assessment, the potential duration of continued operation is calculated based on turbine technical documentation, as well as the environmental operating data. Wind farm operators are responsible for arranging the assessment on time and for presenting the relevant documents. Required documentation includes information relating to turbine construction and commissioning; the operating permit of the turbine; repair, inspection and maintenance reports; operating and yield data; and wiring and hydraulic diagrams. In addition, a technical report is required documenting the conditions of the rotor blades, carried out within the last year of operation.

It is not unusual for technical documentation to be incomplete. Missing certificates and technical documents can be obtained from the manufacturer. This includes documentation from the construction and commissioning phases. However, if a turbine manufacturer is no longer available, comparisons with other turbines and assessments based on previous experience may be used to bridge the knowledge gaps.

Analytical evaluation

In the analytical part of the lifetime extension assessment, operating and design loads are compared. The results of the physical inspection are considered in these calculations. Fatigue loads are simulated using software-based models that take into account site-specific wind conditions as well as design conditions. Load-bearing components contributing to the structural stability of the turbine are examined: the tower and foundation, screws and bolts, load-bearing parts of the drive train, the hub, the shaft, the rotor blades, brake system and safety functions. This report specifies the remaining time until design loads are reached. Based

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on the calculations, a statement is prepared highlighting immediate measures required for continued operation, as well as measures that become necessary at defined points in time, e.g. exchange of components or individual inspection strategies.

Photo: 8.2 Group; Root cause analysis (RCA) of a rotor blade

3.5.3 Repowering

In addition to ambitious erection goals, it is very more important to include established and widely accepted locations in the considerations in order to ensure an efficient use of space. This usually reduces the number of plants significantly, while the yield multiplies due to modern plant technology. Interest in using these locations with existing infrastructure within the scope of repowering often exists not only among the respective plant operators, but also among local residents, property owners and municipalities. For locations without repowering options - for example because the areas are outside currently defined priority areas or due to restrictive planning and licensing regulations such as extended distance requirements - continued operation is sometimes the only option for further use of the area and existing infrastructure.

Wind turbines in continued operation also show a considerable benefit for the overall system after the end of their conveying period. They often enjoy a high level of acceptance among the population, make an important contribution to climate protection and conserve resources through the continued use of existing infrastructure. Systems can be operated beyond the calculated service life of 20 years if proof of the suitability of the system and the duration of

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possible further operation is ensured. Due to past technical retrofitting programs, existing systems in continued operation do not pose a problem for network stability.

3.5.4 New installations

According to the German Wind Energy Association (BWE) from 2021 onwards, the German wind industry will no longer be solely focused on the construction of new turbine capacities, but for the first time on large scale dismantling, replacement and long-term operation without subsidies. Wind turbines with a total output of about 4,000 MW will then reach the end of the funding period (20 years) and will no longer benefit from the federal feed-in tariff.

Until 2025, an average amount of 2,400 MW per year is going to lose federal support. If one assumes that most turbines cannot be operated in a profitable way without the feed-in tariff and compares the figures with the federal deployment corridors, which call for an increase of wind energy from 2,800 to 2,900 MW each year, it becomes clear that there is a definite need for action. Under the current framework conditions, the total capacity of wind energy in Germany is likely to decrease in 2021 for the first time since the Renewable Energy Act (EEG) has been implemented.

In its coalition agreement, one of the federal government's main targets is to increase the share of renewable energies in electricity consumption from today's 40 percent to 65 percent in 2030. To achieve this goal, the expansion of onshore wind energy is essential. However, many project planners are already facing difficulties when it comes to approval procedures. In many places, local authorities hesitate to allocate suitable areas and approval procedures are slowing down. Construction projects for new turbines take an increasingly long planning period and are sometimes not realized at all.

3.6 Offshore maintenance: specificities and defies

Offshore wind energy is becoming more and more established in the German electricity mix. Currently there are almost 7.5 gigawatts (GW) of power installed in the North Sea and Baltic Sea and this is set to increase to 20GW by 2030. Continuous expansion enables cost reductions based on optimized plant technology and improved operating concepts. The industry currently employs around 27,000 people according to the German Wind Energy Association BWE.

Stronger and constantly blowing winds on the open sea make offshore wind energy an attractive option. The energy yield is twice as high as with comparable systems on land due to higher full-load hours. Therefore, offshore wind farms are making a steadily growing contribution to energy supply.

The German offshore wind sector is subject to special conditions. For reasons of nature conservation (protection of mudflats) and to exclude effects on the landscape, the German offshore parks - in contrast to Scandinavian and British projects – are located far off the coast at water depths of up to 40 meters. Most suitable areas therefore lie outside the 12 nautical mile zone (minimum 22.2 km from the coast) in the Exclusive Economic Zone (EEZ). The technical requirements (foundations, tower construction, cable laying, logistics and maintenance) are therefore much more demanding than for the construction of turbines directly off the coast. Maintenance on the high seas and regular condition monitoring are also of central importance due to the constant exposure to salt water, storms and tides.

The Federal Maritime and Hydrographic Agency (BSH) is responsible for the approval of offshore wind farms outside the 12 nautical mile zone, i.e. in the EEZ. Approval is granted after a detailed assessment of the effects on ecosystems, fisheries, shipping and the military. For applications within the 12 nautical mile zone, the authorities of the respective federal state are responsible.

Photo: 8.2 Group; Inspection of a WTG in the german area of the North Sea

The development of the German offshore wind sector has as previously stated created around 27,000 jobs. These are not only located near the coast, but also in southern and western Germany, where important components such as bearings, gearboxes and generators are manufactured.

However, the coastal regions benefit in particular from this development. Ports on the North Sea and Baltic Sea have adjusted to serve the offshore wind sector. For example, areas for plant and component manufacturers have been created and heavy-duty terminals and berths for special ships in the industry are being built.

Employees are trained in service, maintenance and assembly in special training centres. The operation of the systems is monitored in control centres. In addition there are contracted service providers such as helicopter service, logistic companies, scientific experts, cable carriers and shipping companies.

In the event of turbine failures, operators of offshore wind farm owners lose huge amounts of money due to the high yields of multi-megawatt turbines. Especially if repairs are delayed due to weather conditions. Therefore, reliable systems and sophisticated service and maintenance concepts are necessary. Electronic remote turbine monitoring and redundant systems are standard, regular inspection and maintenance of foundations, rotor blades or cable connections are crucial. Experts estimate that service and maintenance account for up to a quarter of the costs of offshore wind farms, while the turbines themselves account for around a third.

Onshore, the costs of the systems account for two thirds of the total costs, while the share of service and maintenance is well below the 10 percent range. In addition to costs, the offshore industry has to deal with challenges in spare parts supply and personnel logistics. Especially in heavy seas, service teams are subject to several hours of travel and difficult transitions from the ship to the wind turbine. Helicopter transfers are faster but more expensive and often have to be cancelled due to fog and strong winds.

Therefore, the development of improved and new solutions for operation and maintenance (O&M) of offshore wind turbines and wind farms is an important contribution to make offshore wind power more cost-effective.

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4 France

4.1 Power, number of wind farms and turbines.

Wind power France is a growing industry. The installed capacity was approximately 16,5 Gigawatt (GW) at the end of 2019 according to the latest RTEBE report (January2020), with NO power from offshore installations. In 2019, a 7,2 % of the country's total electricity was generated using wind power 34,1Tw, compared to an estimated 1,6% in 2010. As of the end of 2018 France was the seventh largest producer of wind power in the world by installationsand the fourth in Europe.

4.2 Manufacturers and technologies with presence in the market.

France has a singel turbine technologists, nowadays:

- Vergnet in Orleans, that mades under 300kw windturbines, and distributes SL1500 and SL3000 Chinese made Sinovel windturbines, has fallen under Judicial Administration in 2017.

In the France market, there are two main manufacturers today.

- General Electric, after the adquisition of Alstom Wind (formerly the Spanish Ecotècnia) in 2014-2018, has two production sites, one in Saint-Nazaire, for Nacelles of Eliade Series(Eliade 150 and Eliade X), mainly focused in the offshore market, and another in Chabourg, for foundations and towers.

- Siemens Gamesa, is building in Le Havre a blades and nacelles production site. The site works started in 2019 and is previewed to finish in 2021-2022.

Francèole, that builded towers for de german market has fallen under Judicial Liquidation in 2019.

The technologies present in france, in June 2019, are:
Vestas: 4544 MW
Enercon: 3956 MW
Senvion: 2471MW
Nordex Acciona: 2157 MW
Siemens Gamesa: 1667MW
GE Renouvables Energy: 819MW
Vergnet: 80 MW
Others : 122 MW

4.3 Market structure by ownership.

79,5% of wind power installed in France is owned by 21 companies with more tan 200MW installed windfarms as 30 juin 2019. The bigest ENGYE, that controls 2160MW. (Observatoire 2019). There were 1876 windfarms in December 2019, in Metropolitan France.

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4.4 Presence of ISP (Independent Services Providers).

There are ISP in France. There is not a trade asociation of them. It's difficult to identify which companies providing services of maintenance in the french market are independent and wich are linked to the owner or to a technologist.

4.5 Main critical challenges on maintenance activities:

The first wind turbines in France were installed in 2001. and before 2005 the total installed capacity in France was 393 MW. After that, the rate of increase in France has been 10 to 100% every year, with an average of 28% in the period.

4.5.1 Aging of maintenance labour force

Very few workers can have more than 15 years experience in the wind sector in France. Among all the workers, there are some workers older than 40 years old. It isn't know how many wind turbines in france have elevators, that is the main problem for workforce in windfarms.

4.5.2 Life time extension trends

Due the youth of the wind market in France, very few wind turbines are in Lifetime extension period. France is under discusion on what is best, if repower the wind turbines or to life extend them. But in the PPE2020 is stated that they considere better to repower than to life extend.

4.5.3 Repowering

In 2017 the market opted to repower, starting to replace four 750 KW wind turbines by four 2.3MW wind turbines in Finisterre, Bretagne. In another windfarm, placed in a protected area close to Pointe de Raz, also in Bretagne, has replaced 750 KW wind turbines for 800 KW wind turbines, obtaining a 20% more economic performance due to the technological advance, and limiting the increase power obtained from the windfarm to 20%.

4.5.4 New installations

Onshore

For 2023 its forecasted to have an Onshore installed power in France of 21800 to 26000 Mw (24100Mw expected), and for 2028 of 33200 to 34700 Mw, as stated in the Programation Plurianuelle de l'Energie 2020.

Main complementary measures to transversal measures:

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• Prioritize the use of tenders to support the sector by reducing the perimeter of the window open to small parks developed in constrained areas and citizen parks.

• Maintain a stable regulatory framework with regard to park authorization, simplify it if possible and allow reasonable development times for project leaders, while ensuring that environmental issues are taken into account and the impacts on the environment and local residents.

• Make compulsory by 2023 the recycling of the constituent materials of wind turbines during their dismantling.

• Encourage the reuse of wind sites at the end of their life to re-establish more efficient machines.

• Launch experiments with innovative solutions to reduce light pollution while preserving aircraft safety and allow the consideration of new devices that can qualify for approval in early 2021.

• Develop a protocol for accurately and indisputably measuring levels of noise generated by wind turbines.

• Generalize the principle of total excavation of wind turbine foundations during dismantling and increase the amount of financial guarantees to take account of new technologies.

• Put in place a mechanism for the development of wind power be more balanced at national level and avoid risks of saturation.

Proposals will be made in 2020. Tenders will be launched up to 1,850 MW / year (excluding repowering) according to a scheduled timetable, from 500 MW to 925 MW per 6 months period.

Offshore

For 2023 its forecasted to have an offshore installed power in France of 2400 Mw, and for 2028 of 5,2 to 6,2 Mw, as stated in the Programation Plurianuelle de l'Energie 2020.

The commercial development of the offshore wind power sector was initiated by the launch of two calls for tenders in 2011 and 2013 and the allocation of nearly 3,000 MW distributed over six wind farms off Normandy, Brittany and Pays de la Loire. A third offshore wind tender was launched in December 2016 off Dunkirk. It was awarded in June 2019 for a capacity of nearly 600 MW. Regarding floating wind turbines, a technology at a less advanced stage of maturity, four pilot farm projects of 24 MW each were designated as winners of a call for projects launched by ADEME in 2017 as part of the Investment Program for future: one in southern Brittany, three in the Mediterranean. The first commissionings, linked to the first tender, are scheduled for 2021.

The exploitable technical potential for wind power installed according to ADEME is 90 GW. Due to limits linked to reconciliation with other uses of the sea, the potential is currently

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estimated at 16 GW. The technical potential for floating wind power would be 155 GW according to ADEME, of which 33 GW would be accessible taking into account the limits linked to reconciliation with other uses of the sea. In order to develop sea wind power, consultations were held were carried out with all the stakeholders in the context of the preparation of strategic plan documents , which in particular provide for the determination of areas intended to accommodate offshore wind projects. Given the success of the consultation which has been conducted, the first floating wind tenders will be launched in southern Brittany, then in the Mediterranean. The next wind turbine call for tenders will be launched in Normandy. From 2024, calls for tenders will notably be launched on extensions of offshore wind farms previously allocated, with shared connection with them.

4.6 Offshore maintenance: specificities and defies

France will import the knowledge of other countries for the maintenance of Offshore windfarms, but the first and second tender have been focused on close offshore sites, with sites going from 10 to 25 km far from the shore line.

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5 Netherland

5.1 Power, number of wind farms and turbines.

5.1.1 General perspectives

Wind power in the Netherlands had an installed capacity of 4,600 MW by the end of 2019, consisting of 3,482MW onshore and 1,118MW offshore [1]. This provided 10% (net) of the Netherlands electricity demand during 2019 according to CBS (Centraal Bureau voor de Statistiek or Statistics Netherlands). This corresponded to 2318 installations of which 289 were offshore. The Dutch government has a comprehensive plan for utilization of wind energy especially offshore based wind farms in North Sea. This plan has been divided into the three road maps, from years 2019-2023, 2023-2030 and 2030-2050.

5.1.2 Onshore development plan

For onshore based wind farms, the initial plan was to reach an installed capacity of 6000MW by the end of 2020.It was realized in the 2018 that only 4700MW of this target can be achieved so a new plan to install a total capacity of 7200 MW by the end of 2023 was provided [2]. In terms of numbers, at the end of 2015, there were at least 2,525 turbines installed onshore which could generate a total of 3,000 MW. To reach the target of 7,200 MW electricity generation by 2023, around 1000-1500 new wind turbines on land should be installed [3],[4].

5.1.3 Offshore development plan

The Dutch government has considered offshore wind energy as a main source of renewable energy for the country. According to a PBL report (Planbureau voor de Leefomgeving), three road maps have been considered for the development of offshore wind farms in the North Sea [5],[6]. The first road map covers a period from 2019-2023 and has the aim to install an offshore capacity of 3663MW at Hollandse Kust North and South and Borssele Kavels I,II,III,IV and V. This installed capacity corresponds to 372 offshore wind turbines.

The second road map covers the period from 2023-2030 when it is expected that a capacity of 6100 MW will be installed at Hollandse Kust West, North of the Wadden Islands and Ijmuiden Ver I,II,III and IV. Through this plan it is expected that 40% of the Netherlands electricity demand shall be provided by offshore wind energy by the end of 2030. This installed capacity corresponds to 426 number offshore wind turbines [7], [8], [9], [10].

Through a long-term plan covering the period 2030-2050, an average installation of more than 2.5 GW per year has been considered. According to this plan, by the end of 2050, there is an aspiration that a total installed capacity of 60,000MW of offshore wind power capacity will help fulfil 100% of the national energy demand from renewable energy. The status of existing and future offshore wind farm is shown in the Table 1. The source of this data is from a study commissioned by RVO (Netherlands Enterprise Agency) and TKI Wind op Zee (Top Consortium for Knowledge and Innovation Offshore Wind) in July 2019 [9].

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Table 7: Existing and future Dutch wind farms
Sources: 4C Offshore (2018) and MinEZK (2018a, 2019b), [17],[18],[19];

Offshore wind energy farms in the Netherlands	Installation start year	Commissio-ning start year *	Total capacity (MW) **	Single turbine power (MW) ***	Total number of turbines ***
Existing large wind farms					
PAWP - Prinses Amalia	2006	2008	120	2	60
OWEZ - Egmond aan Zee	2006	2007	108	3	36
Luchterduinen	2014	2015	129	3	43
Gemini	2015	2017	600	4	150
Total			*957 MW*		*289 WTGs*
Roadmap 2023					
Borssele 1 and 2	2019	2020	752	8	94
Borssele 3 and 4	2019	2020	732	9.5	77
Borssele 5 ****	2020	2020	19	9.5	2
Hollandse Kust South 1 and 2	2021	2022	760	10	76
Hollandse Kust South 3 and 4	2021	2022	700	11	64
Hollandse Kust North	2022	2023	700	12	59
Total			*3,663 MW*		*372 WTGs*
Roadmap 2030					
Hollandse Kust West	2024	2024-2025	1,400	13	108
Ten noorden van de Waddeneilanden	2025	2026	700	14	50
IJmuiden Ver 1	2026	2027-2028	1,000	15	67
IJmuiden Ver 2	2027	2027-2028	1,000	15	67
IJmuiden Ver 3	2028	2029-2030	1,000	15	67
IJmuiden Ver 4	2029	2029-2030	1,000	15	67
Total			*6,100 MW*		*426 WTGs*

* Commissioning year of future wind farms is an indication based on information from various sources;
** Realised and projected capacities; rounded figures with no decimals;

*** Indication of single turbine capacity and total number of turbines of realised projects and future projects; **** Borssele 5 is an innovation site.

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5.2 Manufacturers and technologies with presence in the market.

Companies in the Netherlands which manufacture and supply wind turbines are summarized as follows [11]:

2B Energy: This company are developing 6 MW offshore wind turbines. Their product has not yet been delivered to the market, but it is presently under development. They started activities in 2001.

EWT: This company supplies wind turbines in the range 250, 500, 900 and 1000 kW with a production capacity of 100 wind turbines/year.

Lagerwey: This company supplies wind turbines in the range 1, 5, 2, 3, 2, 5, 4 MW and 250-4000 kW (including older models) with a production capacity of 50 wind turbines/year. It is now at the forefront of the Russian market and is part of Enercon.

Seawind: This company is developing floating wind turbines of capacities 6.2 MW and 12MW for the offshore market. Their products have not been delivered to the market but are presently in testing. They started activities in 2014.

WES: This company supplies wind turbines in the range 50, 80, 100 and 225 kW with a production capacity of 12 wind turbines/year. So far, 1200 of these wind turbines have installed worldwide.

XEMC-Darwind: This company supplies onshore wind turbines in the range 2-4 MW with a production capacity of 150 wind turbines/year. They intend to supply 5 MW offshore wind turbines which are presently under the development. The Xiangtan Electric Manufacturing Corporation (XEMC) Ltd in China is the parent company of XEMC-Darwind.

Photo: 8.2 Group; Port of Eemshaven - Netherlands; Inspection of a 5MW rotor before shipping

5.3 Market structure by ownership.

Dutch-based companies Nuon (now part of Vattenfall), Shell, and Eneco (recently acquired by Japanese companies Mitsubishi and Chubu) were in the forefront of development of the early offshore wind farms in the Netherlands. Subsequent development of offshore wind farms, has seen other international developers such as Northland Power, Ørsted, and Vattenfall entering the market.

The Canadian independent power producer Northland Power is now the largest operational wind farm portfolio shareholder. However, this market leadership position will change with the commissioning of Borssele I and II, developed by Ørsted, and Hollandse Kust South I ,II , III and IV, developed by Vattenfall. If both developers meet their commissioning plan, Ørsted will be the largest operational wind farm portfolio holder in 2020 (with 752 MW) and Vattenfall will be the largest by 2022 (with 794 MW) and 2023 (with 1554 MW),[12].

In the development of wind farms, Dutch companies aim to stay competitive by the means of vertical cooperation, i.e., partnerships between developers and supply chain companies. A good example is the close cooperation of Eneco, Shell, and Van Oord, which are a part of the Blauwwind consortium (constructing Borssele III and IV), and the Witwind consortium that bid for the recent tender for Hollandse Kust South III and IV. Percentage ownership of existing and future Dutch offshore wind farms is shown in Table 8 [12].

Table 8: Shareholder/Ownership percentage per project, Source: Guidehouse analysis

Fully Operational					
Egmond aan Zee	50% Shell	50% Vattenfall			
Prinses Amaliawindpark	100% Eneco				
Luchterduinen	50% Eneco	50% Mitsubishi			
Gemini	60% Northland Power	20% Siemens	10% ALHIF[1]	10% HVCG[2]	
Pre-construction					
Borssele I & II	100% Ørsted				
Borssele III & IV	45% Partners Group	20% Shell	15% Mitsubishi	10% Eneco	10% Van Oord
Borssele V (innovation site)	33% Green Giraffe	33% Investri Offshore	33% Van Oord		
Under development					
Hollandse Kust Zuid I & II	100% Vattenfall				
Hollandse Kust Zuid III & IV	100% Vattenfall				

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Utility companies have the largest ownership of operational and projects under development in the Netherlands with 57% of the market. International financial investors with 11% and independent power producers (Northland Power) with 16% control more than a quarter of the total market. The remaining 15% portfolio share is distributed among other corporate entities, an oil & gas and low-carbon energy company (Shell), and a maritime contractor (Van Oord).The detailed breakdown of this ownership is shown in Figure 1 [12].

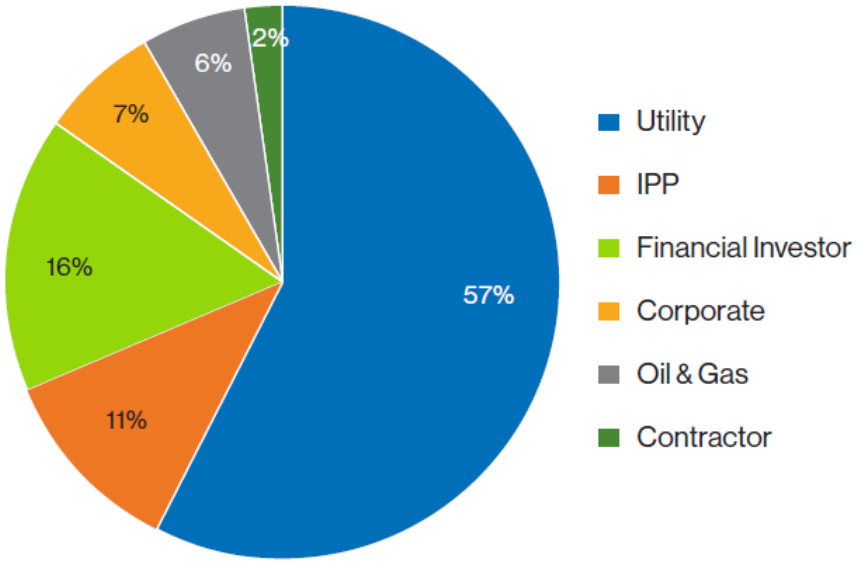

Figure 4 - Breakdown of market share of wind farms in the Netherlands
Source: Guidehouse analysis

5.4 Presence of ISP (Independent Services Providers).

ISP's are involved in all stages of the life cycle of an offshore wind farm, i.e. development, construction, operations & maintenance and decommissioning. Most relevant activities of ISP's in the Netherlands offshore wind energy can be categorized under the following headings [9]:

Foundation supply and installation

For the development of offshore wind farms in the Dutch part of the North Sea, mono-piles are used at present and this is expected to continue for the foreseeable future. The production of mono-piles and transition pieces is currently done in three shifts during five working days a week. Due to the development of ever larger turbines, monopiles are expected to increase in diameter to 12 m with masses in excess of 2 Gtonnes, substantially increasing required coating surfaces. These larger dimensions will also increase the number of manufacturing hours per monopile by more than 25%. A large proportion of the employment in the manufacturing of monopile and transition pieces is related to factory workers with general expertise in computer numerical control (CNC), metal working (laser cutting, rolling, milling, welding and assembly) and coating. Other employee categories include engineers, draftsmen, planners,

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shopkeepers, process operators, surveyors, logistics specialists, maintenance technicians, contract engineers and quality control (QC) professionals.

The installation of foundations includes monopiles and transition pieces. This work can be split into two categories: transportation and installation of the foundation. The resource involved for these two activities is mostly crew members of vessels and offshore personnel, e.g. offshore construction managers, drilling operators, superintendents, surveyors, riggers, lifting supervisors, bubble curtain operators, surveyors for geotechnical and geophysical and seismic investigation, QC and Health, Safety and Environmental protection (HSE) professionals. Regional stakeholders related to this area are, for example, Boskalis, DEME, and Van Oord.

Turbine installation

Turbine installation involves pre-assembling of towers and nacelles at the harbour site and offshore installation of these subassemblies including hub and blades. The high-level employment groups related to this work can be split into: 1) technicians and service engineers for onshore pre-assembly, 2) offshore personnel, i.e. offshore construction managers, superintendents, surveyors, lifting supervisors, riggers, site managers, wind turbine technicians and engineers, foremen, QC & HSE professionals, and riggers; and 3) vessel crew members. Relevant stakeholders are the offshore wind turbine manufacturers such GE Renewable Energy, MHI Vestas, and Siemens Gamesa Renewable Energy, and installers such as Van Oord.

Photo: 8.2 Group; Port of Sassnitz; Preassembly of rotors and towers before shipping

Cable installation

This work consists of the following: array cable laying, array cable pulling and termination. Regional stakeholders include: Acta Marine, Boskalis Subsea Cables & Flexibles, DEME, Van Oord, and Visser & Smit Hanab. The high-level employment groups related to this work are: 1) vessel crew, e.g. dynamic positioning operators, 2) offshore personnel for cable laying (i.e. offshore construction managers, superintendents, welders, bosuns, deckhands, crane operators, cable operators, deck foremen, tower teams, Remotely Operated Vehicle (ROV) pilots, surveyors for depth of burial inspections and post & pre cable lay inspections and professionals in geotechnical and seismic work); and 3) offshore personnel for cable termination.

Other support during installation

Part of this work involves various activities which support the developer, the wind turbine manufacturer and the main installation contractors to complete the installation activities efficiently and safely. Support services include: unexploded ordnance (UXO) surveys and removal, the supply of guard vessels, oil-clean up services, the supply of fuel and waste disposal. Some of these services are provided by local companies, while others are supplied by highly specialist companies that work nationally and internationally. Vessel crews are the most important employee group regarding this work package. Additional employment categories are related to the marine management and marine coordination services, maritime pilot services, helicopter support, weather monitoring and surveying with geotechnical, geophysical and seismic techniques. Key regional stakeholders in this work include: Acta Marine, Braveheart, C-Ventus, DEEP, DUC Marine, Fugro, MCS, Meteogroup, and SeaZip.

Wind turbine operation

Wind farm operation is generally done by the owner-operator or via subcontractors of the owner-operator. Large operators have centralized, regional control centres. Wind farm operations include day-to-day workflow management and the use of systems to control operation, store and analyze data, i.e. supervisory control and data acquisition (SCADA) systems and condition monitoring systems (CMS). These systems allow the operators to organize the necessary spares, tools and technicians before (large) failures occur. This results in more efficient use of resources and reduction in the loss of energy production. Stakeholders in this work are owner-operators of the wind farms, turbine manufacturers, and operations service providers. From an employment perspective various groups can be involved in this work package: management, monitoring coordinators, control room operators, systems engineers, professionals involved in data modelling and analysis, planning, engineers and technicians, administrators, QC and HSE professionals.

Turbine maintenance

This work involves preventive and corrective maintenance. Most wind turbines need a major overhaul after 10 years, because not all of the main components last the lifetime of the

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turbine. Major repairs are mostly carried out by specialist service technicians who are not stationed in the Netherlands.

Typically, wind turbines are supplied with a five-year, ten-year or fifteen-year service agreement and wind turbine manufacturers provide full turbine maintenance services during this period. At the end of the service agreement, the wind farm owner may negotiate for an extension or undertake the wind turbine maintenance itself or contract to a third-party services company.

Regional stakeholders in this work are turbine manufacturers such as GE Renewable Energy, MHI Vestas, and Siemens Gamesa Renewable Energy, and maintenance service providers like Deutsche Windtechnik. In general, the personnel involved are offshore wind technicians (levels 4-7). Level 4 and 5 technicians have general competencies in turbine inspection, maintenance, and repair. Level 6 and 7 technicians have more in-depth technical expertise for troubleshooting and team lead/coaching competencies. Other employment groups/professionals active in turbine maintenance are: site manager/coordinators, service managers, commercial project managers, stock keepers, project controllers, and HSE managers.

5.5 Main critical challenges on maintenance activities:

5.5.1 Aging of maintenance labour force

Developed countries are currently in an unprecedented transition to a new era with ageing populations [13]. Ageing will result in a smaller proportion of the population being employed in the coming decades. According to Statistics Netherlands (CBS) [14], there will be 4.2 million over-65s in the Netherlands by 2030.This is 920 thousand more than the numbers in 2019. This group will constitute 23 percent of the population by that year, versus 19 percent at the present. The number of over-80s will rise in particular, from 0.8 million at present to 1.2 million by 2030 [14]. The fertility rate in 2020 in Netherlands is 1.7 births per women which is under the standard norm of 2.1 which is required to replace the older generation by the new one. It is anticipated that with this population ageing trend, almost a quarter of the population will be over 65 in 2023 and with a reduced fertility rate, the overall labour market will face a shortage in the coming decades [15].

According to a TKI Wind op Zee report [9]. the total direct human resource that is needed specifically for turbine maintenance, inspection and logistics for the road map between 2019-2023 is 269 full-time equivalent (FTE) positions/year of which 139 FTE/year is technicians for turbine maintenance, 35 FTE/year is technicians for structural inspection and maintenance,

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62 FTE/year is other staff and 33 FTE/year is personnel on crew transfer vessels (CTV) and service operational vessels (SOV). All these jobs are related to direct human resource as indirect resource was not considered in this study. Moreover, these figures are only for the road map of 2019-2023; for the longer road map of 2023-2030 and the ambitious road map of 2030-2050, significantly more resource would be required. In addition, these jobs require specific competences which make it difficult to provide suitable resource. Therefore, educational institutes should facilitate more specialist courses and training which are aligned with relevant industry requirements [9].

5.5.2 Lifetime extension trends

The design lifetime of a current offshore wind farm is typically 20-25 years. The lifetime of an offshore wind farm is dependent on the lifetime of the most critical components, i.e. turbine and foundation. A critical design factor which plays an important role in defining the lifetime of these components is their fatigue life [16].

The electrical infrastructure can usually operate for 40 years assuming that it has been operated within the boundaries of its capacity, although this timescale cannot be guaranteed by its suppliers.

Typically, the subsidy plan to support a wind farm stops after 15 years of operation meaning that economic lifetime of a wind farm is less than its technical lifetime. Developers and wind farm owners also generally consider that the economic operational lifetime of a wind farm is 15 years [16]. An important decision factor which should be considered for lifetime extension of a wind farm is the conditions under which the wind farm has been operated during its 20 years of life. To determine its condition, appropriate monitoring data should be available especially for analysing the fatiguing of the turbine blades and foundations. Therefore, setting up of a data management team to extract these data and store them for future fatigue analysis is important when considering lifetime extension of a wind farm. This fatigue analysis determines the remaining lifetime of the important components. For other components, e.g. the electrical infrastructure, a similar analysis should also be considered. In the Netherlands, the Transmission System Operator (TSO), TenneT are responsible for the substation on site and the power cables to the main grid onshore. The question frequently asked now is whether these systems can economically and technically be used for 40 years or even longer.

5.5.3 Repowering

Repowering a wind farm site generally means re-using the existing electrical infrastructure and foundations (if possible) and replacing the wind turbines with new ones. The main technical and commercial difficulties which can arise from this concept can be categorised as follows [16]:

Turbine rating

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The first technical constraint is that a new wind turbine should not exceed the loading on the foundation for which the original turbine was designed. This is not a major technical problem, but the main challenge is whether a new turbine can be supplied to replace the old one in the following two decades. With the current trend for increasing the size of wind turbines, it seems financially not reasonable for a supplier to supply turbines with a relatively small (by whatever are the current standards) or out of date model unless re-powering is considered as an integral part of the wind farm life cycle from the beginning.

Support structure and foundation

The support structure and foundations are not designed and built with re-powering in mind. The support structure is designed for the 20-25 years' lifetime of the wind farm. If the support structure were to be designed for with re-powering in mind, the same challenge as described above still remains, namely that related to the availability of commercially available similar sized turbines twenty years in the future. Otherwise, the additional cost of the structure designed for re-powering would be wasted. For the foundations of a new wind farm with corrosion protection systems and if the health monitoring of the structures showed no degradation beyond design limits, then the re-use of wind farm foundation up to 35 years later may be an option.

Electrical infrastructure

The design lifetime of cables is far greater than other components of the wind farm so there is more opportunity to use them for re-powering. It might be interesting to consider the installation of higher capacity cables during the design phase. In addition to the purpose of re-powering, they could be used for the future extension of a wind farm or for a new wind farm utilising up-to-date turbines with larger rated power. However, investing in a larger capacity and doubling the operational life of cables would significantly increase the present levelized cost of electricity (LCOE). In the Netherlands, the offshore Lely wind farm in the IJsselmeer owned by Vattenfall (formerly Nuon) has been out of operation since 2014 but there is no plan for re-powering and the site is being decommissioned. The Irene Vorrink offshore wind farm, also owned by Vattenfall, is being assessed for re-powering.

5.6 Offshore maintenance: specificities and defies

In the German market, after the bankruptcy of Senvion in 2019, there are still three major manufacturers

Turbine maintenance consists of preventive maintenance (calendar-based and conditioned - based) and corrective maintenance. Calendar-based preventive maintenance is mostly planned during the months with acceptable weather conditions and it involves offshore checks of various systems, e.g. hydraulics, mechanical, electrical, control etc, and activities such as filter changes, bolt tightening and lubrication of mechanical parts. Condition-based preventive maintenance includes services which are based on a certain performance level where the wear levels of (sub) systems and components are inferred via monitoring systems.

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Unplanned corrective maintenance can cover a wide range of tasks, from resetting of (sub) systems to replacing (large) (sub) systems. This last type of maintenance is most intensive in the first stages after commissioning and at the end life of the wind turbines. The maintenance of a wind farm usually involves coordination between two main parties: the technical services and logistics (transfer facilities, personnel, tooling and spare parts).

The detailed logistics depends primarily on the distance of the wind farm to the port, the type of maintenance (preventive maintenance, corrective maintenance) and the effect of failure on the downtime of the wind farm. Transport options for the maintenance of existing and Roadmap 2023 Dutch wind farms are:

- Crew transfer vessels (CTV)
- Service operation vessels (SOV)
- Helicopters
- Combination of the previous options

It is expected that helicopters be used for the troubleshooting of large (+10MW) turbines during bad weather, as the downtime costs increase with increasing turbine size. As an example, currently the Dutch Gemini wind farm uses helicopters for wind turbine troubleshooting and the inspection of the offshore substations. The most common types of transport in Dutch waters for preventive maintenance are CTV and SOV. Of the existing offshore wind farms, Gemini uses SOVs and all the other wind farms use CTVs for preventive maintenance. For the Road Map 2023, Borssele III & IV wind farms will use SOVs and all the other wind farms will use CTV. For the Roadmap 2030, all offshore wind farms are expected to use SOVs.

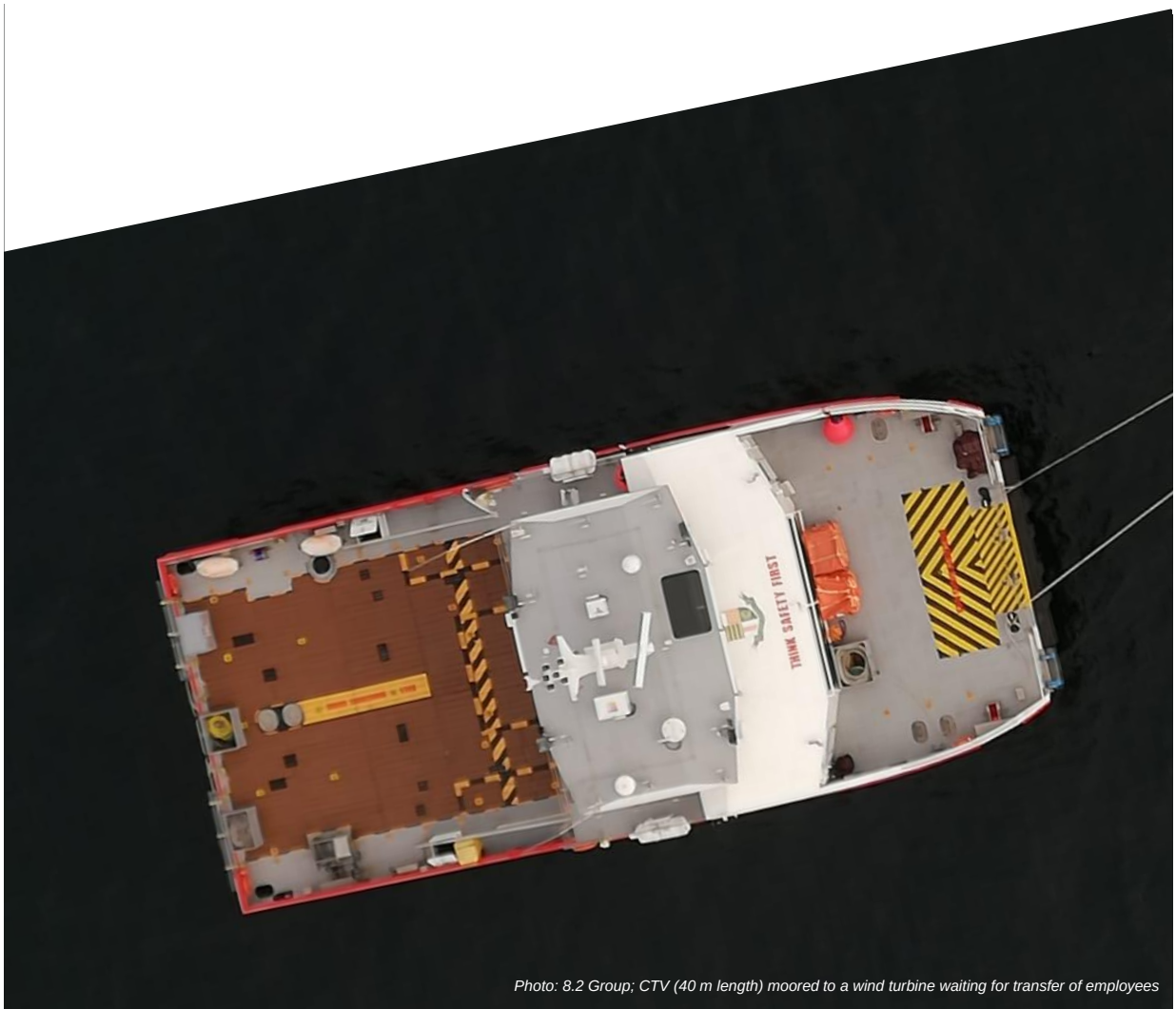

Photo: 8.2 Group; CTV (40 m length) moored to a wind turbine waiting for transfer of employees

A CTV shift of 12 hours or less (i.e. 4-4-week rotation) needs one captain and one sailor and a CTV shift of more than 12 hours needs one captain, one maritime officer, and two sailors, So the CTV concept is best suited for a local workforce living nearby the port. SOV crew member should consist of 15 persons. Persons for deck handling, crane handling and other facilities are part of these crew members. CTV shifts in the Netherlands consist of 8 working hours per day (shifts of 5 working days and 2 weekend days) or 12 working hours per day (4-days shifts). SOV shifts have 12 workings hours per day (2-week shifts) [9]. Vessel crew members are seamen who fall under the working and resting hours regime for seafarers. Vessel passengers (mostly maintenance technicians) fall under the Dutch Working Hours Act and cannot work as long as the vessel crew during a shift. A bottleneck is the current Dutch Working Hours Act [9],[20], especially due to limitations on shifts of longer than 12 hours and more flexible shift periods.

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6 Portugal

6.1 Power, number of wind farms and turbines.

In 2018 Portugal had a total installed capacity of wind energy of over 5.4GW. Figure 1 shows the evolution of the yearly installed wind power capacity (blue bars, left-side axis) and the cumulative installed capacity (orange line, right-side axis). The period between 2004 and 2010 represented the golden era of the investment associated with strong government support.

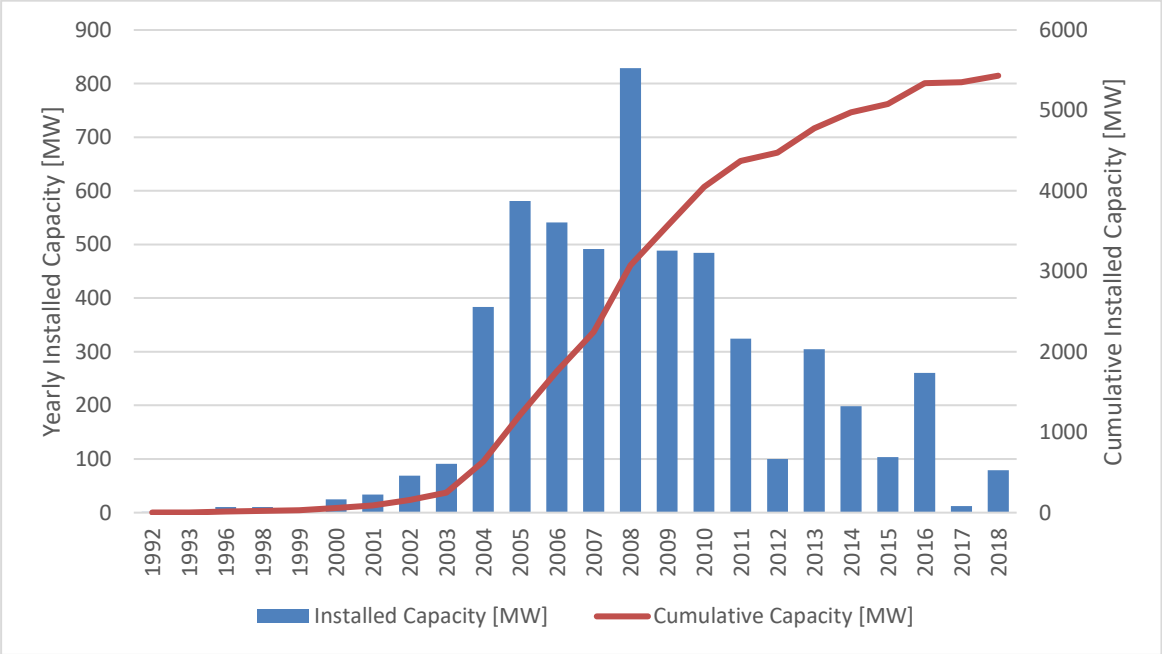

Figure 5 - Evolution of yearly installed and cumulative wind energy capacity

In Figure 2, the evolution of the Portuguese wind energy market in terms of number of wind turbines (WTG) installed is shown. The number of yearly installed wind turbines is represented by the blue bars (left-side axis) and the orange line represents the cumulative number of wind turbines (right-side axis). Most of the wind turbines were installed in the aforementioned period associated with the increase of the capacity.

Photo: 8.2 Group; Wind energy supply for one of the largest blade factories in Europe; Aveiro-Portugal

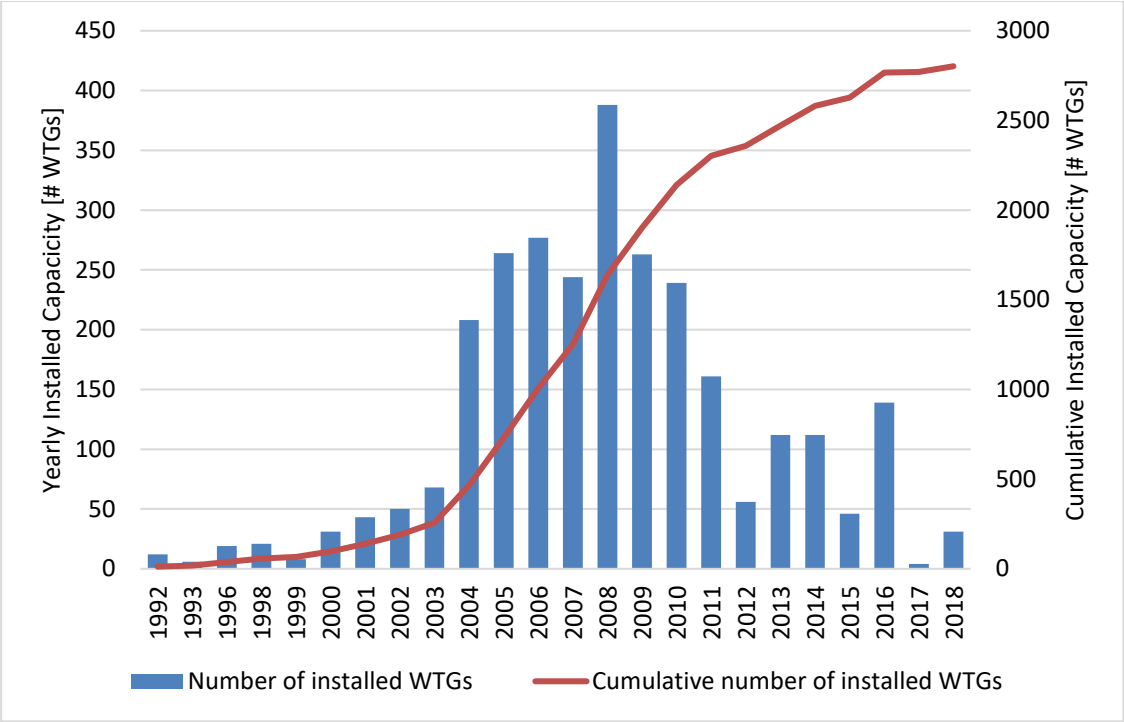

Figure 6 - Evolution of yearly installed and cumulative number of wind turbines

Another fact that emerges from analyzing both indicators together is a steady increase in the average wind turbine capacity. This is shown in Figure 3 where it can be observed that the during the rapid expansion of the installed based the average wind turbine size was around 2MW, while the latest installations are associated with larger wind turbine whose nominal power exceeds 2,5MW.

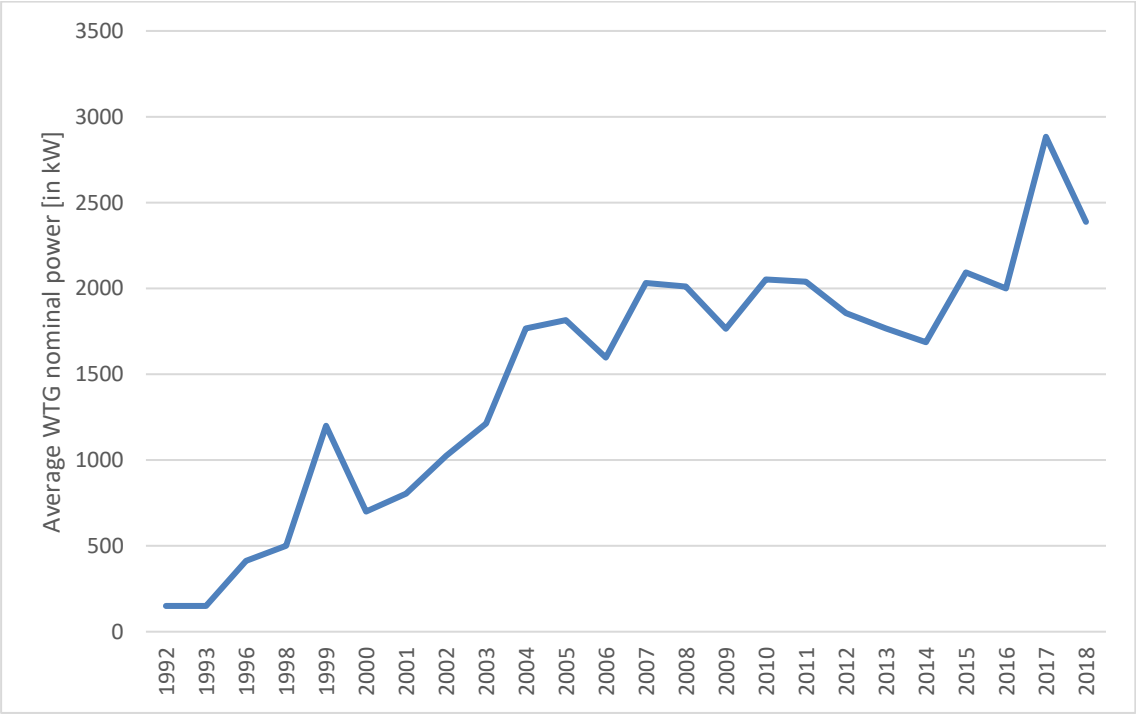

Figure 7 - Evolution of the average wind turbine size

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6.2 Manufacturers and technologies with presence in the market.

The main manufacturers present in the Portuguese wind turbine fleet are shown in Figure 4. More than half of the installed capacity is associated with wind turbines of Enercon. The five most representative manufacturers represent a total of 92% of the installed capacity (Enercon, Vestas, Gamesa, Senvion, Nordex). A total of 15 manufactures are represented in the Portuguese fleet.

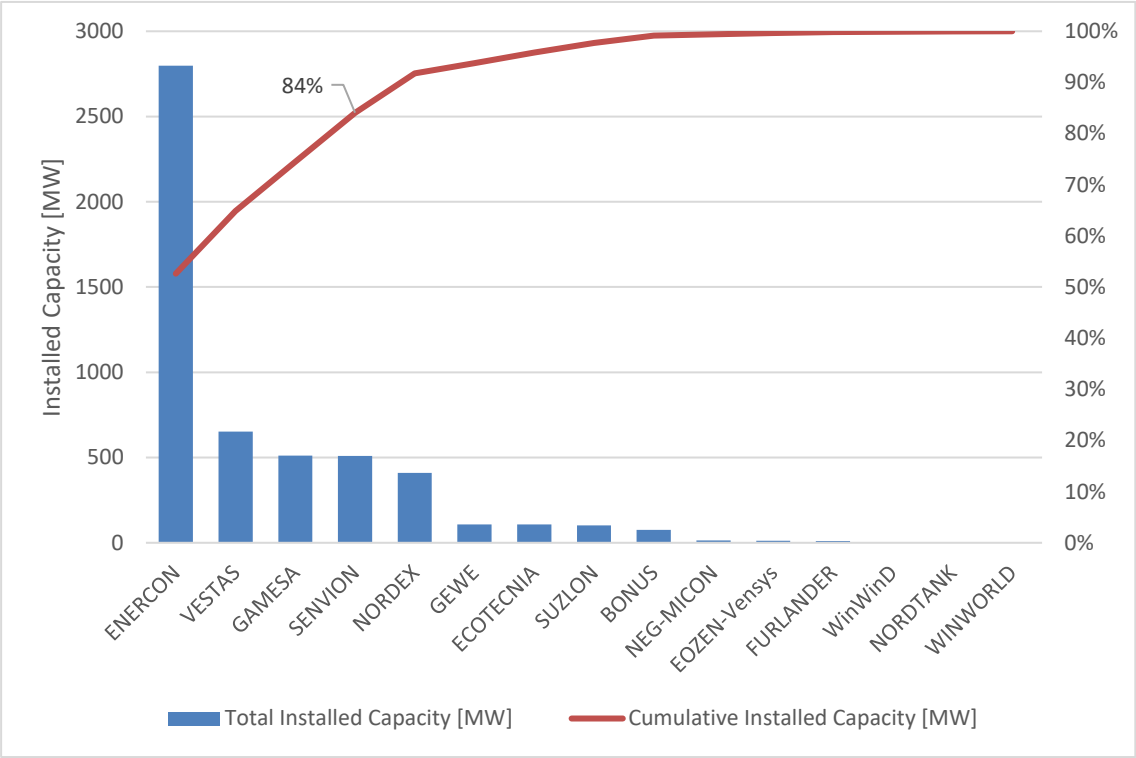

Figure 8 - Distribution of the installed capacity by manufacturer

Analyzing the evolution over time of the installed capacity per manufacturer, that the majority of the new installations are Enercon wind turbines, although recently a significant number of Senvion turbines are also being installed. The evolution of the installed capacity of the five major manufacturers in depicted in Figure 5.

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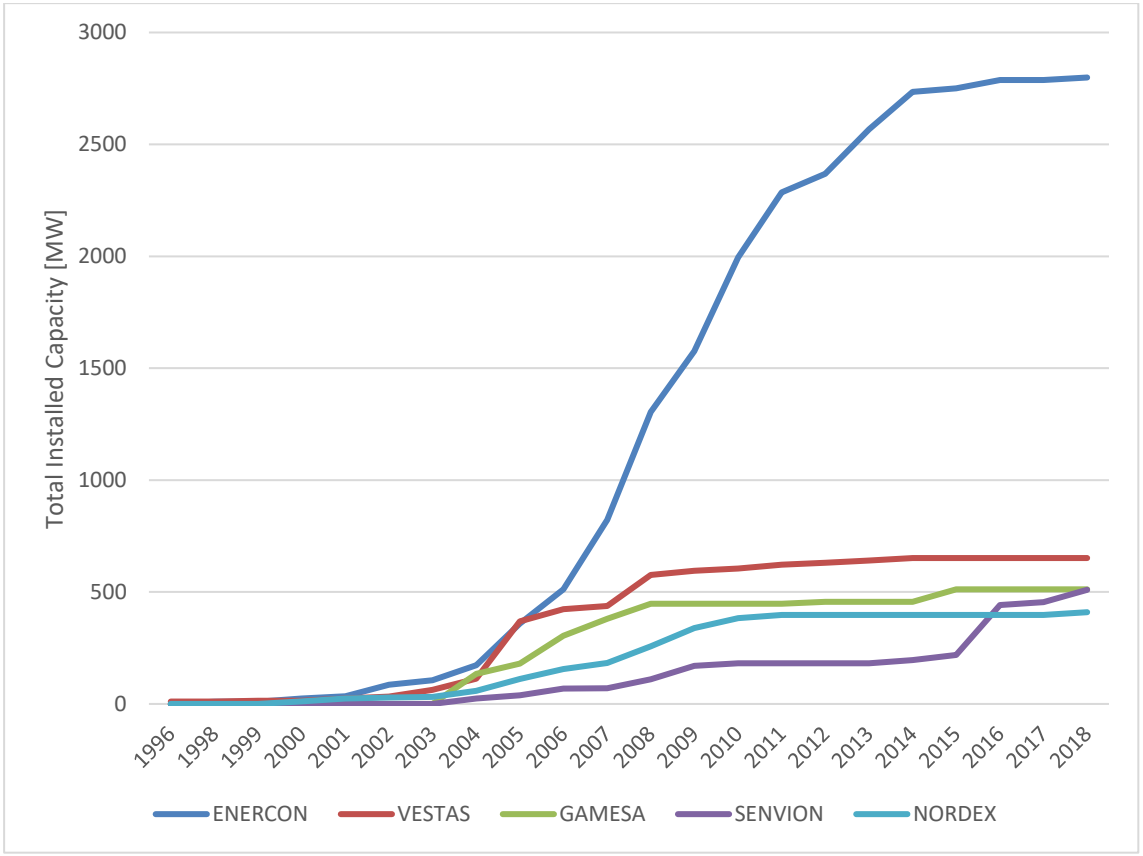

Figure 9 - Evolution of the total installed cap. of the five most repr. manufacturers

Regarding the technologies, Figure 6 presents the most common wind turbine models in the Portuguese fleet. As expected, many Enercon models are in evidence (E-82, E-70 and E-92), yet there are also other representative models such as Vestas V90, Nordex N90, Senvion MM92 and Gamesa G87.

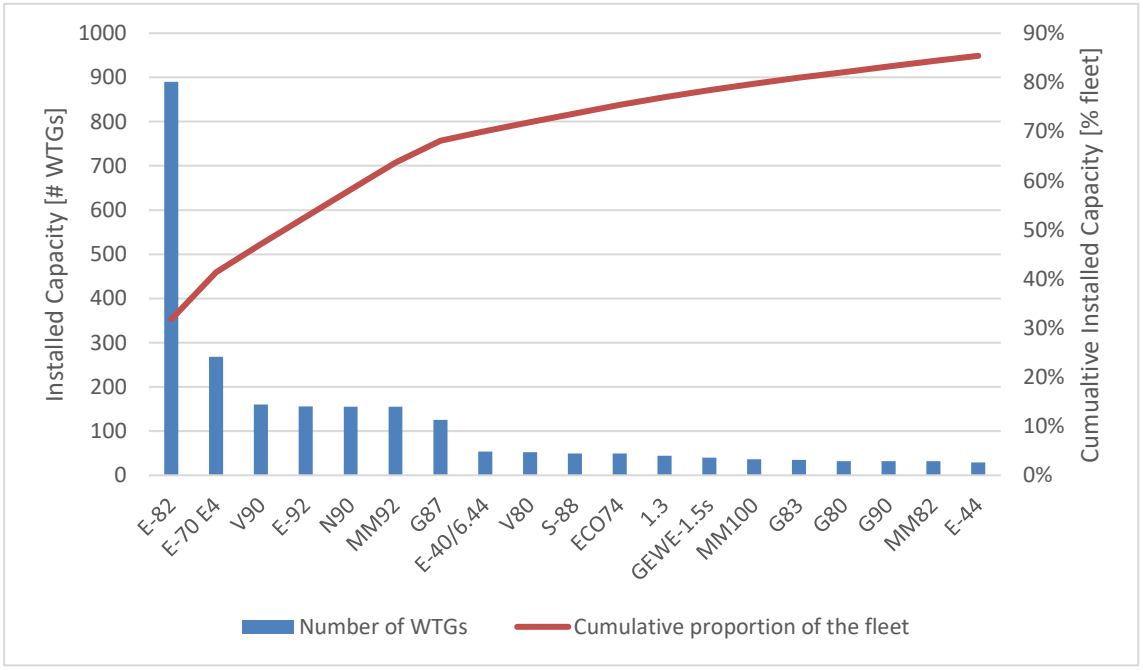

Figure 10 - Most representivite wind turbine models in the Portuguese fleet

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The distribution of the wind turbine fleet per wind turbine capacity range is depicted in Figure 7. It is observed that the most common size is between 2 and 2,5 MW. In fact, the majority of the fleet (almost 50%) has a nominal power of 2MW.

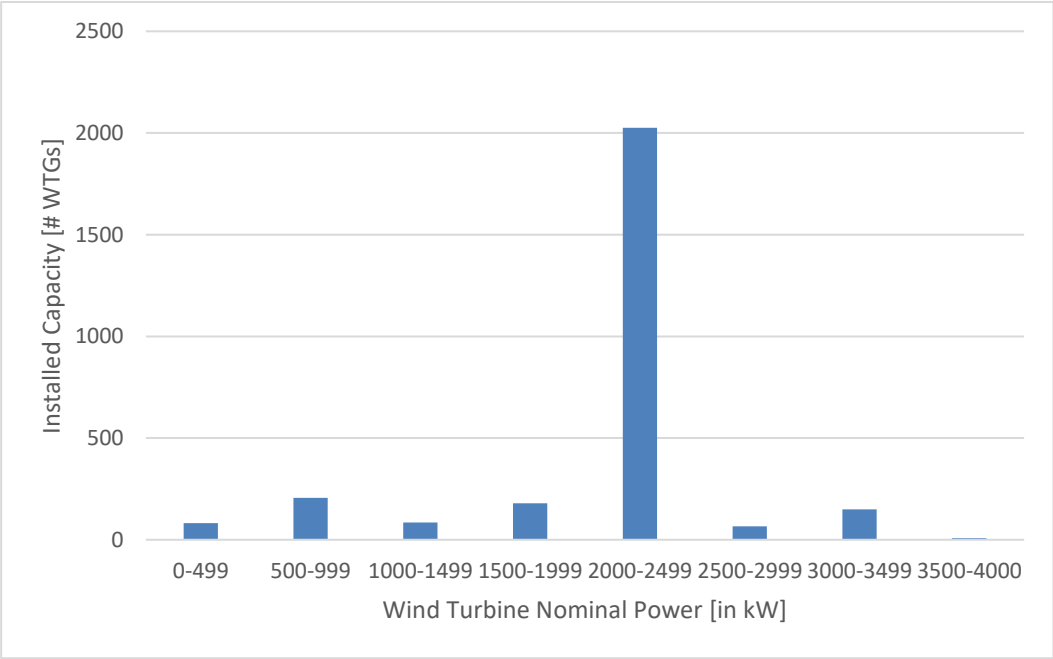

Figure 11 - Distribution of the number of wind turbines per nominal power in kW

6.3 Market structure by ownership.

The structure of ownership is presented in Figure 8.

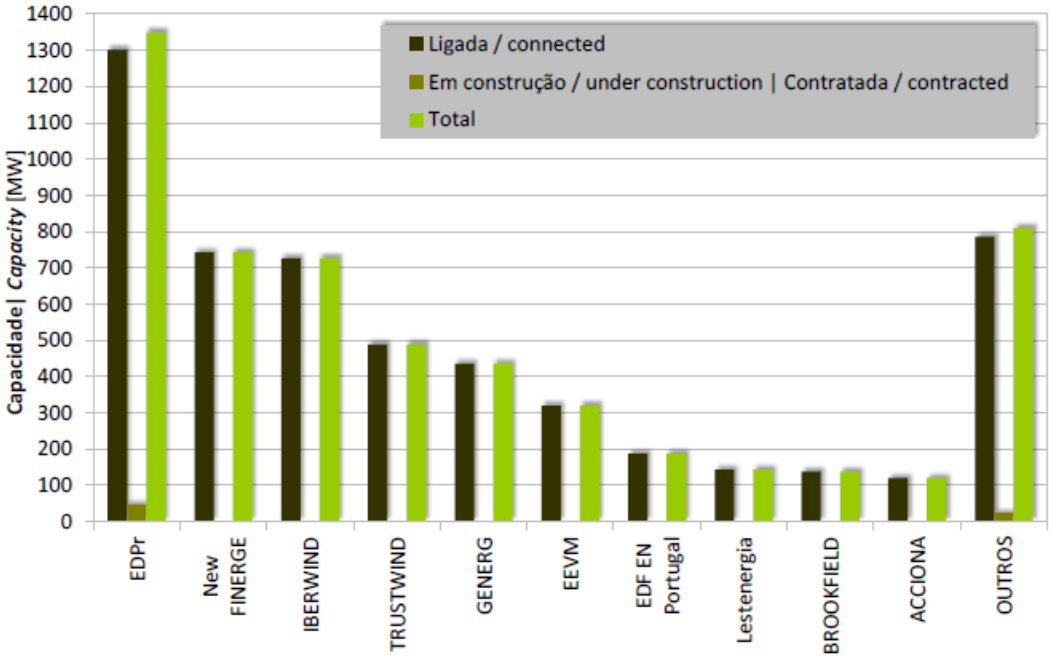

Figure 12 - Main promoters in Portugal

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6.4 Main critical challenges on maintenance activities:

6.4.1 Lifetime extension trends

Despite the opportunity and the potential value-added for wind power plants with evaluation programs and life span, the country still requires a long-term regulation work that defines the rules for repowering actions in order to ensure or increase the current power of power that the country meets its international commitments assumed for the future.

6.4.2 New installations

According to the report of APREN (Portuguese Renewable Energy Association) and INEGI (Institute of Mechanical Engineering and Industrial Management) dating from December 2018 there were three new wind farms under construction, representing a total of 70.9 MW.

Table 9: New wind farms installed from 2018 in Portugal

Name	*District*	*Total capacity* [MW]	*Number of WECs*	*Nominal power*[kW]	*Manufacturer*	*Model*	*Condition*
RIABLADES	Aveiro	3.7	1	3700	SENVION	3.7M140	Construction
PENACOVA	Coimbra	46.8	13	3600	SENVION	3.6M114	Construction
MARVILA II	Leiria	20.4	6	3400	SENVION	3.4M122	Construction

6.5 Offshore maintenance: specificities and defies

The first floating wind farm in Portugal is under construction, it will be one of the largest floating wind farms in the world, it uses semi-sub technology. The project is called WindFloat Atlantic and was created by EDP Renováveis, Repsol and Principle Power with €60 million funding from the European Investment Bank.

When operating the wind farm should inject energy into the grid enough electricity to supply 16,000 homes. The WindFloat Atlantic farm will have three 8.4MW wind turbines and the platforms will be deployed in-line, all at the same latitude, and at about 600 m from one another.

Since the platform will be deployed in very deep seas off the coast of Viana do Castelo, floating foundations (rather than 'traditional' foundations, whose bases are fixed to the seabed) have been chosen. This project will contribute to creating a new technological standard in wind power exploitation thus also being important to the specificity of offshore maintenance.

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7 Uruguay

7.1 Power, number of wind farms and turbines.

By the end of 2019 there was 1,507 MW wind power capacity installed in Uruguay. There are 42 installations greater than 150 kW.

In total there are 677 wind turbines installed in the country.

7.2 Manufacturers and technologies with presence in the market.

The Uruguayan wind energy market is shared between several foreign manufacturers.

Vestas (559 MW), Gamesa (390 MW), Nordex (309 MW), Enercon (169 MW), Suzlon (65,1 MW), Others (Net Wind, etc.) (18,45 MW)

7.3 Presence of ISP (Independent Services Providers).

Several companies, mainly with European origin, provide independent services in Uruguay:

Ingeteam, Ynfiniti, Tecnovex, Fibervent, Safework, etc.

7.4 Main critical challenges on maintenance activities:

7.4.1 Lifetime extension trends and repowering

Older wind turbines started generating in 2009 and work properly, most from 2014, it is not yet time to think about extending useful life or repowering.

7.4.2 New installations

The priority now is for photovoltaic generation due to its complementarity with wind generation. But it is not announced in the near future. New wind generation facilities would come even later. It depends on the growth of electricity demand, etc.

7.5 Offshore maintenance: specificities and defies

There ist not offshore generation in Uruguay yet. There are still many possibilities for onshore installations in Uruguay. In the short to medium term it is not expected that offshore wind energy will be installed.

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8 Spain

8.1 Power, number of wind farms and turbines.

With over 26 GW of wind power capacity installed, Spain holds the second position in Europe and the fifth worldwide. Figure 1 shows the evolution of the yearly installed wind power capacity (blue bars, left-side axis) and the cumulative installed capacity (orange line, right-side axis). As can be seen, there was a period of over 10 years with over 1 GW being installed per year. Period of which, during several years, it even overcame 2 GW per year. The effects of the economic crisis can also be clearly appreciated in the graph (after 2010, up until last year). It appears that new installations will be resumed, as it happened already in 2019, and as it is stated in the Spanish Integrated Climate and Energy National Plan (*Plan Nacional Integrado de Energía y Clima, PNIEC*).

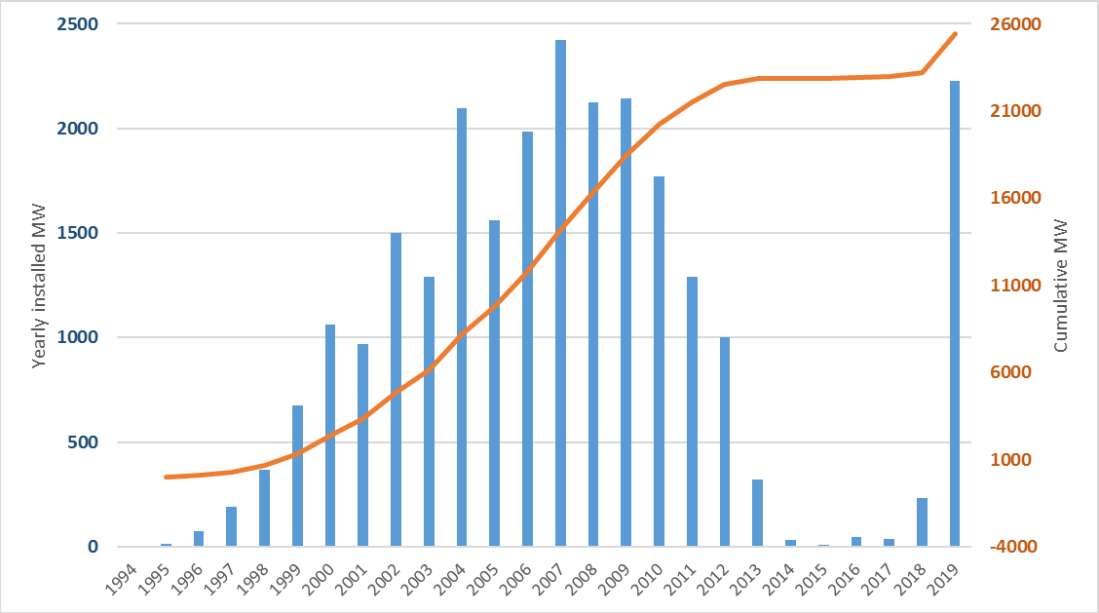

Figure 13 - Evolution of yearly installed and cumulative wind energy capacity

In Figure 2, the wind energy market evolution in terms of number of wind turbines installed is shown. The number of yearly installed wind turbines is represented by the blue bars (left-side axis) and the orange line represents the cumulative number of machines (right-side axis). Once again, the rapid growth between 2000 and 2012 is observed, as well as the effects of the economic crisis after that, and how the trend is now changing towards a new growth again.

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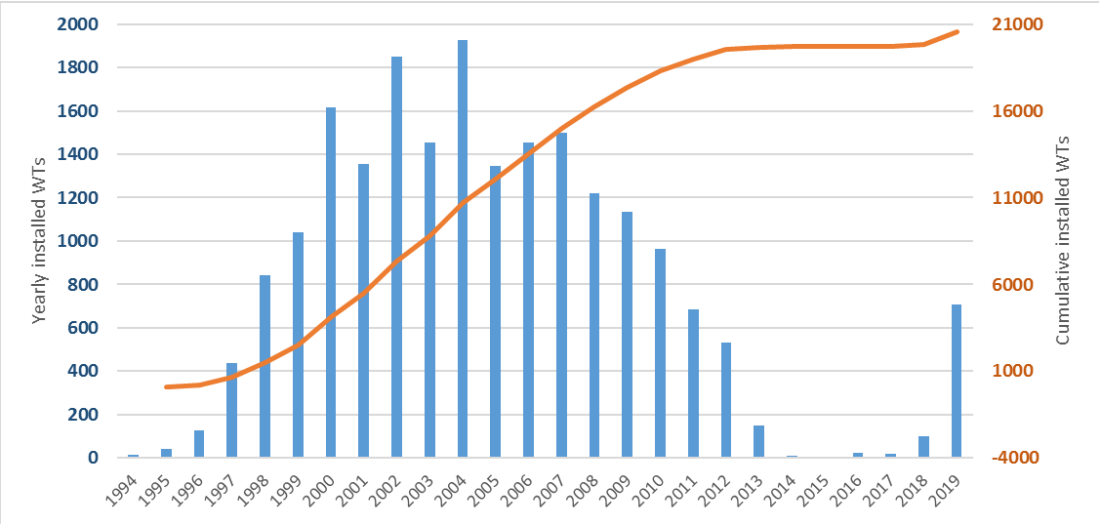

Figure 14 - Evolution of yearly installed and cumulative wind turbines

Analysing both graphs jointly, the rapid growth of the average WT-size is clearly appreciated, from a few kW to over 3 MW wind turbines, as depicted in Figure 3. This is especially clear during 2019 where it appears that the number of wind turbines installed is below the average of the total, but in terms of MWs installed it is over 2 GW (see Figures 1 and 2). As can be seen in Figure 3, the WT-size average trend between 2015 and 2018 is not met, which is likely to be due to the economic crisis where the investments were not usual.

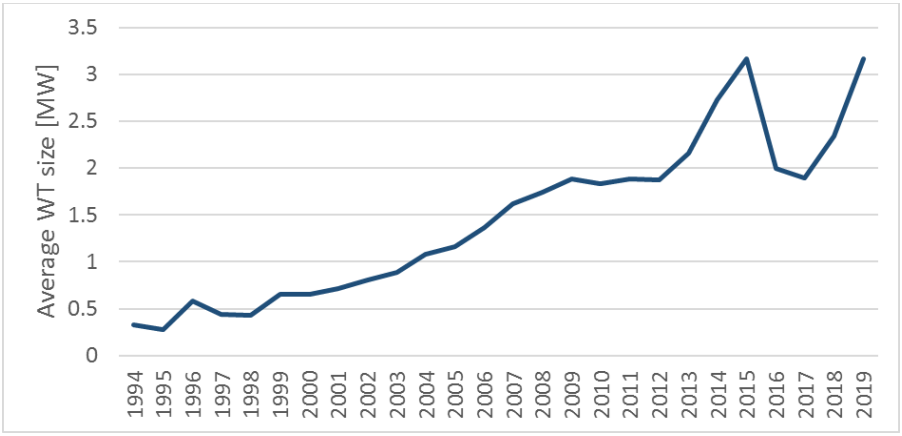

Figure 15 - Evolution of wind turbine size on average

In order to frame the Spanish wind energy production in the electricity market, the national electric demand covered by wind is depicted in Figure 4. As ca be seen, around 20% of the electric demand is covered by wind energy. In this regard, Spain holds a worthy position in the European ranking, being among the top-5.

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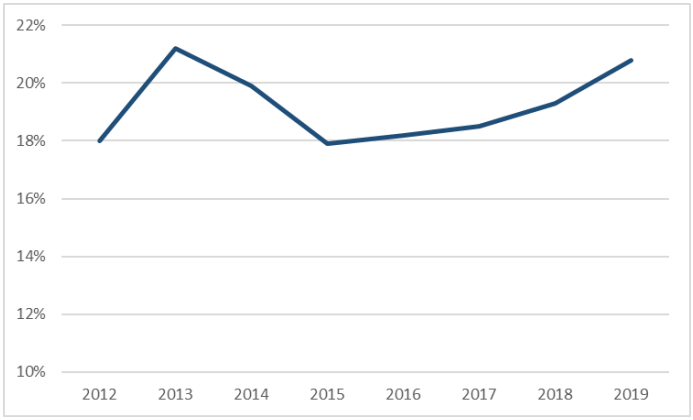

Figure 16 - Electric demand covered by wind in Spain

8.2 Manufacturers and technologies with presence in the market.

The main manufacturers present in the Spanish wind turbine fleet are shown in Figure 5. There have been changes in some of the main companies in terms of ownership and fusions along the past fifteen years, such as the famous Siemens and Gamesa case, or Nordex and Acciona.

Figure 5 depicts the current scenario, i.e. the distribution in terms of manufacturers of currently operating wind turbines. The prevalence of Siemens Gamesa, representing over 50% of the fleet, is clear, followed by Vestas (15.63%), MADE (9.18%) and Alstom Ecotecnia (7.52%). Nordex Acciona Wind Power and General Electric represent 5% of the fleet (each). The rest of the manufacturers show percentages around 1%. Finally, the category "MIX" (less than 1%) includes 144 wind turbines manufactured by Electria Wind (1), Eozen (3), Fuhrländer (15), Lagerwey (50), M-Torres (32), Norvento (3), Repower (13), Sinovel (12), Vesys/Goldwind (1) and Windeco (1). The rest 13 are from unknown manufacturer(s).

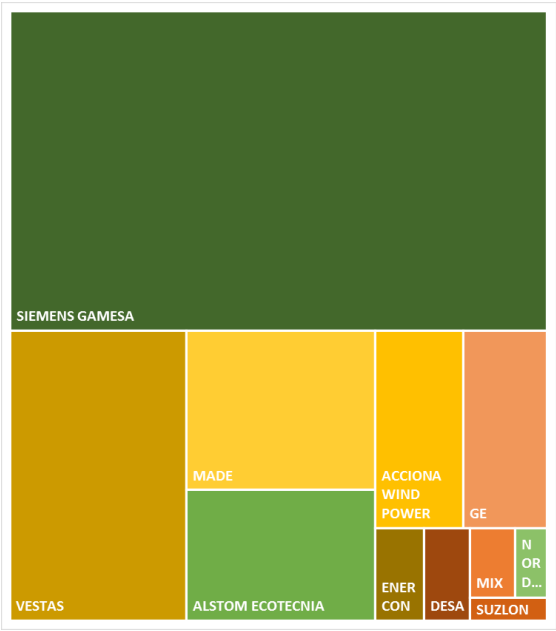

Figure 17 - Distribution of wind turbine manufacturers *(2019)*

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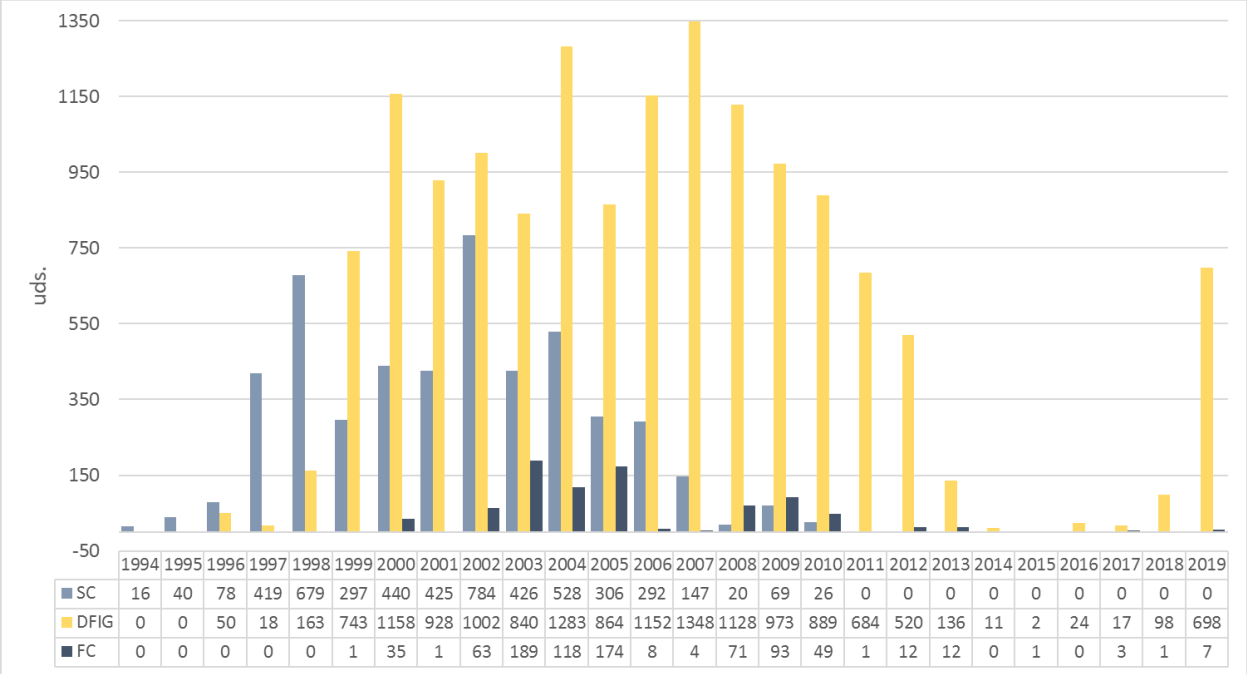
Regarding wind turbine technology and size, a detailed analysis per year of installation is described as follows. Three technologies are distinguished: squirrel cage (SC), doubly-fed induction generator (DFIG) and full converter (FC). In Spain, 71.63% of the wind turbines are DGIF, 24.28% are SC and 4.10% are FC. Figure 6 depicts the evolution of yearly installed wind turbines per wind turbine technology.



	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
SC	16	40	78	419	679	297	440	425	784	426	528	306	292	147	20	69	26	0	0	0	0	0	0	0	0	0
DFIG	0	0	50	18	163	743	1158	928	1002	840	1283	864	1152	1348	1128	973	889	684	520	136	11	2	24	17	98	698
FC	0	0	0	0	0	1	35	1	63	189	118	174	8	4	71	93	49	1	12	12	0	1	0	3	1	7

Figure 18 - Evolution of wind turbine technologies

The wind turbine size is also analysed as follows, the distribution of the wind turbine fleet per wind turbine capacity range can be seen in Figure 7. It is observed that the most common sizes are between 0.5 and 1 MW, and around 2 MW.

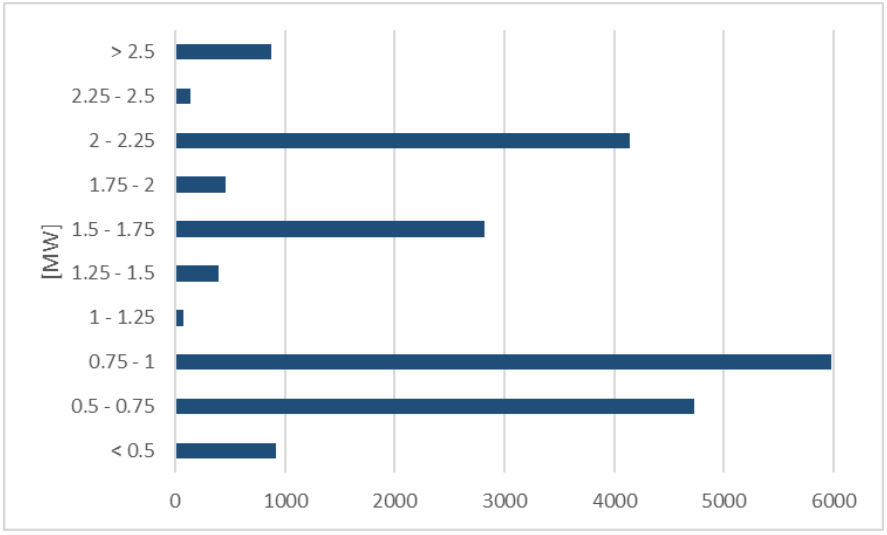


Figure 19 - Number of WT per WT-size *(2019)*

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8.3 Market structure by ownership.

The structure of ownership is presented in the following table; it is important to notice the big presence of utilities among the main developers in Spain.

Table 10: Share of the Wind market in Spain-2019 (Source: AEE)

PROMOTOR	Potencia eólica instalada en 2019 (MW)	Potencia acumulada a cierre de 2019 (MW)	Cuota de mercado sobre el acumulado (%)
IBERDROLA	69,3	5.646,23	21,97%
ACCIONA ENERGÍA	0	4.297,82	16,72%
EDP RENOVÁVEIS	52,88	2.084,05	8,11%
ENDESA(ENEL GREEN POWER ESPAÑA)	501,74	1.993,29	7,75%
NATURGY	549,65	1.798,01	7,00%
EOLIA RENOVABLES	0	654,3	2,55%
SAETA YIELD	0	512,56	1,99%
VAPAT	0	471,25	1,83%
RWE	0	442,71	1,72%
OLIVENTO	0	420,79	1,64%
VIESGO	24	404,61	1,57%
ENERFÍN	0	390,13	1,52%
BORA WIND ENERGY MANAGEMENT	0	329,99	1,28%
MOLINOS DEL EBRO	0	284,65	1,11%
SIEMENS GAMESA	49	269,46	1,05%
MEDWIND	0	246,75	0,96%
RENOVALIA RESERVE	0	243,96	0,95%
FORESTALIA	242	241,56	0,94%
IBEREÓLICA	0	194,3	0,76%
ALDESA ENERGÍAS RENOVABLES	0	164,05	0,64%
ELECDEY	0	140,1	0,55%
WPD AG	135	135	0,53%
EÓLICA DE NAVARRA	0	134,38	0,52%
NORVENTO	128,25	128,25	0,50%
FERSA	0	79,7	0,31%
GRUPO JORGE	117,44	117,44	0,46%
OTROS	374,96	3878,38	15,09%
TOTAL	2243,28	25.704	100,00%

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8.4 Presence of ISP (Independent Services Providers).

Spain is probably the country where the installation of ISPs has been more successful and there are many companies offering those services, enclosed it can be found a non exhaustive list of some of those companies acting not only in Spain but also overseas, especially in LATAM countries.

Table 11: Spanish Maintenance Companies-2019 (Source: AEMER)

SPANISH MAINTENANCE COMPANIES
ALTERTEC
AMARA
AS SOLAR
ATM ESPAÑA / EFACEC
BAYWA
COVER VERIFICACIONES ELÉCTRICAS, S.A
FIBERVENT
GDES / COMSA GENERACIÓN DE ENERGÍA SOSTENIBLE, S.L
GES
GILDEMEISTER ENERGY SERVICES IBERICA SLU
INGETEAM SERVICE
MAGMA, GESTIÓN INTEGRAL DE MANTENIMIENTO
METALÚRGICA BB,S.L.
OHL INDUSTRIAL
OPDE O&M (OPDENERGY)
OREMOTOR
PINE INSTALACIONES Y MONTAJES
REVERGY
SANTOS MAQUINARIA ELÉCTRICA
SOLARIG
SUNGROW IBÉRICA
ADVENTIS
ASAKEN
COMANTUR
CORFREE
EROM
HUSO 29
IM FUTURE
MANVÍA
PINILLA HIDRÁULICA
RESGREEN
TAMOIN
TECNORENOVA
WIND 1000
COVERWIND
COBRA ENERGÍA
YNFINITI ENERGY GROUP

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8.5 Main critical challenges on maintenance activities:

8.5.1 Aging of maintenance labour force

In order to understand the required O&M activities, knowing the age of the wind turbine fleet is essential. In this regard, the age of the Spanish wind turbine fleet is analysed in terms of MWs and number of machines, as depicted in Figure (left and right, respectively).

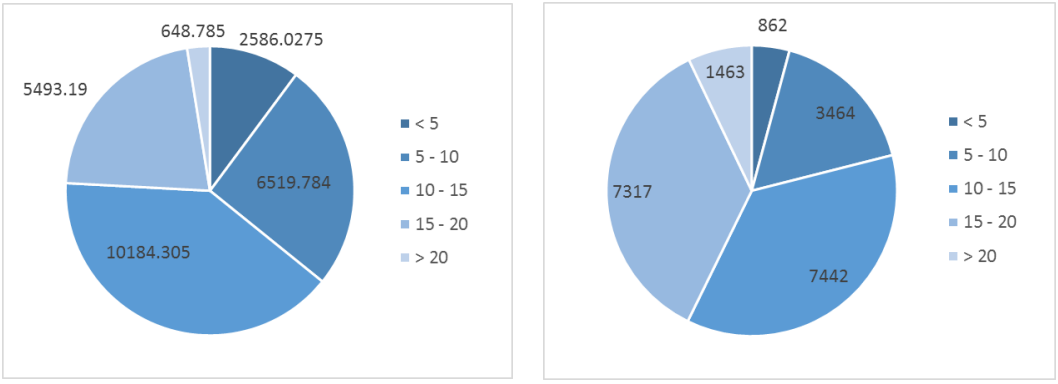

Figure 20 - Spanish WT fleet age in MWs *(left)* and in number of machines *(right)*

Over 60% of installed MWs and 70% of number of machines are over 10 years old. In terms of installed MWs, 2.55% has overcome the expected 20 year lifetime. Looking at the number of machines, more significant considering maintenance activities, 7.12% of the fleet is over 20 years old. As follows, the age distribution per technology is analysed (Figure 9). As can be seen, SC shows the oldest distribution, with nearly 25% of the machines being over 20 years old and nearly 50% of them between 15 and 20 years old. The DFIG technology shows a more spread distribution with small percentages over 20 years old, or younger than 5 years old. As opposed to SC technology, the FC one is the youngest part of the fleet, with cero wind turbines being over 20 years old, and around 65% of them being younger than 15 years old.

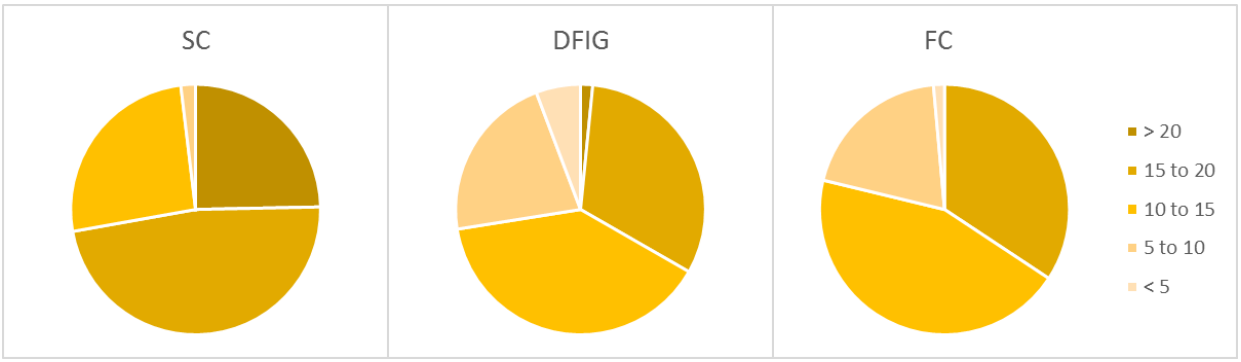

Figure 21 - Spanish WT fleet age distribution per technology

8.5.2 Life time extension trends

The general trend in the Spanish market is the life extension of the assests as far they are already repaid and the net income is based in the difference between the spot price (wind

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farms in operation before 2004 have lost the premium) and the variable OPEX. Therefore, it is important to guarantee a high level of availability and therefore the attention is concentrated on the components presented in the following figure.

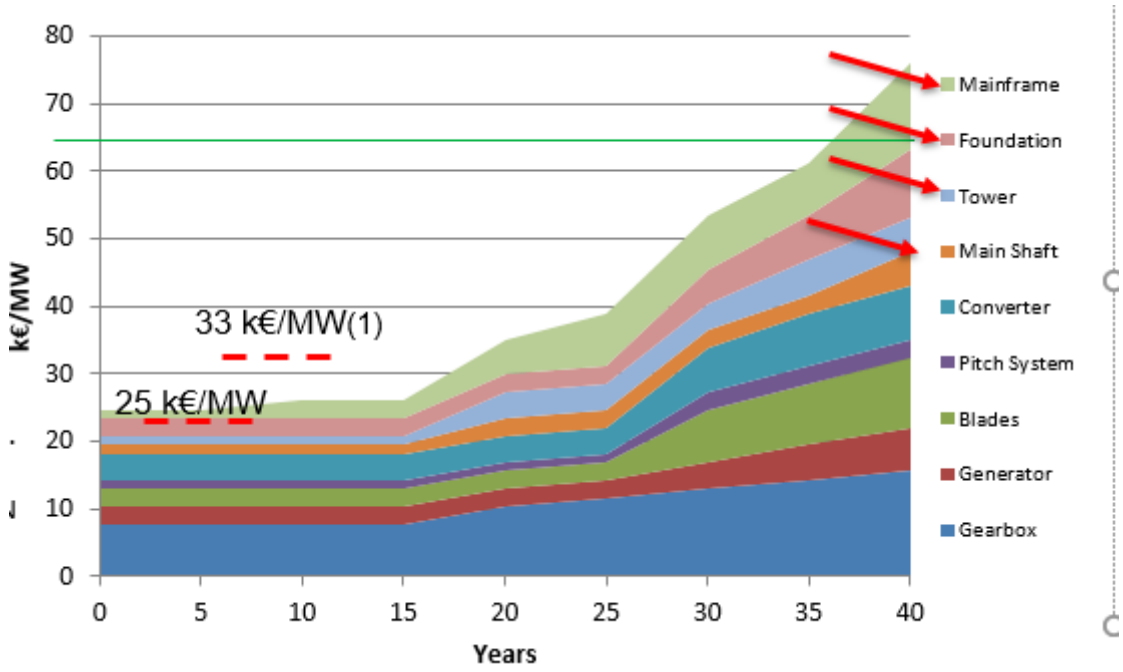

Figure 22 - Wind turbine aging function *(Source: J.Teson EGp)*

These figures are based on the theoretical fatigue behavior and the expected evolution of the parts supply cost, including technological obsolescence. Correlation between failures and age is heavily site, maintenance track, and WTG model specific. The qualitative failure depends on the proper maintenance done in the previous years and the accumulation of loads through the years. There are not published papers about Opex evolution beyond year 30.

8.5.3 Repowering

In the following figure is presented the aging of the wind farms in terms of power in different time thresholds. In principle, as it was mentioned in the previous section, it would be necessary some kind of incentives, especially if the goal is to get new orders for turbines manufacturers and to achieve the 2030 emissions reductions because new wind farms can duplicate the production for the same power and more of the old turbines are in the best wind conditions.

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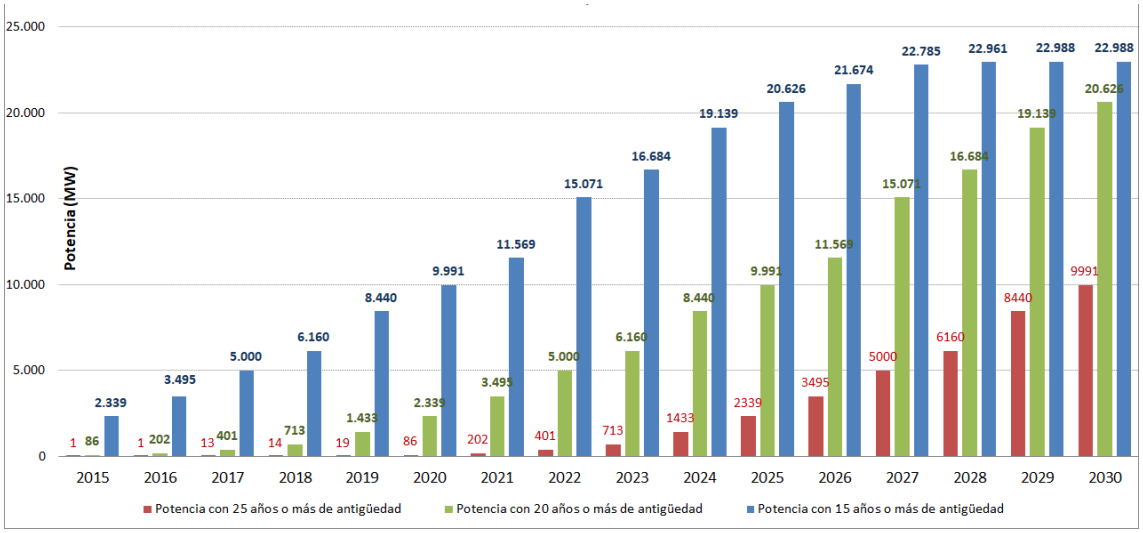

Figure 23 - Wind Farms aging in Spain *(Source: AEE)*

Only, nearly 200 MW have been repowered in Spain since 2007. The following table presents all wind farms that have been repowered in the country, including its main characteristics:

Table 12: Repowered Plants In Spain (Source: AEE)

Rep. Year	Wind Farm	Location	New WF MW
2007	Los Valles	Lanzarote (Canary Islands)	6.50
2008	PESUR	Tarifa (Cádiz-Andalucia)	4.00
2008	SEASA	Tarifa (Cádiz-Andalucia)	64.00
2012	Juan Adalid	Canary Islands	1.60
2012	Fuencaliente	Tenerife (Canary Islands)	2.25
2012	Carretera de Arinaga	Islas Canarias	6.32
2014	Cordal de Montouto	Galicia	14.00
2016	Cabo Vilán	Galicia	18.00
2017	Malpica	Galicia	38.66
2017	Punta Gaviota		15.87
2018	El Cabrito	Andalucia	90.00
2019	Zas	Galicia	24.00

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8.5.4 New installations

According to the NPEC (integrated National Plan of Energy and Climate) the goal for wind energy is to reach 50.333 MW (see below table) to achieve the expected emissions reduction that it means around of 2.300 MW per year between 2020 and 2030, using the auctions scheme based on price. This model shall have an important impact on maintenance services due to main reasons: first, low offered prices, which make an important pressure on O&M through the project life span and second, that useful life will not be of less of 30 years, long period to keep a more or less stable availability.

Table 13: Target scene of the generation mix (MW)

Target Scene of the generation mix (MW)				
Year	**2015**	**2020***	**2025***	**2030***
Wind power (on- and offshore)	22,925	28,033	40,633	50,333
PV	4,854	9,071	21,713	39,181
CSP	2,300	2,303	4,803	7,303
Hydraulics	14,104	14,109	14,359	14,609
Mixed Pumping	2,687	2,687	2,687	2,687
Pure Pumping	3,337	3,337	4,212	6,837
Biogas	223	211	241	241
Other renewables	0	0	40	80
Biomass	677	613	815	1,408
Coal	11,311	7,897	2,165	0
Combined cycle	26,612	26,612	26,612	26,612
Cogeneration	6,143	5,239	4,373	3,670
Fuel and Fuel/Gas (islands)	3,708	3,708	2,781	1,854
Residues and others	893	610	470	341
Nuclear	7,399	7,399	7,399	3,181
Storage	0	0	500	2,500
TOTAL	**107,173**	**111,829**	**133,802**	**160,837**

*2020, 2025 and 2030 are estimates of the NECP Target Scene

Source: Ministry for Ecological Transition and Demographic Challenge

8.6 Offshore maintenance: specificities and defies

Although Spain is foreseen to develop a strong offshore wind energy market, for the time being there are only one offshore wind turbine in the country, with 5 MW of power in Canarias, being furthermore experimental as far it is using a concrete telescopic tower fix bottomed in the sea bed. There are many initiatives, specially floating projects, Spain has not continental platform, and it expected their consolidation in the near future.

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