2019 WIND OBSERVATORY

Analysis of the French wind power industry: market, jobs and challenges
Foreword

The French energy landscape is gradually shifting towards renewable energies. Ambitious targets have been set, aiming to increase the share of renewables to 33% of the energy mix and 40% of power generation by 2030. Wind power clearly stands out, as a key sector, alongside solar energy, faced with new challenges and offering high expectations.

As the Multiannual Energy Programming is about to be disclosed, wind power (both onshore and offshore), is regarded as one of the cornerstones of the energy transition in the French power mix. Over the past year, wind power has indeed covered 6% of France’s power needs. The industry has also demonstrated its competitiveness in relation to the latest calls for tenders, specifically with regards to the wind farm awarded off Dunkirk. In this buoyant context, wind energy is also a major driver of regional economic development and employment, with a 6.4% increase in jobs in 2018. The industry must, however, continue to improve project integration in terms of local territories, the environment, and the landscape.

The current development dynamic is confirmed in the Multiannual Energy Programming, which sets ambitious targets for 2028 through the installation of the first offshore wind farms. The French Parliament has scaled up its ambitions in terms of the development of offshore wind power generation and now aims to award 1 GW per year by 2024.
Foreword

The industry can count on the support of the French Government. More than a year has passed since the wind power working group presented its findings and numerous streamlining measures have been implemented. A lot of work remains to be done to fully apply the framework for future calls for tenders, and to prepare the ‘end of life’ and replacement of early facilities. The provisional tender calendars included in the multiannual energy programming will also provide the visibility to support future development. The industrial sector now holds all the cards to show that the ecological transition is both good for the territories and in terms of employment.

I wish to commend the work of the professionals of the wind industry. They are working towards the energy transition on a daily basis and can be proud of the progress made over more than two decades and the various challenges that have been met.

Élisabeth Borne

Minister for the Ecological and Inclusive Transition
Op-ed

The French wind power sector is committed to the future and now boasts 18,200 jobs and 15.3 GW in service capacity, as at 31 December 2018.

First and foremost, it has demonstrated that it is competitive within the electricity generation sector. Wind power is France’s largest renewable energy sector and has managed to improve industry performance through technological innovation and an improved integration in its environment, effectively offering consumers a clean, competitive and job-creating source of electrical power. Production costs continue to be reduced, and quality improved, through increased investment and the implementation of digitalisation and new technologies.

In a society with an ever increasing awareness of the threats posed by global warming, the wind power industry is also a means of taking our environmental responsibilities a step further. Indeed, not only do wind turbines provide intrinsically low-carbon energy, but also achieve carbon neutrality after only six months of operation. In addition, they have upwards of 90% recyclable content.

Furthermore, there is a strategic interest in keeping the industry European. While most of the major manufacturers are European firms, the majority of subcontractors supplying these key equipment and turbine manufacturers are French companies, based throughout the country, ensuring a near equilibrium in the French trade balance.

Finally, the wind industry represents a pool of diversified jobs, both currently and in the future. In large cities, the wind power sector requires an increasing number of skilled workers in key areas such as project development; across French regions, it calls for engineers in construction and technicians in wind farm operation and maintenance. These jobs are both non-relocatable and long-term, with a twenty to twenty-five year time frame at the very least. Changes in business lines and job types in power distribution networks and transmission grids, will make it possible to further sustain and diversify the jobs of the future (digitalisation, aggregation, etc.). However, industry leading businesses are facing talent shortages and a difficulty in recruiting qualified staff in certain fields, such as maintenance and development. This must be addressed by prompt training programmes to adapt to the new types of jobs that are emerging within the industry

The wind power sector has a bright future and is experiencing dynamic growth, but wind power companies need to be able to invest confidently, within a stable and simplified regulatory framework. An ambitious multiannual energy programming (PPE), combined with the continued support of national and local elected representatives to further develop wind power, will contribute to the industry gaining a strong foothold throughout the country, providing clean jobs for the future and playing a key role in the energy transition efforts away from fossil fuels, demanded by the younger generation.

Nicolas Wolff, President of the Industry Committee, and Cécile Maisonneuve-Cado, Vice-President of the Industry Committee
The wind industry

Overview of the wind industry value chain

1. Development
   - Porting
   - Pre-project engineering

2. Component manufacture
   - Structural components
   - Large electrical components
   - Electronic systems
   - Mechanical systems
   - Assembly

3. Installation, commissioning
   - Design engineering
   - Site preparation
   - Logistics
   - Connection to the grid

4. Operation
   - Technical expertise engineering
   - Other services
   - Operation
   - Maintenance

5. End of life*
   - Wind farm renewal/repowering
   - Dismantling
   - Recycling

* End of life is not yet at the heart of FEE’s actions and will only be briefly touched upon in this report

Source: ADEME - Study on the French wind energy sector: assessment, prospects and strategy
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The wind power market
Introduction

Now that the objectives for 2018 have been achieved, the challenge is to increase growth to 2 GW of newly connected capacity per year to reach the 2028 PPE’s target

With **1,548 MW newly connected to the grid in 2018**, France will have to ramp up new installations to **2,000 MW** per year to achieve its target of 34 GW of total installed capacity by 2028.

The findings of the wind power taskforce headed by secretary of state Sébastien Lecornu, and then by Emmanuelle Wargon, is expected to result in the simplification of the regulatory framework and an acceleration of wind power development in France. In addition, by encouraging the introduction of larger and more efficient turbines, it will be possible for more sites to come into operation.

The 2019 PPE and its objectives will be confirmed by an implementing decree towards the end of 2019.
The wind power market

A. Overview of the wind power market
Overview of the installed capacity

Grid-connected capacity expanded by 1.5 GW in 2018

MW commissioned by manufacturer (1) (rounded to the nearest unit) from 1 January 2018 to 31 December 2018

Newly grid-connected wind capacity in 2018: 1,552 MW
Overview of the installed capacity

As of 30 June 2019, there is a total grid-connected capacity of 15.82 GW in France

MW in service by manufacturer

<table>
<thead>
<tr>
<th>Manufacturer</th>
<th>Capacity (MW)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vestas</td>
<td>4,544</td>
</tr>
<tr>
<td>Enercon</td>
<td>3,956</td>
</tr>
<tr>
<td>Senvion</td>
<td>2,471</td>
</tr>
<tr>
<td>Siemens Gamesa</td>
<td>2,156</td>
</tr>
<tr>
<td>GE Renewable Energy</td>
<td>1,667</td>
</tr>
<tr>
<td>Vergnet</td>
<td>80</td>
</tr>
<tr>
<td>Jeumont</td>
<td>41</td>
</tr>
<tr>
<td>Vensys</td>
<td>12</td>
</tr>
<tr>
<td>POMA</td>
<td>3</td>
</tr>
<tr>
<td>Autres</td>
<td>66</td>
</tr>
</tbody>
</table>

Total capacity as of June 30, 2019: 15,820 MW
Overview of the installed capacity

16 operators run an installed wind power capacity of upwards of 300 MW

MW in service that are operated either directly or on behalf of third parties

Active wind capacity as of 30 June 2019: 15,820 MW

(1) Data from the FEE database as of 01/07/2019; data for the last semester are consolidated on the following semester
Overview of the installed capacity

French regions are very dynamic

Wind capacities are distributed over the country, with almost 1,380 wind farms featuring more than 7,950 wind turbines that are located in all regions of mainland France as well as in overseas territories.

“Hauts-de-France and Grand Est are France’s top wind power regions”

Hauts-de-France and Grand Est are the top wind regions, boasting 315 and 259 wind farms respectively. But these two regions alone represent 50% of France’s grid-connected capacity. But in 2018/2019 the Hauts-de-France region has commissioned a record 600 MW, for a total of upwards of 4 GW, far ahead of Grand Est and its 180 MW of newly grid-connected capacity.

The coastal regions of Normandy, Brittany and Pays de la Loire have commissioned less than 100 MW each (36 for Brittany), while Corsica, Provence-Alpes-Côte d’Azur and Île-de-France have not installed any at all over the period.
The wind power market

B. The French wind market within the European context
The French wind market within the European context

Europe’s wind energy sector continues to expand but with stark disparities between countries, and France claims 4th place in Europe in terms of grid-connected capacity

In Europe, total grid-connected wind power capacity at the end of 2018 was 189 GW, of which 170 GW was onshore wind and 19 GW offshore wind. Wind power now represents the second largest grid-connect generation capacity in the EU, ahead of coal and behind natural gas. This grid-connected capacity generated 362 TWh of electricity in 2018 and covers 14% of Europe’s total electricity needs.

The increase in installed wind power capacity in Europe has risen by only 11.7 GW in 2018, well beneath the 2017 figure of 17.1 GW.

Four countries account for 65% of Europe’s grid-connected wind capacity in 2018: Germany, the United Kingdom, Sweden and France.

Germany remains in the lead in terms of commissioned wind farms with an annual newly grid-connected capacity of 3,122 MW in 2018. The United Kingdom remains in second place with 1,901 MW. Nevertheless, newly grid-connected capacity in these two countries was halved between 2017 and 2018.

France was the third largest European country in terms of wind farms commissioned with 1,552 MW newly grid-connected. This growth is in line with historical trends, and close to the 2017 figure (1,692 MW).

At the end of 2018, France remained the fourth largest country in Europe by grid-connected wind power, with an grid-connected capacity of 15.3 GW, lagging far behind Germany, which keeps its European lead with a total capacity of 59.3 GW. On another note, wind power in France covered 5.84% of total power consumption in 2018.

The French wind market within the European context

Europe’s wind energy sector continues to expand but with stark disparities between countries, and France claims bronze for dynamism

The 15 countries with the highest grid-connected capacity at the end of 2018

<table>
<thead>
<tr>
<th>Country</th>
<th>2016 grid-connected capacity (MW)</th>
<th>2017 grid-connected capacity (MW)</th>
<th>2018 grid-connected capacity (MW)</th>
<th>Combined installed capacity at the end of 2018 (MW)</th>
<th>... of which offshore capacity at the end of 2018 (MW)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Germany</td>
<td>5,443</td>
<td>6,581</td>
<td>3,122</td>
<td>59,311</td>
<td>6,400</td>
</tr>
<tr>
<td>Spain</td>
<td>49</td>
<td>96</td>
<td>397</td>
<td>23,494</td>
<td>0</td>
</tr>
<tr>
<td>UK</td>
<td>796</td>
<td>4,270</td>
<td>1,901</td>
<td>20,970</td>
<td>8,200</td>
</tr>
<tr>
<td>France</td>
<td>1,692</td>
<td>1,552</td>
<td>0</td>
<td>15,309</td>
<td>0</td>
</tr>
<tr>
<td>Italy</td>
<td>283</td>
<td>252</td>
<td>452</td>
<td>9,958</td>
<td>0</td>
</tr>
<tr>
<td>Sweden</td>
<td>468</td>
<td>197</td>
<td>707</td>
<td>7,407</td>
<td>200</td>
</tr>
<tr>
<td>Poland</td>
<td>682</td>
<td>41</td>
<td>16</td>
<td>5,864</td>
<td>0</td>
</tr>
<tr>
<td>Denmark</td>
<td>223</td>
<td>342</td>
<td>268</td>
<td>5,758</td>
<td>1,300</td>
</tr>
<tr>
<td>Portugal</td>
<td>268</td>
<td>0</td>
<td>53</td>
<td>5,380</td>
<td>0</td>
</tr>
<tr>
<td>Netherlands</td>
<td>887</td>
<td>81</td>
<td>104</td>
<td>4,471</td>
<td>1,100</td>
</tr>
<tr>
<td>Ireland</td>
<td>255</td>
<td>426</td>
<td>193</td>
<td>3,564</td>
<td>0</td>
</tr>
<tr>
<td>Romania</td>
<td>48</td>
<td>5</td>
<td>0</td>
<td>3,029</td>
<td>0</td>
</tr>
<tr>
<td>Belgium</td>
<td>168</td>
<td>467</td>
<td>513</td>
<td>3,360</td>
<td>1,200</td>
</tr>
<tr>
<td>Austria</td>
<td>228</td>
<td>196</td>
<td>201</td>
<td>3,045</td>
<td>0</td>
</tr>
<tr>
<td>Greece</td>
<td>234</td>
<td>282</td>
<td>192</td>
<td>2,844</td>
<td>0</td>
</tr>
</tbody>
</table>

Grid-connected capacity (onshore and offshore) in Europe at the end of 2018

Sources: WindEurope 2019, “Wind energy in Europe in 2018”
The wind power market

C. The place of wind power in the French energy mix
The place of wind power in the French energy mix

Wind power currently accounts for 5% of French power generation and is currently experiencing significant growth: +15% between 2017 and 2018.

Total electricity generation: 548.6 TWh, +3.7%

- Nuclear: 393 TWh, +3.7%
- Hydropower: 68 TWh, 27.5%
- Wind: 28 TWh, 15.3%
- Solar: 10 TWh, 11.3%
- Bioenergy: 10 TWh, 2.3%
- Thermal: 39 TWh, -26.8%

Sources: RTE – Electricity report for 2018
The wind power market

D. Economic and fiscal benefits for local authorities
Economic and fiscal benefits for local authorities

Wind power contributes to the economic dynamism and appeal of French host regions and localities...

Wind energy acts as a catalyst for the energy transition of French regions. Many local authorities, including municipalities, local public service companies (EPCI), départements and regions, are working to support wind development. Private players with strong local links, the syndicats d’énergie (local authorities in charge of the management of the electricity and gas concessions), local distribution companies and local elected officials are committed to helping new wind farms set up successfully, thereby sending a strong signal of the vitality and modernity of the local economy and institutions.

Similarly, the development of wind farm locally often brings about other promising local projects, including biomass boilers, the rehabilitation of public buildings, the creation of short food supply chains and so on.
Economic and fiscal benefits for local authorities

...and contributes to the budget of local authorities

Among their economic windfalls, wind power installations generate various tax revenues, notably in the form of property taxes, the corporate real estate tax (cotisation foncière des entreprises – CFE), the company value-added contribution (cotisation sur la valeur ajoutée des entreprises – CVAE), and the flat tax on network infrastructure companies (impôt forfaitaire sur les entreprises du réseau – IFER). These tax revenues are in the range of 10 to 15,000 euros per grid-connected MW per annum; they are redistributed between the different local authorities mainly based on the tax regime of the EPCI (public inter-municipal cooperation establishment) of the host locality of the project site.

Generally speaking, for projects commissioned in 2019–2020, the locality receives approximately €7,500 per grid-connected MW per year, considering all taxes, from the local (departmental) tax office, and the département and region together receive another €4,500 per MW.
Economic and fiscal benefits for local authorities

Focus on IFER, the flat tax on network infrastructure companies

The proceeds from IFER is distributed between the host locality, the département and the EPCI (public inter-municipal cooperation establishment, which is an administrative entity that brings together several municipalities). The distribution of IFER proceeds differs according to whether the host community belongs to an EPCI or not (and the choice concerning local taxation):

<table>
<thead>
<tr>
<th>Single municipality</th>
<th>EPCI with complementary taxation (EPCI à fiscalité additionnelle — FA)</th>
<th>EPCI with zonal business taxation (EPCI à fiscalité professionnelle de zone — FPZ)</th>
<th>EPCI with single wind power taxation (EPCI à fiscalité éolienne unique — FEU)</th>
<th>EPCI with single business taxation (EPCI à fiscalité professionnelle unique — FPU)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tax components of IFER for wind turbines</td>
<td>20% for the municipality 80% for the département</td>
<td>20% for the municipality 50% for the EPCI 30% for the département</td>
<td></td>
<td>70% for the EPCI 30% for the département</td>
</tr>
</tbody>
</table>

In some cases, host communities may receive nothing from IFER (when the EPCI choose not to redistribute any funds) including when the municipality has in fact been proactive in helping with the installation of a wind farm within their territory. One of the measures put forward by the national taskforce on wind power headed by the Secretary of State Sébastien Lecornu makes it possible to systematically allocate 20% of the tax proceeds from IFER to host communities for projects authorized since January, 1st 2019.
Economic and fiscal benefits for local authorities

A recently commissioned French wind farm generates around €50 million in revenue over its lifetime as well as contributing €20 million in local tax revenues.

### Wind farm revenues

- **A recently commissioned French wind farm**
  - Features 5 turbines
  - Of approximately 3 MW each
  - Generating power 2,500 hours per year in full power equivalent
  - Under a 20-year contract
  - With a price fixed by tender at
  - €63*/MWh

### Contributions to the French state

- Corporate income tax (impôt sur la société – IS)

### Local contributions

- IFER, the flat tax on network infrastructure companies (impôt forfaitaire sur les entreprises du réseau): €7,470 per grid-connected MW per annum (vs. €3,115 per installed MW per annum for nuclear and fossil-fired thermal)
- Corporate real estate tax (cotisation foncière des entreprises – CFE)
- Company value-added contribution (cotisation sur la valeur ajoutée des entreprises – CVAE)
- Property tax (taxe foncière)
- Rent

- €50m over 20 years, of which €40m come from the market and €10m from subsidies (additional income)
- €3m in total tax contributions to the French state over 20 years
- €17m of total local tax contributions over 20 years

* Result of the last call for tender on 13/06/2019
The wind power market

E. Onshore technologies are continuing to make progress
Onshore technologies are continuing to make progress

Wind turbines transform the kinetic energy of the wind into electrical power

Modus operandi

The operating principle of wind energy is based on the transformation of kinetic energy into electrical power:

1. The wind rotates the blades, which in turn rotate the generator of the wind turbine.
2. The generator then transforms the wind’s kinetic energy into electrical power.
3. The electric current is then transformed and fed into the grid, ultimately powering our homes.

Wind turbines must aim for an optimal rotor size to be able to capture winds that are both strong and continuous.

The larger the diameter of the rotor (5 and 6), the higher the energy captured.
Onshore technologies are continuing to make progress

Supersize wind turbines are arriving in France

Supersize wind turbines are gradually arriving in France with the Chamole wind farm in the Jura département and Massay in the Cher département. On these sites where near-surface winds are less attractive for power generation, only very large wind turbines can reach the stronger and steadier winds higher up. A larger rotor diameter also makes it possible to produce a greater power output. In both cases, the wind turbines have a blade-tip height of 193 m and a hub height of 135 m.

Nevertheless, the average blade-tip height of wind turbines in France remains between 120 and 155 m, with a hub height of between 80 and 100 m and a rotor with a diameter of 80 to 110 m.

These figures are still well below those of Germany, where wind turbines had an average total height of 175 m and an average hub height of 120 m in 2017. Germany’s largest projects even peak at 246.5 m — the height of the world’s tallest in Gaildorf park.

Although such projects are no longer out of the ordinary, they remain all too rare in France: indeed, installing larger wind turbines would bring down the cost of wind power.

Sources: Bundesnetzagentur 2017, MTES, lenergeek
Onshore technologies are continuing to make progress

Several factors are delaying the emergence of supersize wind turbines

The scarcity of supersize wind turbine projects can be explained by several factors:

- **Regulatory barriers**: regulations in force in France haven’t yet evolved to accommodate large wind energy, in particular because of the constraints related to civil and military aviation.

- **Logistics**: large components (blades exceeding 74 m) are more difficult to transport.

- **Environmental reasons**: some site constraints do not allow the installation of these technologies.

It is now almost impossible to locate a wind turbine within less than 30 km of a military radar. As a result, more than 50% of the French territory is currently prohibited to wind turbines that are more than 150 m high.
Onshore technologies are continuing to make progress

The industry is focusing its efforts on lowering the full costs of production, increasing public buy-in and creating value

In the face of restrictive regulations, the industry is looking to increase industry performance by decreasing the costs of turbine manufacturing and maintenance. To do so, manufacturers are:

- Introducing **industrial platforms** based on standardized modules that provide customized solutions while optimizing production and assembly lines
- Introducing **options** that meet certain local requirements and constraints (load, temperature, cut-in speed, cutting speed, ice resistance ...)
- Implementing **data analysis systems** that make predictive maintenance possible

Substantial efforts have been undertaken by developers to increase public buy-in to wind power, most notably by: Including:

- Decreasing blade noise
- Dimming nocturnal lights
- Detecting birds and bats.
- ...

The next technological revolution will be driven by value creation and changes in the way wind energy is marketed – participating in wholesale markets and producing direct on-demand energy for industrial and commercial customers, as well as to relieve networks by taking part in systems services. The turbines will therefore have to increasingly capture, process and restore (internal and external) data in real time.
The wind power market

F. Offshore wind
Offshore wind

Offshore wind power as a potential driver of economic growth

In 2019, there were 11 awarded offshore projects under development in France. While offshore wind represents 23% of the newly commissioned wind turbines at the end of 2018, it should represent 10% of grid-connected capacity in France in 2023.

The offshore wind market is segmented based on distance and foundation type:

### Bottom-fixed offshore wind

Fixed-bottom wind turbines are intended for seabed depths of up to 70 m and can harness strong coastal winds.

### Floating offshore wind

Floating wind turbines are connected to the seabed by anchor lines and can therefore be located further offshore at seabed depths starting at 30 m.

“Offshore wind is expected to form 10% of France’s grid-connected capacity by 2023”
Offshore wind

France is positioning itself in a growing European offshore wind market

With its 3,500 km of coastline, metropolitan France has the second largest wind power potential in Europe, behind Great Britain and ahead of Germany. France is now less ambitious than its European neighbours however: the “Grenelle de la Mer” strategy sets a 6 GW target for offshore wind by 2020, while the British government’s initial target for offshore wind over the same period is three times this, at 20 GW. Germany should surpass its 2020 target of 6.5 GW and is expecting to achieve 15 GW by 2030.

<table>
<thead>
<tr>
<th>Year</th>
<th>Event</th>
</tr>
</thead>
<tbody>
<tr>
<td>2011</td>
<td>The first call for tenders for bottom-fixed offshore wind power was issued and awarded in 2012 to four projects for a total of approximately 2 GW.</td>
</tr>
<tr>
<td>2013</td>
<td>The first call for tenders for bottom-fixed offshore wind power was issued and awarded in 2014 to two projects for a total of approximately 1 GW.</td>
</tr>
<tr>
<td>2015</td>
<td>The third call for tenders for pilot floating offshore wind is launched and awarded in 2016 to four projects for a total of 96 MW.</td>
</tr>
<tr>
<td>2017</td>
<td>The offshore wind projects of the first and second call for tenders are confirmed.</td>
</tr>
<tr>
<td>2018</td>
<td>Adoption of the strategy regarding the planning of offshore wind and maritime activities. Public discussions on the 4th call for tenders in Normandy. Adoption of the 2019 PPE.</td>
</tr>
<tr>
<td>2019</td>
<td>Commissioning of the projects of the first call for tenders for fixed-bottom offshore wind.</td>
</tr>
<tr>
<td>2021</td>
<td>Commissioning of the second call for tenders for fixed-bottom offshore wind projects.</td>
</tr>
<tr>
<td>2023-2024</td>
<td>Proposed commissioning of the commercial floating offshore wind projects.</td>
</tr>
</tbody>
</table>

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**Legend:**
- **Green** = Bottom-fixed wind
- **Blue** = Floating wind
Offshore wind

France boasts many advantages as far as offshore wind power is concerned, most notably its extended maritime boundaries as well as its industrial, energy and maritime expertise and port infrastructure.

Offshore wind turbines are cutting-edge technology, both innovative and mature, specifically designed for the highly challenging marine environment. They are more productive than onshore turbines as they can harness stronger and more regular winds.

These new facilities generation offshore renewable energy generation will both help achieve the national objectives for diversifying the energy mix and help bring about a vibrant wind power sector with the capacity to reach export markets. Several plants and hundreds of wind power jobs have already been created; several thousand more will emerge following the installation and commissioning of the current projects (see the focus devoted to the 2018 Observatory for marine energies).
Offshore wind

The first offshore wind farms will be operational in 2021

- **Courseulles-sur-Mer**
  - 75 turbines – 450 MW
  - Haliade 150*
  - Project authorized
  - Commissioning scheduled for 2023

- **Saint-Brieuc**
  - SG 8.0-167 DD
  - 62 turbines – 496 MW
  - Project authorized
  - Commissioning scheduled for 2023

- **Saint-Nazaire**
  - Haliade 150*
  - 80 turbines – 480 MW
  - Project authorized
  - Commissioning scheduled for 2022

- **Fécamp**
  - 83 turbines – 498 MW
  - Haliade 150*
  - Project authorized
  - Commissioning scheduled for 2022

- **Dunkerque (Dunkirk)**
  - ~600 MW
  - Commissioning scheduled for 2026

- **Dieppe-Le Tréport**
  - SG 8.0-167 DD
  - 62 turbines – 496 MW
  - Project authorized
  - Commissioning scheduled for 2023

- **Yeu-Noirmoutier**
  - SG 8.0-167 DD
  - 62 turbines – 496 MW
  - Project authorized
  - Commissioning scheduled for 2023

*The first project reaching the final investment decision stage will be fitted by Haliade 150 turbines and the two others will use Siemens Gamesa technology (SWT-7.0-154)
Offshore wind

RTE is positioning itself to adapt its network to the challenges of offshore wind power

In France, a new legal and regulatory framework has been defined to speed up the development of offshore wind projects and reduce associated costs. It is modelled after the approach taken in the North Sea.

The legal corpus is adapting to incorporate new **anticipatory, simplification and project de-risking** measures in the interest of the community, including:

- Connections to the grid will be financed by RTE and rebilled to consumers as a whole
- Financial compensation for connection delays and operational damage
- Envelope permit to gain flexibility
- Maritime spatial planning taking into account the accommodation capacity of the power grid

**RTE is positioning itself as serving an** ambitious development of marine renewable energies via:

- Long-term planning shared with the public authorities and local territories in order to anticipate and optimize the dimensioning of the network, which is making the following possible:
  - The pooling of the public offshore grid (“connection hub”) in order to lower costs and impacts
  - The standardization of certain infrastructures to achieve economies of scale
- The innovative development of multi-purpose platforms at the service of French host regions and localities as well as stakeholders
- The mitigation of social, economic and environmental impacts of power generation facilities
Offshore wind

The first floating offshore wind projects are being launched

In France, the Mediterranean Sea has substantial wind power potential for the installation of floating wind farms due to its highly favourable and regular wind regimes as well as its bathymetry (the ocean floors drop very steeply to a depth of more than 60 m). Three floating wind farm pilot projects are planned in the area. Commercial farms may be launched in the future, to the tune of 3 GW in operation by 2030. Every year for the past five years, Pôle Mer Méditerranée, the Marseille-Provence Chamber of Commerce and Industry and FEE have held FOWT, the largest floating offshore wind event on the French Mediterranean coast.

The western seaboard, particularly off the coast of Brittany, is also endowed with highly favourable resources for floating offshore wind farms. The wind sector aims to develop and put into service new capacities, beyond the pilot farm planned off Groix-Belle Île. The first world-wide commercial tender (250 MW) is expected to be awarded in 2021.

“The Floatgen project has ensured a successful outcome for the first floating wind turbine to be commissioned in France.”

Other pilot projects (see table below) are continuing their development in Brittany and the Mediterranean, following ADEME’s 2016 call for projects; they should be commissioned by 2021.

In French:

**“The Floatgen project has ensured a successful outcome for the first floating wind turbine to be commissioned in France.”**

Other pilot projects (see table below) are continuing their development in Brittany and the Mediterranean, following ADEME’s 2016 call for projects; they should be commissioned by 2021.

<table>
<thead>
<tr>
<th>Wind farm</th>
<th>Characteristics</th>
<th>Industrial partners</th>
</tr>
</thead>
<tbody>
<tr>
<td>Faraman</td>
<td>3 turbines – 24 MW</td>
<td>Capgemini, Senvion</td>
</tr>
<tr>
<td>Groix-Belle Île</td>
<td>4 turbines – 24 MW</td>
<td>Capgemini, Senvion</td>
</tr>
<tr>
<td>Gruissan</td>
<td>4 turbines – 24 MW</td>
<td>Capgemini, Senvion</td>
</tr>
<tr>
<td>Leucate-Barcarès</td>
<td>4 turbines – 24 MW</td>
<td>Capgemini, Senvion</td>
</tr>
</tbody>
</table>
Wind power jobs
Growth in wind jobs

The industry continued to expand in 2018, with a 6.4% increase in wind power jobs, i.e. 18,200 additional jobs as of 31 December 2018.

This new Observatory confirms that the industrial wind power sector has maintained its growth momentum. In 2018, a total of 18,200 direct and indirect jobs were identified throughout the value chain, representing a 6.4% increase compared with 2017 and growth of over 14% since 2016.

These jobs are created by approximately 1,000 companies that are active in all activities of the wind energy sector and that therefore form a diversified industrial fabric. These companies range in size from VSEs to large industrial groups.

With their strong local ties, these companies are helping to shape regional wind power employment by positioning themselves within this promising market, the development of which is overseen by the government’s Multiannual Energy Programming (Programmation Pluriannuelle de l’Énergie – PPE).

French companies are investing in production facilities and R&D in offshore wind. The growth in offshore wind is therefore boosting employment and making French business export-ready.

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French companies are investing in production facilities and R&D in offshore wind. The growth in offshore wind is therefore boosting employment and making French business export-ready.
Key data as at 31 December 2018

15,100 MW grid-connected throughout the country

18,200 wind power jobs in France, including...

1,100 extra wind jobs in 2018, across more than 1,000 companies with activities in the wind industry
Wind power jobs

A. Growth in employment – details by link in the value chain
Growth in wind jobs

The number of wind jobs is continuing to increase

Employment trends in wind power from 2016 to 2018

- 2016: 15,870 jobs
  - +1,692 MW
- 2017: 17,100 jobs
  - 7.8% increase, 1,230 jobs
  - 14.7% increase, +2,330 jobs
- 2018: 18,200 jobs
  - 6.4% increase, +1,100 jobs

MW connected to the grid during the year
Growth in wind jobs

The Observatory confirms the vitality of the industry and captures the key players involved

The structuring process of the wind energy sector is underpinned by the growth in the number of wind farms installed in France. With more than 15 GW of grid-connected capacity as of 31 December 2018, wind power has succeeded in organizing itself as an industry, first in onshore wind power and now in offshore wind... Industry players ranging from small businesses to large corporations gather during industry events such as the annual WindEurope conference, France Énergie Éolienne’s (FEE) National Wind Power Conference, FEE’s Éole Industrie Conference and FEE’s occupational safety and health seminar.

Opposite, the last edition of the annual Éole Industrie conference, which took place in Orléans on 26 and 27 June 2019 on the theme of “Jobs, training and maintenance in the wind power industry: present situation and future prospects”.

This regional event is held every year somewhere in France. It offers technical visits and conferences and provides a forum for industry professionals to meet and exchange information.
## Details by link in the value chain

An activity organized along 4 segments

The French wind power industry has businesses operating along the entire value chain, providing wind power jobs within the following key activities:

<table>
<thead>
<tr>
<th>Segment</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Planning &amp; Design</strong></td>
<td>E.g. engineering consultancies, wind measurement, geotechnical measurement, technical expertise, performance monitoring companies, developers, financial institutions</td>
</tr>
<tr>
<td><strong>Component manufacturing</strong></td>
<td>E.g. casting parts, mechanical parts, rotor blades, nacelles, masts, yaw drives and bearings, brakes, electrical equipment for wind turbines and the electrical grid</td>
</tr>
<tr>
<td><strong>Engineering &amp; Construction</strong></td>
<td>E.g. assembly, logistics, civil engineering, power grid and wind farm electrical engineering, erection, grid connection</td>
</tr>
<tr>
<td><strong>Operations &amp; Maintenance</strong></td>
<td>E.g. assembly, logistics, civil engineering, power grid and wind farm electrical engineering, erection, grid connection</td>
</tr>
</tbody>
</table>
Details by link in the value chain

Strong momentum on links no. 1 and 4

“Employment in development and maintenance are boosting growth in wind jobs”
Details by link in the value chain

Diversified players throughout the value chain

Implementing wind projects draws on many different skills, which are provided by various specialized businesses.

Wind power jobs are spread over a complex and diversified value chain, ranging from specialized structures that are positioned on one of the links in the value chain to integrated players that operate across several fields.

These companies are organized around a cluster of approximately 100 SMEs; they are predominantly young, have a strong entrepreneurial spirit and a pool of diversified expertise, which is a key driver of growth for the wind power industry. These companies are highly responsive, as can be seen in the growth in wind power jobs in 2017.
Details by link in the value chain

Wind jobs are spread across the entire value chain in 2018

Number of jobs by activity and by link

- Other service providers
  - Maintenance
  - Logistics
  - Civil and electric engineering
  - Component manufacturing
  - Operator
    - Developer & Operator
    - Developer
    - Turbine manufacturer
  - BE & Expertise

Planning & Design | Component manufacturing | Engineering & Construction | Operations & Maintenance
Wind power jobs

B. The share of wind employment in France compared to other sectors (an overall perspective)
The share of wind employment in France compared to other sectors

Wind power is the leading employer among renewable energies in France

Breakdown of FTEs in renewable energy in France

<table>
<thead>
<tr>
<th>Energy Type</th>
<th>FTEs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eolien</td>
<td>18,400</td>
</tr>
<tr>
<td>Hydraulique</td>
<td>11,590</td>
</tr>
<tr>
<td>Biomasse</td>
<td>9,041</td>
</tr>
<tr>
<td>Solaire photovoltaïque</td>
<td>7,050</td>
</tr>
<tr>
<td>Valorisation des déchets</td>
<td>640</td>
</tr>
<tr>
<td>Autre</td>
<td>500</td>
</tr>
</tbody>
</table>

Sources: The 2018 barometer of electric renewable energies in France, Observ'ER, IRENA (2019)

"1.2 jobs are created per installed and grid-connected MW"
Wind power jobs

C. Breakdown of wind jobs by region
Breakdown of wind jobs by region

As was the case in 2017, the jobs created in 2018 are spread over almost the entire French territory, with a large number in Île-de-France.

Breakdown of the growth of FTEs across French regions

Île-de-France
Occitanie
Pays de la Loire
Hauts-de-France
Auvergne-Rhône-Alpes
Grand Est
Nouvelle-Aquitaine
Bourgogne–Franche-Comté
Brittany
Normandy
Provence-Alpes-Côte d’Azur
Centre-Val de Loire

2017  2018
Breakdown of wind jobs by region

The wind power sector creates pools of employment throughout France and close to local operations

Spatial distribution of wind power labour pools in France

- The Grand Est and Hauts-de-France regions, where wind power is currently progressing rapidly, contributing to local economic vitality;
- The Paris Basin (Île-de-France and part of the Centre-Val de Loire and Normandy regions), where many head offices of companies involved in the industry are traditionally based;
- The Greater West (Brittany, Pays de la Loire and part of the Nouvelle-Aquitaine region), which has many wind power installations and whose seaboard will benefit greatly from the growth of offshore wind;
- The Auvergne–Rhône-Alpes and Bourgogne–Franche-Comté regions, traditionally industrial regions that are diversifying their economic activities and are specialized in component manufacturing for the wind industry;
- The Mediterranean (Sud-Provence-Alpes-Côte d’Azur and Occitanie regions), which is the cradle of the wind power industry and where several historical players are established.
Breakdown of wind jobs by region

The wind power sector is creating jobs across the whole country, including in rural areas.

Contribution of the wind sector to regional employment

Companies active in the wind power sector that are operating in the region. NB: Île-de-France and Corsica are not to scale.

Wage employment in the market sector by region (INSEE) – in millions of jobs.

Number of wind power jobs (from under 1.5 to more than 250).
Breakdown of wind jobs by region

Jobs in Planning & Design are mostly located in the vicinity of France’s major urban centres

Wind jobs in Planning & Design compared to jobs in the market services sector

Companies active in the wind power sector that are operating in the region

NB: Île-de-France and Corsica are not to scale

Wage employment in the market service sector in thousands of jobs (INSEE category)

More than 80 companies
60-80 companies
40-60 companies
Less than 40 companies

Wage employment in the market service sector by region (INSEE) – in millions of jobs

Non-exhaustive list of logos
Multisite companies
Breakdown of wind jobs by region

Component manufacturing generates 4,000 jobs across the country

Wind jobs in component manufacturing compared to jobs in the industrial sector

Companies active in the wind power sector that are operating in the region

NB: Île-de-France and Corsica are not to scale

Wage employment in the industrial sector in thousands of jobs (INSEE category)

Wage employment in the market service sector by region (INSEE) – in millions of jobs

Non-exhaustive list of logos
Multisite companies
Breakdown of wind jobs by region

In Hauts-de-France and Occitanie, 10% of all construction jobs are generated by the wind industry

Wind power jobs related to engineering and construction compared to jobs in the construction sector

Companies active in the wind power sector that are operating in the region

NB: Île-de-France and Corsica are not to scale

Wage employment in the construction sector by region (INSEE)

Non-exhaustive list of logos

Multisite companies
Breakdown of wind jobs by region

Jobs in Maintenance & Operation are located in the immediate vicinity of wind farms in rural areas

Wind power jobs in Operations & Maintenance relative to installed capacity

Regional wind power jobs in Component manufacturing

Companies active in the wind power sector that are operating in the region

NB: Île-de-France and Corsica are not to scale

More than 30 companies
20-30 companies
15-20 companies
Less than 15 companies

Total installed wind farm capacity – MW as of 31 December 2018
Wind power jobs

D. Driving the industry forward
Driving the industry forward

The industry is driven by a variety of stakeholders that can be grouped in three main types:

- **Competitiveness clusters**
  - There are seven active competitiveness clusters in wind power in France. They are all located near areas where offshore wind is being developed: Brittany and the Mediterranean.

- **Clusters**
  - Grouping of public and private stakeholders enabling knowledge transfers between those involved. Eight clusters involved in wind power have been identified in France.

- **Other relevant actors**
  - Professional unions and federations that, like France Énergie Éolienne, bring together wind industry professionals: FNTP, FNTR, UFL, Cluster Maritime Français, Gimélec, SER, etc.
Driving the industry forward

Mapping the actors involved in the industry

FEE facilitates the wind industry in the various regions thanks to its regional representatives (regional groups).
Driving the industry forward

Focus on Tenerrdis

Tenerrdis is the Auvergne-Rhône-Alpes competitiveness cluster that is focused on the energy transition; it aims, through effective innovation, to expand sectors of excellence creating lasting employment opportunities.

Tenerrdis oversees a dynamic network of 300 members and partners
- **Industry**: Industrial groups (energy companies and end users), SMEs, start-ups
- **Research laboratories and technical centres**
- **Local authorities**

Six strategic areas:
- Renewable power generation and insertion in the low-carbon mix
- Intelligence and cybersecurity of energy systems
- Energy storage and conversion
- Multi-vector micro-networks
- Carbon-free mobility
- Energy efficiency in construction and manufacturing

Tenerrdis works with members of the cluster and their partners on issues related to new energies:
- **Supporting innovative projects** that are mostly collaborative (at a regional, national or European scale) and supporting access to public and private funding.
- Its work to enhance and promote the industrial sectors of these new forms of energies, including internationally.
- The coordination of stakeholders opening up the full range of required technical skills (materials, weather forecasting, aging of facilities, storage, hybridization)

**Key data for 2018:**
- 320 projects and demonstrators with a combined budget of €1.8 billion, of which €594 million is funded by the state or by regional or local authorities
- 35 new R&D projects were accredited by the cluster in 2018, including the FUI (inter-ministerial fund) on wind turbine foundations & repowering (FEDRE).
Driving the industry forward

Focus on Cemater

To support companies in their development and in achieving sustainability, the Cemater group offers them support on various topics: skills and know-how upgrading, commercial development, recruitment, innovation, pooling within companies and so on.

Cemater’s member companies have made a commitment to comply with a code of ethics that guarantees an optimum level of quality to their clients. The components of Cemater’s code of ethics are based on the following elements:

- Consulting/advice
- Education
- Mutualisation/pooling
- Adaptation
- Transparency
- Engagement/involvement
- Respect

Sources: Cemater
Driving the industry forward

Focus on the French Maritime Cluster

CMF currently brings together 430 industry players in maritime activities of all types. FEE is a member of CMF. These actions are undertaken with its members to reinforce France’s maritime position and achieve a true ecosystem that both furthers the public maritime interest and the number of business opportunities generated. Since 2007, CMF has set up two synergy groups that have helped kick-start the MRE sector:

Since 2007, CMF has been instrumental in promoting and defending the MRE sector among decision-makers, as well as in creating synergies between operators in the maritime and energy industries.

Since 2017, CMF has created the Observatory of the energies of the sea (Observatoire des énergies de la mer), to which FEE contributes. See the results of the 3rd edition on www.merenergies.fr

France has the world’s second largest marine territory in the world: French overseas territories give the country 97% of its 11-million sq. km. EEZ (Exclusive Economic Zone). Fully aware of the opportunities offered by Overseas France (especially as regard the development of MREs), CMF has developed clusters there: Recognizing the opportunities offered by France’s overseas territories (including in terms of the development of MRE), the CMF has developed overseas clusters in Guadeloupe, Réunion, French Guyana, Martinique, French Polynesia and New Caledonia.

CMF has partnered with Euromaritime, Europe’s largest trade show on the maritime economy. The last edition, which took place in 2017, attracted a total of 5,000 visitors. This European trade show showcases the expertise of the maritime sector and is becoming the reference event for marine-focused technology, innovation and activities. The next event will take place from 4 to 6 February 2020 in Marseille!
Driving the industry forward

Focus on FOWT, the world’s largest event in floating offshore wind, co-hosted by FEE

Since 2013, Pôle Mer Méditerranée and the Marseille-Provence Chamber of Commerce and Industry have co-hosted the Scientific and Technical Seminars of Floating Offshore Wind every year, thus fostering the emergence of the sector. The conference, renamed FOWT (Floating Offshore Wind Turbines) in 2016, is co-hosted by France Énergie Éolienne.

FOWT has three ambitions: to accelerate the increase in the share of floating wind power in the global energy mix; to support the structuring of an ecosystem and to promote interactions between participants of the FOW value chain; and to turn FOWT into a showcase for international expertise of the floating offshore wind industry. FOWT 2020 will be held from 22 to 24 April 2020 in Marseille.

**FOWT 2020 will be held from 22 to 24 April 2020 in Marseille.**

**Topics covered**
Funding, insurance, zoning, regulatory frameworks, environmental impacts, technological innovation, etc.

All these topics are covered during the seminars in order to help reveal the key issues related to the emergence and the industrialization of floating offshore wind in France and in the rest of the world.

**The best in science & the best in technology**
In order to ensure than the programme is relevant and diverse during the whole three days, the event committee launches a call for papers.

Among the keynote speakers of the 2019 edition: Giles Dickson (WindEurope), Laurent Michel (French Ministry of Ecological and Solidarity Transition / DGEC) and other major market players such as Ideol, PPI, SBM Offshore, EDF EN, Equinor, Shizen Energy, Engie, Naval Energies, the Carbon Trust, Siemens Games and more.


**Key data on the event (2019 edition):**
Four partner regions: The Occitanie region, the Sud-Provence-Alpes-Côte d’Azur region, Brittany and the Pays de la Loire region • More than 40 sponsors and industrial and institutional partners • 2 days of plenary conferences • 1 academic day • 810 participants • 28 nationalities represented • 500 B2B meetings / Meet the Buyers
Driving the industry forward

Focus on the Neopolia EMR competiveness cluster

Located in Saint Nazaire, Neopolia EMR brings together more than 100 industrial companies that combine their know-how in order to find innovative answers to the needs of the renewable marine energies market. Neopolia EMR is part of the Neopolia network composed of 6 clusters that are present in the Pays de la Loire region.

The role of this cluster is to strengthen partnerships with the major players in the renewable offshore wind market, to build a network of skills, to act as a driver of the renewable offshore wind industry in the Pays de la Loire region by bringing together the players of the industry, to manage R&D projects and to market comprehensive and collaborative industrial offers.

Neopolia EMR offers several integrated solutions at the service of MRE projects including:

- Project development engineering
- Offshore installation support
- Operations & Maintenance
- System Health Monitoring
- Monitoring of concrete in marine conditions

Neopolia EMR was a partner of the Éole Industrie 2018 workshop on the subject of “Onshore and offshore wind: perspectives and technological innovations” that took place in the Pays de la Loire region on 25 and 26 June 2018. It will also be a partner of the 10th FEE National Wind Symposium.
Driving the industry forward

Focus on Pôle Mer Méditerranée

The Mediterranean area has significant potential for wind power and is yet to be exploited in France. However, bathymetric conditions are suited only to floating offshore operations.

Pôle Mer Méditerranée is active in the regions of Sud Provence-Alpes-Côte d’Azur, Occitanie and Corsica and is involved in six strategic action areas:
- Maritime defence, security and safety
- Naval industry and boating
- Marine biological resources
- Environment and coastal development
- Ports and maritime logistics and transport
- Marine energy and mineral resources (which includes offshore wind)
  Namely
  - 36 floating offshore projects accredited and funded
  - with a total budget of:
    - €90 million for floating wind power

And 3 cross-cutting themes:
- the ecological transition;
- digital transformation;
- robotics.

Now boasting more than 422 members (laboratories, large corporate groups, ETIs and SMEs), Pôle Mer Méditerranée started actively identifying all potential participants in the floating wind sector in 2013. The census identified 452 potential participants including 40 confirmed participants in the regions of Sud-Provence-Alpes-Côte d’Azur, Corsica and Occitanie. 65 are already members of the Pôle Mer Méditerranée.

Pôle Mer Méditerranée also co-hosts the international Floating Offshore Wind Turbines (FOWT) conference, along with the Marseille-Provence Chamber of Commerce and Industry and France Énergie Éolienne.

Sources: Pôle Mer Méditerranée
Driving the industry forward

Focus on: Pépinière Entreprises Énergies Renouvelables (80)

The Pépinière d'Entreprises Énergies Renouvelables is a business incubator that is geographically positioned in the Hauts-de-France and Normandy regions; it contributes to the development of onshore and offshore wind farms and other renewable marine energies through its operational actions with SMEs as well as its products and services.

Directing the CCI Business EnR brokerage platform between prospective buyers and suppliers in renewable energies

- 1,970 members in fixed-bottom wind, floating wind, tidal barrage and tidal stream
- Active on all of continental France’s seaboard
- Joint organization of regional B2B events, joint development and publishing of tenders (CEI), mapping of local businesses grouped by technical field, etc.

Accompanying the diversification in wind power and MREs

Personalized expert support for industrial SMEs from the Normandy and Hauts-de-France regions among potential contractors, including 25 local companies via the Windustry facility, working from the Oust-Marest incubator (in the Somme and Seine-Maritime départements) or at international trade fairs such as Windenergy Hamburg (28–29 September 2016) and Offshore Wind London (6–8 June 2017).

Wind companies in the renewable energy incubator Pépinière EnR

- Enercon: Onshore service base
- Energie Team: Development and operation of onshore wind farms
- Jade Network: Training and advisory services in working at heights, fall protection, PPE

Co-hosting and co-organizing events on wind power on a national or interregional scale

FEE/Éole Industrie event at the regional Chamber of Commerce and Industry in Lille (23 June 2015) and a Technical one-day Operations & Maintenance event at the renewables incubator, Pépinière EnR (03 November 2015)

- Windustry France business conventions in 2010 (Oust-Marest), 2011 (Amiens), 2013 (Le Havre), etc.
- International SEANERGY MRE conventions at Le Havre (21–24 March 2017), Cherbourg (12–14 June 2018) and Dunkirk (5-7 June 2019)
- Business event on offshore wind with 15 international contracting authorities and 50 regional companies at the Chamber of Commerce and Industry in Dunkirk (8 November 2017)
- Corporate day in Dunkirk/CUD Promotion of awareness of MREs at the Pavillon des Maquettes in Dunkirk (April 4, 2019)
Driving the industry forward

Focus on: École Centrale de Nantes and the SEM-REV platform

École Centrale de Nantes is one of the main French academic institutions specializing in Marine Renewable Energies (MREs) and it provides a full range of training programmes in MREs for all levels, particularly in engineering. SEM-REV is an ocean platform managed by the LHEEA laboratory and intended for R&D projects. It is the first European sea trials base combining several technologies related to offshore wind and wave power; furthermore, it is connected to the national grid.

This project originates in ECN’s prospective work that dealt with the demonstration of offshore wind power in France in particular. Experiments related to this technology took three different formats: computer modelling; tank-based experiments applying various wind and wave conditions on scale models (of wind turbines for instance); real-size experiments conducted with a test offshore wind turbine.

The site hosting FLOATGEN, France’s first offshore wind turbine (that was been generating power since September 2018) is located in a reserved 1 km² area off the Croisic in the Pays de la Loire region. It is connected to an electrical substation and Enedis’ medium voltage grid by means of a submarine hub and cable. An onshore research base also hosts researchers and engineers.

Activities on the site include:
- operation and maintenance of the test offshore wind turbine
- receiving data from marine weather studies
- the study of the environmental impact of the MREs employed (on fauna, sediment transport and so on)
- evaluating the resistance of these MRE technologies when they are operated in a marine environment.
- the security and surveillance of maritime space.
Wind power jobs

E. Prospective vision of the wind power job market
Prospective vision

More than 70% of industry players are planning to hire in 2019

In addition to the census, a survey was conducted to find out what the hiring prospects were for 2019 as well as skills in demand by employers. Based on these answers, an estimate of the 2019 employment prospects was calculated.

Wind jobs in Planning & Design compared to jobs in the market services sector

Representative sample of 150 companies from the wind sector contacted over April 2019 to June 2019
Prospective vision

...mainly for maintenance and development jobs but also new types of jobs

- **Operations and maintenance** represent a large pool of jobs throughout the country that are not relocatable and will last over the service life of the facilities.
- Given how dynamic the industry is, many projects are to be anticipated, particularly in offshore wind. As a result, many employment opportunities are to be expected, especially in **project development** as well in the numerous **expert consulting and research** firms, both technical and legal.
- The **engineering and construction** sector is benefiting from the numerous approved projects that are currently being launched and built across the various regions of France and on the coast.
- The **component manufacturing** sector has been steadily growing in recent years, a trend that is expected to continue.
- Finally, new business models and digitalisation will require **new types of jobs** including financial engineers, aggregators, public affairs representatives, data analysts, smart grids experts, IT developers and so on.
Prospective vision

Many wind jobs remain vacant, particularly in development and maintenance.

EOLE's last conference dealt with the issue.

All stakeholders must improve communication regarding available employment positions: wind sector companies, labour unions, employment centres, the Ministry of Ecological Transition and the Ministry of Labour and so on.

Education and training programmes must be constantly adapted to the needs of the sector. This can only be done in consultation with all stakeholders.

Contribute to the attractiveness of local territories and jobs.

EOLE's last conference dealt with the issue.
Wind power jobs

Focus on the Observatory for marine energies
Focus on the Observatory for marine energies

Jobs in offshore wind and its place in MREs

At the end of 2018, 87% of all FTEs in MREs were in offshore wind, i.e. a total of 1,814* FTEs (63% in fixed-bottom offshore wind and 24% in floating offshore wind, or in other terms 1,313 FTEs and 501 FTEs respectively).

The number of FTEs is lower than at the end of 2017, with a loss of 318 FTEs for bottom-fixed offshore wind and a loss of 55 FTEs for floating offshore wind. The relative share of jobs in the wind energy market is increasing for the third year in a row in spite of the decline in the absolute number of jobs. This is due to a fall in employment in the tidal power sector.

Among all marine technologies, offshore wind is the largest in terms of revenue in France. Offshore wind is furthermore the technology that captures the largest share of investment in MREs, i.e. 95% of total investment.

Source: 2019 Observatory for marine energies
* The figures are extrapolated from 2019 Observatory figures and are not directly quoted from the report.
Focus on the Observatory for marine energies

Breakdown of FTEs in offshore wind by company size

“The French offshore wind industry concerns all types of companies, ranging from very large companies to start-ups and local SMEs.”

Source: 2019 Observatory for marine energies
Focus on the Observatory for marine energies

Breakdown of FTEs in offshore wind by company size

More than 90% of all projected hiring for 2019 by large and medium-sized firms (VLEs and MSEs) is related to offshore wind, three-quarters of which in fixed-bottom offshore wind. The impetus of large companies proves that the offshore wind sector is mature and that their confidence in the market is high.

On the other hand, very small enterprises (VSEs) are very much absent in fixed-bottom offshore wind, which can be ascribed in part to the high level of capital investment required to enter the market. VSEs are more likely to operate in emerging fields such as tidal stream and wave energy, where start-up companies are driving many innovations.

Lastly, SMEs have a strong presence in floating wind, which is a sign how far technology has progressed.

Source: 2019 Observatory for marine energies
Focus on the Observatory for marine energies

Breakdown of FTEs in marine energy in France

The number of jobs in marine energy in France has dropped between 2017 and 2018.

Generally speaking, FTEs are down in all regions, particularly in Pays de la Loire. The region recorded the largest decline with nearly half of the FTEs lost, i.e. 591 fewer FTEs. These decreases are due in particular to the end of the “Chantiers de l’Atlantique”. The activity should pick up again in 2019 in the region with the kick-off of the construction of the offshore wind farm at Saint-Nazaire.

Île-de-France and Hauts-de-France also recorded a loss of 21 and 42 FTEs respectively.

There has nevertheless been some instances of increases in headcount, especially that of the Normandy region, which recorded a gain of 81 FTEs.

Source: 2019 Observatory for marine energies
The challenges of the wind industry
Overview of the key challenges

Wind power lies at the heart of many issues

- New business models
- Integration into the environment
- Public buy-in
- Grid integration
- Storage
- Competitiveness
  - Digitalisation
  - R&D
  - Innovation
- Circular economy
  - Disassembly
  - Wind farm repowering/renewal
  - Recycling
- Training
The challenges of the wind industry

A. Public buy-in on wind power in France
Public buy-in on wind power in France

Methodology of the survey on the buy-in of the French public

A Harris Interactive study published in October 2018 was conducted to learn about the perceptions of wind power and wind farms by the French public.

This study is based on two surveys:

- A survey focusing on the general public that was conducted online from 25 to 27 September 2018 on a sample of 1,091 people representative of the French population (of 18 years of age and over).
- A survey targeting “neighbouring residents” that was conducted over the telephone from 24 September to 02 October 2018 on a sample of 1,001 people representative of the French population living in the vicinity of a wind turbine (within 5 km).

The following methods were used:

- Quota sampling controlling for the following variables: gender, age, socio-occupational category and region of the interviewee.
- Quota sampling controlling for the following variables: gender, age, socio-occupational category, region, residence in a locality with a wind turbine or located less than 5 km from a wind turbine.

Source: Harris Interactive – October 2018
Public buy-in on wind power in France

Wind energy is perceived positively in France, and in particular among neighbouring residents

- **Eight out of ten French people** expressed their concern about global warming and its consequences.
- **Eight out of ten French** people believe that the energy transition is a significant issue for present-day France.
- Across regions, the perception of wind power among neighbouring residents varies between **74%** positive opinion in the Hauts-de-France region and **89%** in Normandy.

Source: Harris Interactive – October 2018
Public buy-in on wind power in France

Economic benefits of wind farms near local operations are perceived positively

Source: Harris Interactive – October 2018

- Contributes to creating jobs in the territories where wind turbines are located: 58% (Neighbouring residents), 65% (French population)
- Generates economic activity for the territories where wind turbines are located: 72% (Neighbouring residents), 70% (French population)
- Generates income for the territories where the wind turbines are located: 75% (Neighbouring residents), 76% (French population)
Public buy-in on wind power in France

One out of two people opposed to the construction of a wind farm change their mind after its completion.

Before construction:
- Support: 44%
- Oppose: 9%
- Not sure: 40%

After construction:
- Support: 85%
- Oppose: 52%

Before the construction of a wind farm, 44% of respondents are in favour of the project and 9% are opposed. Of these 9%, one out of two change their mind after the wind farm is constructed.

Source: Harris Interactive – October 2018
The challenges of the wind industry

B. Competitiveness
Competitiveness – R&D

The offshore wind sector is ramping up its R&D efforts, allowing the French wind power sector to position itself as a key international player.

The development of offshore wind bolsters the R&D efforts of French companies in system design issues, allowing them to aim for leadership positions on an international scale. On the other hand, onshore R&D focuses mostly on the performance of turbines and wind farms.

Onshore
- Performance issues in the operation and maintenance of wind farms
  - Forecasting of generation potential: Lidars (Léosphère), short and mid-term simulation tools (Météodyn, Mines ParisTech)
  - Managing variable and predictable energies
  - Aerodynamic losses (Polytech Orléans)
  - Interaction with radars (ONERA)
  - Increase in rotor and mast size (EOLIFT / INSA Rouen)
  - R&D efforts aiming to lower raw material costs

Offshore
- Growth strategy aimed at gaining market share by designing the wind power systems of the future (including floating offshore turbines)
  - Combination of Naval / Oil & Gas expertise
  - Marine structures and conditions
    - Impact of foundations (Universities of Le Havre and Caen)
  - Ageing of materials (IRT, Jules Verne, etc.)
  - Simulation tools (IFPEN, CORIA, etc.)
  - Analysis of coupled phenomena, requiring testing resources (pools and wind tunnels with FEM’s VALEF project, etc.)

R&D activities bring together both public and private operators for collaboration on research projects. In particular, thanks to the €67bn budget from the Future Investment Programs (PIA) (of which €57bn over the period 2010-2017 and €10bn for PIA 3, which was launched in February 2017), part of which is earmarked for the energy transition, ADEME acts as a significant catalyst by de-risking projects at the demonstrator stage through funding.
Competitiveness – R&D

Wind power market dynamics are encouraging new players to enter the market, driving innovation in existing and future markets

Businesses ranging from start-ups to large organizations are establishing a foothold in the wind power market, both to provide innovative and diverse new solutions and to position themselves as key players in the industry. Companies frequently rely on the transfer of expertise and technology.

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<th>CHOMARAT</th>
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<td>Development of electric substations / Marine technologies</td>
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Capgemini invent | France Energie Eolienne
Competitiveness – R&D

Mapping of R&D players

Key:
- University or Grande École
- Private R&D operator
Competitiveness – R&D

GE Renewable Energy is building the world's most powerful offshore wind turbine in France

On March 1st, 2018, GE Renewable Energy announced that it was building the most powerful high-performance offshore wind turbine ever conceived: Haliade-X. The wind turbine will be fitted with a 12 MW direct-drive generator, producing more power than any other turbines on the market. A single unit will produce 67 GWh of electricity a year, representing the power consumption of 16,000 homes and will save 42 million tons of CO2 equivalent per year, equivalent to taking 9,000 cars off the road.

GE Renewable Energy is investing more than $400 million in France. Approximately $60 million are being invested in adapting its Saint-Nazaire nacelle and generator manufacturing plant. In addition, LM Wind Power, a subsidiary of GE Renewable Energy, is investing US$100 million in its Cherbourg offshore wind turbine blade plant.
Competitiveness – digitalisation

Digitalisation is key means to enhance competitiveness in the management of wind power assets

**Improved productivity:**
- Allows for an overall analysis of wind farm performance
- Optimizes distribution on the grid
- Enhances the utilization of wind power through data-based trading strategies and machine learning

**Cost reduction:**
- Decreases the number of unplanned stops
- Cuts down the number of emergency interventions
- Bolsters maintenance-focused strategies
- Optimizes workforce productivity
Competitiveness – digitalisation

An example of a digitalisation project: Predict-to-Prevent, Nordex

Project description
The “Predict to Prevent” project makes it possible to analyse the probabilities of component failures. The programme offers intelligent solutions based on machine learning and artificial intelligence. These solutions monitor the conditions of components and alert the technicians in the event of an anomaly. Increased responsiveness and reduced intervention times allow for a decrease in operational costs.

“Reduced production losses for customers and lower operational costs for Nordex”,
Nordex 2019
Competitiveness – Innovation

Wind power coupled to the charging stations of tomorrow

Providing an attractive high-powered charging infrastructure is an important step towards making electric mobility sustainable within the next decade.

Enercon has developed electric vehicle fast-charging stations that bring together a wind power source, a container for energy conversion and storage, as well as charging stations.

Another advantage is that fast-charging solutions can also contribute to the stability of the network through the exchange of reactive power during charging operations. This is an important factor in enabling the development of such fast-charge infrastructure.
Competitiveness – Innovation

Wind at the heart of microgrid solutions

**Microgrids** are a scaled-down version of conventional power grids. Power is directly fed in to a group of users from a local power generation unit. It is usually connected to the national grid but in one point only that acts as a switch. It can then be disconnected and become completely autonomous. To be able to function, a microgrid must include three basic components:

- a **local energy power generation** unit: photovoltaic panels, wind turbines, a cogeneration unit, a heat pump, a biomass power station or a hydropower turbine, and, in addition, a backup generation system (power generator).
- a **storage system**: batteries, water supply for pumped storage and, in the future, supercapacitors and latent heat storage;
- an **intelligent management system** to ensure constant balance between electricity generation and demand.

**Saint-Nicolas-des-Glénans** is an island in the Glénans archipelago that receives 1,000 to 1,500 visitors a day during the summer. A microgrid is being set up by Enedis at a cost of €250,000 to ensure that the island is supplied with 100% renewable power by 2021.

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**Source:** Bretagne Économique
Competitiveness – innovation

Blade Asset Management by Vestas and drone-based inspection

It is crucial for the wind industry to carry out blade inspections on a regular basis, both to ensure proper performance of the assets and in order to keep operation and maintenance costs under control.

Solution

Vestas launched its Blade Asset Management (BAM) services in 2019.

BAM is can be accessed via VestasOnline® and provides an overview of the condition of the turbine blades for a given fleet or wind farm, the objective being to strive to maximize wind turbine performance and service life.

Information on the state of the turbine blades is collected via drone-based inspection, which take up to 200 photos per inspection per turbine. Inspection time is kept to a minimum as a result. In 2019, more than 750 inspections were conducted in this way in France.

Defects are triaged using artificial intelligence and then reviewed by Vestas maintenance teams with the aim of putting up this information on the BAM portal and in reports on Vestas Online after the inspections are carried out.

VestasOnline is a collection of digital applications by Vestas that is designed to make operating a wind power portfolio both easier and more profitable.

“Downtime is kept to a minimum throughout the life cycle of wind turbines thanks to a optimized comprehensive process of inspections and repair scheduling.”
The challenges of the wind industry

Grid integration
Integration into the network – at all levels

Enedis and RTE are preparing the grids of the future, which will be able to accommodate five times more renewable power than today by 2035

The following pages have been prepared in collaboration with Enedis, which manages the public electricity distribution network in France, and RTE, which is France’s public electricity transmission system operator.

Enedis and RTE have been engaged in a process of major adaptation of their networks for several years.

Their objective is to accommodate new electricity generating facilities, including wind power, while ensuring the safety and security of the electric power system. Network operators are working to accommodate renewable energies in the current network and making long-term investments to develop a network that is capable of feeding in increasing levels of renewable electricity. By 2035, power grids must be in capacity to accommodate five times more solar and wind power than today. To rise to this challenge, Enedis and RTE are working along three main lines:

- Field experiments that test innovative and flexible solutions needed to accommodate renewable energies:
- Planning, to anticipate the accommodation of the influx of renewable energies by power grids
- Developments in the regulatory framework
Integration into the network – at all levels

The integration of renewable energies is being prepared at all geographical levels

Local

At local levels, carrying out grid connection work, fostering dialogue with local authorities and contributing to the consultation phases of locally-based projects.

Regional

At regional levels, particularly in the development and implementation of the S3REnR (Schémas régionaux de raccordement au réseau des énergies renouvelables) regional grid connection schemes.

National

At a national level, thanks to their presence during discussions regarding the accommodation of renewable energies conducted by the French government and the Energy Regulation Commission (CRE). These include consultations concerning the roll-out of European grid codes in France and work groups on the energy transition.

European

At a European level (interconnections, grid codes, etc.) thanks to their contribution to the preparation of EU directives to organize the influx of renewable power into the grid.
Integration into the network – at all levels
... as well as for different time scales

The power distribution grid is developed based on technical and economic studies over various time frames. To carry out these studies, it is necessary to have a prospective outlook of the trends involved in the broad determinants of the power grid: electricity use, the French energy mix - notably the development of renewable energy production - and international trade.

The initial prospective outlook is then gradually refined as further in-depth studies are conducted on the projects and increasingly specific assumptions regarding the key determinants are taken into account.

All these studies are based on the exercises of the Multiannual Energy Programming (Programmation Pluriannuelle de l’Énergie – PPE), RTE’s Bilan prévisionnel forecast, the S3ReR (Schémas régionaux de raccordement au réseau des énergies renouvelables) regional grid connection schemes, the EU’s Ten-Year Network Development Plan (TYNDP) and RTE’s ten-year network development plan (Schéma décennal de développement du réseau – SDDR).

RTE’s Bilan prévisionnel forecast is an in-depth review of trends in electricity generation and consumption, and of the solutions required to ensure that these are balanced, based on various energy mix scenarios.

RTE’s ten-year network development plan (Schéma décennal de développement du réseau – SDDR) summarizes the short-term, medium-term and long-term visions of the French transmission network (see following pages).

And lastly, the S3ReR regional schemes are key to identifying and anticipating needs on the grid and thus realizing the ambitions for renewable energy development set out by the region prefects on a ten-year forecast horizon (see following pages).
Integration into the network – at all levels

The ten-year network development plan (SDDR) anticipates the requirements of the electricity system of the future

The SDDR (Schéma décennal de développement du réseau) is a mission entrusted to RTE by law since 2011. It informs the various stakeholders about the technical, economic and environmental consequences of the developments of the electricity grid, based on different energy policy scenarios on various time scales:

- **in 3 years time**: it lists investments that have already been decided upon as well as new investments that are set to be carried out within the next three years.

- **in 10 years time**: it points out the main transport infrastructure that will have to be constructed or modified, and provides a timeline for these investment projects.

- **in the longer term**: it provides a strategic and prospective vision of the overall evolution of the network up to 2035 by assessing the economic and environmental impacts of the various scenarios of the Bilan prévisionnel forecast and the PPE. This work highlights in particular the fact that the needs for adaptations of the transport network will be largely determined by the actual rate of development of renewable energies, and remain second to the overall cost of the energy transition.

For the latest instalment, RTE wished to broadly involve stakeholders in the drawing-up of the 2019 plan via a formal consultation that was organized in May 2018.
Integration into the network – at all levels

S3REnRs make it possible to better connect renewable energies

The S3REnR schemes are network planning tools established by the Grenelle II Act that were developed by RTE with the support of distribution system operators, including Enedis. They serve to anticipate the need for capacity on the grid to accommodate the intake of renewable energies and therefore optimize future outcomes for the power grid. The S3REnR schemes have a threefold purpose: to provide medium-term visibility on the grid’s accommodation capacities (by 2020 for the current schemes); to optimize and anticipate all necessary developments over the next ten years; and to pool costs across producers in order to ensure that the first renewable energy projects do not bear all of the infrastructure costs.

The S3REnR schemes have entered a new phase of preparation. Indeed, pursuant to ordinance no. 2019-501, the Prefects of each region will determine the accommodation capacities of the new schemes for 2030, while taking into account the national renewable energies development objectives defined by the PPE, the regional ambitions defined in the SRADDETs (the first of which are expected by the end of 2019) as well as the dynamics of RE development in the region.

RTE is already working with French regions in order to develop these new schemes, particularly in the Nouvelle-Aquitaine, Grand-Est, PACA, Occitanie, Centre and Hauts-de-France regions, since the S3REnRs in these regions are near the revision threshold or are saturated. In other regions that are very dynamic in terms of renewable energy development, grid operators have initiated preliminary work for the stakeholder review. Pending the approval of the revised schemes, grid operators are implement the scheme adaptations that will reduce the local overloads identified in the networks.
Integration into the network – at all levels

To date, the 21 S3REnR schemes represent a grand total of 28 GW accommodation capacity of renewable energy across the country...

Key data for 2018

- All 21 schemes are currently in force.
- Reminder of the ambitions in terms of renewables (excluding historical in terms of renewables (excluding historical hydropower) that are set out in the regional SRCAE schemes: **48.2 GW**
- Total accommodation capability reserved for renewable energies: **27.5 GW**

Total investment in the accommodation of renewable energies in the regional S3REnR schemes as of the end of 2018

- Works on the Enedis network: €143 million spent on infrastructure development and €27 million on infrastructure enhancement as of the end of 2018
- Works on the RTE network: €127 million for infrastructure development and €100 million for work on the existing network
Integration into the network – at all levels

... nevertheless, there are still significant disparities in the use of reserved allocation capacities as at mid-2019

(1): Source: RTE
Integration into the network – at all levels

The Anticipation S3REnR working group aims to speed up grid connection

A working group was launched in 2018 within the Committee of users of the electricity transmission network (CURTE) on the acceleration and anticipation of network adaptations that necessary for the development of renewable energies.

The working group has achieved two concrete results:

Preparation of a summary of the proposals that could accelerate and anticipate network adaptations

- The main proposal concerns anticipating studies and administrative procedures on key structuring infrastructure (requiring more than 4 years to be implemented).

The objective is to carry out a periodic prospective exercise every 5 years at the most, in order to identify opportunities for key structuring infrastructure that will be needed beyond the S3REnR in force, as scouted by federations of producers, and to consult on them with stakeholders, and to then launch the studies and administrative procedures required for these projects without waiting for the revision of the scheme to be enacted.

Setting up a specific body to monitor and improve S3REnR schemes

- This body that brings together the federations of producers, network operators as well as the Energy Regulatory Commission (CRE – Commission de régulation de l'énergie) and the Directorate General of Energy and Climate (DGEC – Direction générale de l'énergie et du climat) convened for the first time in May 2019.

The aim of this body is to share the regional and national visions of the S3REnR in force, changing outlooks on France’s renewable energy resource potential, progress on the studies being conducted and anticipated procedures and to prepare joint proposals to improve the implementation of the schemes.
Grid integration – Innovation

Network operators innovate in order to accelerate the grid integration of renewable energies

Today building a transmission substation takes about 2 years (preceded by a 3 year period for administrative processes). Enedis is accelerating the construction of the transmission substations with the Poste Source Express (PSE) project.

Enedis has embarked on a transformation of the transmission substation construction process by opting to industrialize and standardize its essential components of the structure in order to reduce construction time.

PSE substations are adapted to rapid deployment in rural areas of the transformation capacities needed to accommodate renewable energies: up to one year is saved in the process.
Preparing the grids of the future

 Operators actively contribute to offshore wind development

The objectives of the offshore wind energy sector are defined in the Multiannual Energy Programming (Programmation Pluriannuelle de l’Énergie – PPE). On the occasion of the designation of the winner of the call for tenders for an offshore wind farm off Dunkirk and in view of the lower costs incurred by the sector, the French government has expressed the desire to accelerate the deployment of wind at sea with the ambition to launch and award future projects at the rate of 1 GW per year.

The legal corpus is adapting to incorporate new anticipatory, simplification and project de-risking measures in the interest of the community, including:

- A procedure known as “competitive dialogue” (dialogue concurrentiel) that streamlines public tendering
- Electrical connections is financed by RTE and covered by electricity tariffs
- Financial compensation for connection delays and operational damage
- Envelope permit to gain flexibility
- Maritime spatial planning taking into account the accommodation capacity of the power grid

RTE is positioning itself as serving an ambitious development of marine renewable energies via:

- Long-term planning shared with the public authorities and local territories in order to anticipate and optimize the dimensioning of the network, which is making the following possible:
  - The pooling of the public offshore grid (“connection hub”) in order to lower costs and impacts
  - The standardization of certain infrastructures to achieve economies of scale
- The innovative development of multi-purpose platforms at the service of French host regions and localities as well as stakeholders
- The mitigation of social, economic and environmental impacts of power generation facilities
Grid integration – Innovation

The Postes de Nouvelle Génération next-generation substations will accommodate up to 30% more renewable power sources for a given infrastructure.

Poste Intelligent is a project that is shaping the electricity network of the future to better serve the energy transition. Through the use of embedded digital and optical technologies, it will optimize the capacities of substations, which are the centrepiece of the electricity transmission network, in order to adapt them to the development of renewable energies on a massive scale. The feasibility of the fully-digital electric substation concept was demonstrated thanks to this pilot.

"At the heart of an electrical system that will change more drastically in the next five years than during the last fifty years, RTE has the ambition to become Europe’s first network operator to bring together electrical technologies and digitalisation" François Brottes, Chairman of the RTE Management Board.

Key data

- **Dates:** since 2013,
- **Budget:** €32 million, €9.7 million of which have been publicly funded under the “Investing for the Future Programme” (Programme d’investissements d’avenir, PIA)
- **Location:** Two smart electric substations in the Somme, covering an area of operation of 490 km
- **Consortium members:**

The concept of a fully-digital substation is now coming to fruition via the Postes de Nouvelle Génération next-generation substations. The deployment of the first 4 examples on the transmission network will be done within the framework of the SMILE project of the Brittany and Pays de Loire regions of the Intelligent Electric Networks plan.

"With this smart substation project, RTE and its partners are one step ahead of the market. Several power grid operators across the world are currently conducting tests, but only on a few of the ‘technological bricks’ that we intend to deploy", RTE project manager.

The proliferation of digital equipment, particularly sensors, will make it possible to manage many operations on future next-generation substations remotely", project manager in the Operations departement.

The Postes de Nouvelle Génération next-generation substations will help accommodate more renewable power sources by increasing accommodation capacity by 30% for any given infrastructure. The generalized monitoring of the equipment of these substations will also help anticipate potential failures much more accurately.

(1) Source: posteintelligent.com
Grid integration – Innovation

Smart Grid Vendée is Vendée’s smart electricity grid

The Smart Grid Vendée project aimed to test out new solutions to manage and modernize the distribution of electricity on the scale of the Vendée département, in the context of the energy transition. Its inclusive approach, which engages all the stakeholders in the electricity system, is based on the use of a demonstrator to test out new concepts relating to optimization of public distribution grids. Optimization at the regional and local levels requires enhanced real-time upstream coordination (planning, forecast management) between stakeholders, based on new digital interfaces and modernized network management tools.

Smart Grid Vendée has made it possible to conduct experiments on several subjects:

- **Innovation**: the development and deployment of technological and organizational solutions in order to help accommodate renewable energies, cost-effectively adapt electric power distribution and improve the quality of the electricity supply.
- **Economics**: the definition of business and earnings models associated with the management of local power systems, for all stakeholders in the electric power system.
- **Environment**: ensuring that the project is socially and geographically well-integrated, and measuring its impact on the local electric power system and on the sector as a whole.
- **Social**: the creation of an engineering degree in smart grids, in the form of an apprenticeship, at the higher education establishment CNAM Pays de la Loire.

Key data

- **Dates**: 5 years, 2013–2018
- **Budget**: €27.8m, €17m of which are funded by Enedis, €0.5m by RTE and €9.5m are publicly funded under the “Investing for the Future Programme” (Programme d’Investissements d’Avenir – PIA)
- **Location**: Vendée
- **Consortium members**:

Virtually dozens of installations in the area have been equipped with sensors to collect real-time information on electricity use and generation. The analysis of this data has revealed consumption trends and made it possible to develop software to optimize network management in real time.

Source: smartgridvendee.com – ADEME funding application.
Alternative technical solutions lower investment costs and shorten grid connection times

Alternative technical solutions (ORI – offres de raccordement intelligentes) result in lower investments costs in terms of grid infrastructure (with savings of approximately €100,000 per installed MW). They also allow grid connection lead time to be reduced (by seven to ten months).

Alternative technical solutions allow producers to return to standard connection conditions at any time if they wish to do so (implementation of the reference technical solution, or ORR – opération de raccordement de référence).

1. HV producers first submit a request for grid connection to Enedis. Enedis then conducts a study of the network topology in order to establish a reference technical solution (ORR – offre de raccordement de référence), which allows for the continual feed-in of the entire output of the power generation unit. In certain cases, this offer may require the creation of a new line or reinforcements on the existing high-voltage grid.

2. At the request of the producer, Enedis can offer an “alternative technical solution” (ORI – offre de raccordement intelligent), which provides faster set-up at lower cost (by connecting to an existing feeder), in exchange for the possibility of feed-in curtailment should constraints appear.

3. Should constraints be projected in advance, Enedis sends a temporary feed-in curtailment order to producers that opted for ORI via its Operation Information Exchange Device / Distribution Management System (DMS).

This solution is offered for grid connections that continuously maintain a high level of power that can be supplied to the grid (guaranteed output ≥ 70% of power supply capacity). The offer potentially applies to one fifth of all HV connection requests.
Grid integration – Innovation

Power utilities are investing in long-term R&D projects to develop a grid that is capable of accommodating increasing volumes of renewable energies

Enedis and RTE are involved in ambitious long-term research projects such as the European BEST PATHS and OSMOSE projects and have close links with stakeholders in the regions and various partners (manufacturers, SMEs, start-ups, universities and laboratories) in order to collaborate on the construction of the electricity grid of the future.

R&D budgets related to the energy transition:

- **RTE**: €45m of Turpe S’s €140m from 2017 to 2020
- **Enedis**: €147m of its €225m R&D budget from 2017 to 2020

Partnerships – what’s new:

**RTE**:
- Accession to France Énergies Marines and Stanford University’s Bits&Watts initiative.
- Partnership on biodiversity with the Paris Museum of Natural History, with whom RTE is undertaking the SPECIES (Submarine Power Cables Interactions with Environment and associated Surveys) project

**ENEDIS**:
- Renewal of the partnership with the Laboratory of Electronics and Electrotechnics of Lille (L2EP) on the integration of the uncertainties on projections and provisional network management.
- Enhanced partnership with the Group of National Schools of Economics and Statistics (GENES) regarding the articulation of system services and decentralized production

The BEST PATHS project

BEST PATHS is a 48-month research project which ended in September 2018. It was funded under the EU’s FP7 research programme. Within this project, the work on the interoperability of HVDC converter stations, conducted by RTE, has generated unprecedented outcomes:

- First proof of the existence of interoperability issues. The estimated rate of occurrence of these problems is 15%.
- First troubleshooting of interoperability issues, with a methodology that ensures that the confidentiality of producer-specific data and technical solutions are guaranteed.

**Budget**: €62.8m, including €35.5m of EU H2020 funds.

**Consortium members**: 39 partners from 11 countries, including France.
Grid integration – Innovation

OSMOSE: an ambitious European research project

OSMOSE was launched following the Low-Carbon Electricity call for projects of the European research programme H2020. It focuses on the “Demonstration of the integration of the energy system with smart distribution and storage grid technology and an increasing share of renewables in the energy mix”. OSMOSE aims to anticipate the needs for flexibility generated by the accommodation of an increasing quantity of renewable energies in the power grid.

It is a comprehensive approach that accounts for all possible needs for flexibility (balancing demand and supply on the energy markets, optimizing existing and future systems services and enabling the active management of the grid) and sources of flexibility (particularly storage, demand management and the flexibility of renewable energies). This approach then reveals the converging lines between the various solutions, for instance to identify the best location for storage capacity to be installed with optimum cost-effectiveness.

RTE is leading this European project and is in charge of the package aimed at setting up a battery demonstrator for testing the provision of several types of services with a given installation. This demonstrator will test, under field conditions, the regulations set out by the European MIGRATE project. This project examines the impact on the grid’s dynamic operation of the massive insertion of renewable energies connected via power electronics. The demonstrator will test the implementation of multiservice storage technologies, as well as synchronization services, to balance supply and demand and manage load and frequency. The multiservice aspect will bring greater financial viability to storage solutions.

Key data

- Dates: 4 years, starting in 2018
- Budget: €28 million
- Consortium members: 33 partners from nine countries, including European power transmission system operators, power producers, generalist equipment manufacturers and/or system operators, equipment manufacturers and/or system operators that are specialized in electrochemical storage and power electronics, computer scientists, energy services providers, consulting companies, software companies, research institutions and universities.
Integration in the network – Training

RTE anticipates the future through training activities

In order to anticipate all future transformations – economic, technological, demographic and in society –, and in accordance with the orientations of the business project, RTE's training areas are regularly updated. In 2018, the training guidelines for the period 2020-2022 aim to consolidate the current base of fundamental skills while adapting it to new technologies (connected objects, data processing, etc.) and new ways of working (drones...), new fields of intervention (underwater links, high-voltage direct current links ...) and the integration of CSR into business training (listening and dialogue with stakeholders, skills development environment, including the eco-design approach, strengthening the workplace safety culture, etc.).

RTE’s training campus in Jonage receives several thousand trainees each year. Since 2017, the professionalization system has expanded with the growing proposal for digital training. This possibility allows a wider and faster access to training. For instance, the CSR awareness course was followed by almost 60% of RTE employees in twelve months.²
The challenges of the wind industry

D. Coupling with storage
Coupling with storage

Storage is one of the keys that can improve integration in the French electrical system

Electricity storage technologies must address major challenges against the backdrop of the expansion of renewable energies. There are a number of **challenges relating to storage** to ensure that renewable energies, and especially wind power, are integrated into electricity systems.

**Security**: securing electrical service and supply to the grids.

**Industrial development**: promoting the scaling up of industrial processes with a view to the market roll-out of storage devices.

**Setting up an institutional and regulatory framework** in the network, enabling several users to share the same storage facilities.

**Environmental**: the lifecycle analysis of storage systems (from design to end-of-life management) ensures that the environmental standards of storage systems are met throughout their life cycle and that carbon emissions are reduced by putting an end to peaking power plants.

**Developing the economic potential** of storage appliances: their technical features can be adapted to various energy applications and business opportunities. Storage systems simultaneously contribute to smoothing out the variations in power generation, optimizing generation scheduling, regulating frequency and power quality on the grid, and balancing power supply-and-demand.
Coupling with storage

Many storage technologies can be put to use at the service of wind power

Technologies used for rapid response (seconds)

Technologies used for week-long or even seasonal storage

*CAES: compressed air energy storage
**STEP: pumped energy transfer stations
Source: JRC, Capgemini
Coupling with storage

Wind power projects coupled with storage are growing all around the world

- **Batwind, Scotland**
  - Wind farm installed capacity: 10 MW
  - Storage capacity: 33 MWh
  - Storage technology: Hydrogen

- **Hornsdale, Australia**
  - Wind farm installed capacity: 309 MW
  - Storage capacity: 129 MWh
  - Storage technology: Li-ion

- **Whitelee, Scotland**
  - Wind farm installed capacity: 539 MW
  - Storage capacity: 50 MWh
  - Storage technology: Li-ion

- **Hùsahagi, Faroe Islands**
  - Wind farm installed capacity: 11.7 MW
  - Storage capacity: 0.7 MWh
  - Storage technology: Li-ion

- **Mainz, Germany**
  - Wind farm installed capacity: 5.6 MW
  - Storage capacity: 2.7 MWh
  - Storage technology: Lithium-ion and Hydrogen

- **Curslack, Germany**
  - Wind farm installed capacity: 12.5 MW
  - Storage capacity: 0.79 MWh
  - Storage technology: Li-ion

- **Les Renardières, France**
  - EU-SYSFLEX project
  - Wind farm installed capacity: 12 MW
  - Storage capacity: 2.3 MWh
  - Storage technology: Li-ion

- **Housetown, Wales**
  - Wind farm installed capacity: 228 MW
  - Storage capacity: 16.5 MWh
  - Storage technology: Li-ion

- **Notrees, USA**
  - Wind farm installed capacity: 153 MW
  - Storage capacity: 24 MWh
  - Storage technology: Li-ion

- **Marie-Galante, Guadeloupe**
  - Wind farm installed capacity: 2.5 MW
  - Storage capacity: 0.45 MWh
  - Storage technology: Li-ion

- **La Plana, Spain**
  - Wind farm installed capacity: 52 MW
  - Storage capacity: 400 kWh
  - Storage technology: Redox-Flow

- **Vametco, South Africa**
  - Wind farm installed capacity: 1 MW
  - Storage capacity: 4 MWh
  - Storage technology: Redox-Flow

- **Flinders Shire, Australia**
  - Wind farm installed capacity: 4.2 MW
  - Storage capacity: 4 MWh
  - Storage technology: Li-ion

- **Les Renardières, France**
  - EU-SYSFLEX project
  - Wind farm installed capacity: 12 MW
  - Storage capacity: 2.3 MWh
  - Storage technology: Li-ion

- **Lem-Kaar, Denmark**
  - Wind farm installed capacity: 12 MW
  - Storage capacity: 0.25 MWh
  - Storage technology: Li-ion

- **Housetown, Wales**
  - Wind farm installed capacity: 228 MW
  - Storage capacity: 16.5 MWh
  - Storage technology: Li-ion

- **Notrees, USA**
  - Wind farm installed capacity: 153 MW
  - Storage capacity: 24 MWh
  - Storage technology: Li-ion

- **Marie-Galante, Guadeloupe**
  - Wind farm installed capacity: 2.5 MW
  - Storage capacity: 0.45 MWh
  - Storage technology: Li-ion

- **La Plana, Spain**
  - Wind farm installed capacity: 52 MW
  - Storage capacity: 400 kWh
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- **Vametco, South Africa**
  - Wind farm installed capacity: 1 MW
  - Storage capacity: 4 MWh
  - Storage technology: Redox-Flow

- **Flinders Shire, Australia**
  - Wind farm installed capacity: 4.2 MW
  - Storage capacity: 4 MWh
  - Storage technology: Li-ion

Note: fully operational projects
Source: companies
Coupling with storage

Towards a hybridization of renewable energy technologies in order to improve efficiency

Renewable energies are subject to the vagaries of the weather: wind power to fluctuations in wind levels, solar power to variations in sunlight. Properly combining the contributions of wind power, solar power and energy storage in batteries and fuel cells would provide the electricity in demand on an almost continuous basis. These combinations depend on variables that are among others the amount of energy needed, the geographical area considered, the vagaries of the weather and so on.

The Siemens Gamesa pilot project: Siemens Gamesa is testing a hybrid energy storage system at La Plana in Spain. The park generates 52 MW of wind power and 245 kW of solar power.

The storage system consists of a redox flow battery connected to the hybrid controller that centralizes the generation of wind and photovoltaic power. Li-ion batteries and a generator complete the system.

Source: Siemens Gamesa
The challenges of the wind industry

E. Education and training
Training & education

Wind energy education and training in France

Key:
- BZEE
- GWO
- BTS MS Option Éolien

4/5 years post-secondary education
+2/+3 years post-secondary education
Training & education

Training programmes cover all branches of the wind industry

**Partnerships with the industry**
Industrial firms and engineering consultancies are now involved in the training process and are developing key partnerships with high schools, universities and training centres. These industrial partners contribute to the funding of training programmes and offer internship opportunities that often result in long-term employment contracts.

**Wind power-related training programmes**
International certified training programmes (BZEE and GWO) are highly valued by wind farm developers and operators. Such programmes can be followed after graduating from high school (as a licence professionnelle, BTS or DUT) or as continuing education.

**Training programmes for all levels**
Programmes specific to the wind industry exist at all levels, from high school level (bac professionnel) to engineering schools. They confirm the need for fully-trained experts to support the sector's development.

**Throughout the country**
These programmes are strongly supported by the regions that are developing wind power generation. Training centres are therefore usually located near production sites.
Training & education

Specialized training programmes, from vocational qualifications to bachelor’s degrees

<table>
<thead>
<tr>
<th>Certification Type</th>
<th>Pre-baccalaureate Programmes</th>
<th>Baccalaureate</th>
<th>2 years post-secondary education</th>
<th>2 years post-secondary education</th>
<th>1 year training programme after 2 years of post-secondary education</th>
</tr>
</thead>
<tbody>
<tr>
<td>Certificat d’aptitude professionnelle (CAP)</td>
<td>31 cities</td>
<td>59 cities</td>
<td>28 cities</td>
<td>10 cities</td>
<td>32 cities</td>
</tr>
<tr>
<td></td>
<td>51 diplomas</td>
<td>158 diplomas</td>
<td>46 diplomas</td>
<td>16 diplomas</td>
<td>50 diplomas</td>
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<tr>
<td></td>
<td>42 institutions</td>
<td>94 institutions</td>
<td>38 institutions</td>
<td>9 institutions</td>
<td>41 institutions</td>
</tr>
<tr>
<td>Bac professionnel (vocational high school diploma)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>BTS (technician certification)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DUT (university technology degree)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Licence Professionelle (bachelor’s degree)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Training & education

Higher education programmes (4 years post-secondary education and beyond) are expanding their specialized offer

Across the country, there are now:

- More than 70 training programmes
- In more than 40 universities / grandes écoles
- 25 cities
- Several hundred graduate students per year

Examples of Universities and Grandes Écoles engineering schools

Focus on two examples of specialized Master's degrees in Renewable Energies in France

Specialized Master’s degrees “Experts in renewable energy projects and production”

- Energy and the environment, renewables and energy management, technologies employed in renewables, renewable energy systems design

Partners

- Renewable energy project management / development, engineering consultancy, etc.

Career opportunities

Specialized Master’s degrees “Experts in Marine Renewable Energies”

- Systems engineering; marine resources; economic, environmental and legal aspects

Partners

- Renewable energy project management / development, engineering consultancy, etc.

Career opportunities
Training & education

Two international training programmes providing certification are available in France

**Technician certificate in wind power systems maintenance**
- Advanced training in wind turbine maintenance techniques and safety measures
- Continuing education or apprenticeship training lasting **6 to 9 months**
- Four of these training centres also offer GWO modules
- More than 320 students were BZEE-trained and certified in France in 2016. They were awarded either the Service Technician for Wind Energy Facilities certificate or the Working at Heights certificate.

**Key modules:** offshore operations, wind energy technology, wind turbine electronics, operations management

---

**Basic Safety Training Certificate**
- Safety-focused training
- Five modules to be completed (over a period of seven days)
- Overall, 25,000 individuals throughout Europe are now certified for between three and five GWO modules.
- Since December 2015, the BZEE certificate has also included GWO modules, including modules on maintenance safety training.

**Key modules:** first aid, manual handling, fire-hazard awareness, working at height, survival at sea.
Training & education

Focus on: the ENERCON training centres in Longueil-Sainte-Marie

The international training centre for wind turbine assembly set up by ENERCON in Longueil-Sainte-Marie (in Oise, Hauts-de-France) has been open since January 2018. This centre required around €3.5m of investment and is staffed with 8 trainers. 350 ENERCON technicians from all over the world are trained each year there. The centre offers two main areas of training in real field conditions: concrete mast installation; and assembly and wiring of appliances, nacelles and pales. Training is provided for wind turbines of 2 MW or more and the training centre is equipped with the latest generation of wind turbines (EP3 platform).

These programmes will empower the trainees and help them access new work opportunities. This is particularly true for service technicians, who can then become technical coordinators, expert technicians, HSE technicians or quality technicians.

In September 2017, Enercon opened another training centre dedicated to maintenance technicians in Meaux, also in Oise. 600 people undergo training there every year.

The opening of these training centres for the French wind power industry, which was instigated by ENERCON, is in line with the strategy set forward by the Minister for Labour, Muriel Pénicaud (photo), as part of the Skills Investment Plan, which provides for the introduction of 10,000 training courses in green jobs.
Training & education

Examples of wind power jobs in the wind power value chain

Wind project development
- Component manufacturing
  - Wind turbine assembly
- Exceptional transport

Wind farm project manager
5 years post-secondary education
Wind farm project managers play a key role in the whole development phase. Their responsibilities include choosing the installation site, coordinating the feasibility studies and working with real estate owners, farmers and local officials on deployment options for each turbine.

Component manufacturing
- Wind turbine assembly
- Exceptional transport

Boilermaker
- Bac Pro (vocational high school diploma)
Boilermakers produce large-scale products from various types of sheet metal. They are responsible for ordering, monitoring and maintaining the computer numerical control machines that cut and assemble the various components of wind turbines.

Site preparation
- Assembly
- Connection to the grid
- Commissioning

Superintendent
3–5 years post-secondary education
Site managers are primarily concerned with the various stages of the construction of a given wind farm, with responsibilities including renovating of access roads, laying foundations, receiving components, assembling and installing wind turbines, connecting wind turbines to the grid and, finally, commissioning the wind farm.

Operation
- Maintenance

Service technician
+3 years post-secondary education
Service technicians undertake the planning and execution of preventive and curative maintenance tasks on a wind farm to ensure maximum availability and productivity of the turbines. The objective of preventive maintenance is to prevent material fatigue in components in order to reduce the likelihood of hardware failure.
The challenges of the wind industry

F. Circular economy
Circular economy

Wind turbines are now more than 90% recyclable

Beyond easing pressure in terms of environmental resources and impacts, the idea is to better integrate wind power locally (in terms of jobs and added value) throughout the project life cycle (production, installation, maintenance, end of service life). Recycling is a major challenge in terms of public buy-in and added value of the wind industry.

Though only few French wind farms have reached the end of their operational cycle, the question of extending their life expectancy is anticipated.

Of the 141.6 GW of the existing fleet in the European Union in 2016, half of all wind farms are set to reach the end of their service life between 2020 and 2030.
## Circular economy

### Definitions

<table>
<thead>
<tr>
<th><strong>Dismantling</strong></th>
<th><strong>Recycling</strong></th>
<th><strong>Wind farm repowering</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>It is a statutory obligation for operators to handle the dismantling of production units and site reclamation at the end of their service life. Dismantling a wind farm entails:</td>
<td>Metal parts such as the mast and the rotor make up more than 90% of the weight of the wind turbines and are recycled in existing channels. As a matter of fact, the market value of the scrap metal often turns the dismantling of wind turbines into a profitable operation. Reinforced concrete foundations can also be reused: once sorted, crushed and deferrated, they are often used as aggregates in the construction sector.</td>
<td>Wind farm renewal/repowering refers to the replacement of an energy installation to make it more efficient at the end of its life. By 2023, 1,600 turbines will be affected in France. The benefits of wind farm repowering/renewal:</td>
</tr>
<tr>
<td>▪ disassembling the wind turbines and the substation.</td>
<td>▪ Wind turbine blades consist of composite materials including fibreglass and/or carbon. Wind turbines are generally more than 90% recyclable and this rate is being improved through innovation.</td>
<td>▪ Modern wind turbines are <em>more powerful, more reliable</em> and require less maintenance, and thus contribute to <em>lower costs</em>.</td>
</tr>
<tr>
<td>▪ excavating the foundations.</td>
<td></td>
<td>▪ Decreasing the number of wind turbines in wind farms <em>limits the drag effect</em></td>
</tr>
<tr>
<td>▪ removing some of the cables (the rest will remain buried on site and inert).</td>
<td></td>
<td></td>
</tr>
<tr>
<td>▪ reclaiming the site, unless their owner does not want to.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>▪ recovering or disposing of the waste generated.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Circular economy

A case of disassembly at sea: Northumberland

In December 2000, the Blyth offshore wind farm off Northumberland on the north-east coast of England was completed. Consisting of two Vestas V66 2 MW turbines, it was built by a consortium composed of E.ON, Shell Renewables, Vattenfall’s Nuon and Border Wind.

Following its dismantling in April 2019, one of the two turbines will be recycled and reused for spare parts within E.ON's onshore farm, while the other will be used for training purposes at Blyth’s port.

Repowering on offshore wind facilities – as is common in onshore wind – still needs to be further explored. Nevertheless, it is expected that all offshore wind farms will be dismantled at the end of their service life. The latest generation turbines are more massive than the previous ones and the foundations that were initially installed are not sized to accommodate them.

“The renewal of offshore wind farms is at its very beginning”
Circular economy

Repowering situations: the issue of recycling

In Sainte-Suzanne (on La Réunion), Quadran, a company in the Direct Energie group, plans to replace the existing fleet of 37 wind turbines with 8 more powerful wind turbines. Where the 37 275 kW wind turbines (i.e. 10 MW in total for the wind farm) generate an average annual output of 12 GWh / year, the eight latest-generation 2 MW wind turbines (for a total of 18 MW) will produce approximately 40 GWh per year.

Due to the lack of suitable recycling channels in France and even more so on the island, it seems that most of the components will be recycled via existing channels. Steel and concrete make up 90% of the composition of a wind turbine. These materials are recyclable. The size of wind turbines can make recycling daunting however. In Germany, Veolia has a specialized saw that is used to cut turbine blades into sections. Another difficulty occurs when treating fiberglass (old models) or carbon fibre, which account for 2% of mast weight. Currently, these materials are transformed into solid recovery fuel (SRF), which is then used in cement manufacturing. The industry is working to identify and implement innovative and sustainable dismantling and recycling solutions. A working group is contributing on this issue within FEE. Another example is the pilot experiment around the AD3R platform, one of the objectives of which is to dismantle and upgrade 1,600 onshore wind turbines at the end of their service life or contract by 2023.
Circular economy

A case of onshore repowering: Souleilla-Corbières Treilles (Aude)

It was the first farm set up by the RES group in 2001. At the time, it was the largest wind farm in France, boasting an exceptional wind resource and a nominal power of 20.8 MW. It consists of 16 Siemens Gamesa 1.3 MW wind turbines and operates with machines that are no longer produced.

By a decree of May 16, 2018 the prefect of the Aude département authorized the replacement of wind turbines, which have reached 18 years of age, with Poma Leitwind turbines of the same size but 1.5 MW of unit power for a grand total of 24 MW. The repowering operation will allow this farm to produce more energy for the same number of wind turbines.
The challenges of the wind industry

G. Focus on new business models
Focus on new business models

The maturity and competitiveness of wind energy is now becoming a reality

The end of the purchase tariffs and the advent of the feed-in premium system
Until 2015, operators benefited from purchase obligations from EDF OA and local distribution companies. These 15-year contracts provide a fixed rate per MWh generated. The system ended in 2016, which was transition year given than on January 1, the feed-in premium system was also introduced. Operators sell the electricity that is generated directly to the wholesale market and at market price. EDF OA then pays for the difference between this market price and a reference value that is defined either by tariff order or proceeds from a call for tenders to operators. Competitiveness is therefore a key objective.

The rise of the aggregation model
The feed-in premium scheme has resulted in the emergence of a new line of business in France: electricity aggregation. Aggregators act as intermediaries between electricity producers (who feed the generated power into the grid) and the electricity market. Aggregators also act as drivers of flexibility and are involved in fluctuations in both energy consumption and generation. In order to act as true coordinators, aggregators must be in a capacity to pool the production of several power plants (leveraging the production of a single generation asset is not enough). Most aggregators use an in-house tool, called a “virtual power plant”, which allows them to collect real-time data on the generation assets in their portfolio.
Focus on new business models

The maturity and competitiveness of wind energy are now becoming a reality

The corporate PPA model

There is growing interest in Corporate Power Purchase Agreements (CPPAs) from all energy players. CPPAs are private power purchase agreements entered into by renewable electricity producers and companies, at fixed prices which are known in advance and for periods ranging from a few years to twenty-five.

In 2019, the first CPPA was signed for 3 years. The food retailer Metro Cash and Carry has committed to purchase the electricity generated by a wind farm operated by Eurowatt.

There are several types of CPPA, including the so-called "sleeved CPPA", which is the most promising type in the case of France.

France Énergie Éolienne has drafted a standard contract for sleeved CPPAs as part of its work on the Economics Committee.

Sleeved PPA: an end user purchases electrical power from a producer and has it delivered by his supplier (who also provides the remainder)

Source: Capgemini Invent
Appendixes
Appendixes

A. The wind industry: regional maps
The wind industry: regional maps

Auvergne-Rhône-Alpes

1829 FTEs | 622 MW

Key figures for wind energy jobs (2018):
- Number of wind jobs: 1,829
- Regional wind capital (FTEs): Greater Lyon
- Top wind employers:

Key figures for wind farms (mid-2019):
- Grid-connected wind farm capacity: 622 MW
- Number of wind farms: 68

Top developers (MW):

Top operators (jobs):

NB: Non-exhaustive list of logos
Multisite companies

* Distribution of jobs on the value chain, as estimated based on data provided by industry
The wind industry: regional maps

Bourgogne-Franche-Comté

848 FTEs | 740 MW

Key figures for wind energy jobs (2018):
- Number of wind jobs: 848
- Regional wind capital (FTEs): Dijon
- Top wind employers:

Distribution of jobs on the value chain*:

158 528 152 10

Planning & Design Component manufacturing Engineering & Construction Operations & Maintenance

Key figures for wind farms (mid-2019):
- Grid-connected wind farm capacity: 622 MW
- Number of wind farms: 48

Top developers (MW):
- Vestas
- SENVION

Top operators (jobs):
- res

NB: Non-exhaustive list of logos
Multisite companies

* Distribution of jobs on the value chain, as estimated based on data provided by industry
The wind industry: regional maps

Brittany

834 FTEs | 1,027 MW

Key figures for wind energy jobs (2018):
- Number of wind jobs: 834
- Regional wind capital (FTEs): La Gacilly
- Top wind employers:

Key figures for wind farms (mid-2019):
- Grid-connected wind farm capacity: 1027 MW
- Number of wind farms: 133

Distribution of jobs on the value chain*:

1. Planning & Design
2. Component manufacturing
3. Engineering & Construction
4. Operations & Maintenance

Wind farm
Fixed-bottom offshore
wind farm
Pilot floating wind farm
Maintenance facility

Top developers (MW):
- Enercon
- Vestas
- Siemens Gamesa
- Siemens Energy

Top operators (jobs):
- Engie
- PST Technologie
- VSB

* Distribution of jobs on the value chain, as estimated based on data provided by industry
The wind industry: regional maps

Centre–Val de Loire

487 FTEs | 1,181 MW

Key figures for wind energy jobs (2018):
- Number of wind jobs: 487
- Regional wind capital (FTEs): Orléans
- Top wind employers:

1. Planning & Design
2. Component manufacturing
3. Engineering & Construction
4. Operations & Maintenance

Distribution of jobs on the value chain*:

<table>
<thead>
<tr>
<th>Planning &amp; Design</th>
<th>Component manufacturing</th>
<th>Engineering &amp; Construction</th>
<th>Operations &amp; Maintenance</th>
</tr>
</thead>
<tbody>
<tr>
<td>147</td>
<td>59</td>
<td>134</td>
<td>81</td>
</tr>
</tbody>
</table>

Key figures for wind farms (mid-2019):
- Grid-connected wind farm capacity: 1,181 MW
- Number of wind farms: 92

Top developers (MW):
- ENERCON
- Vestas
- Acciona
- Volkwind

Top operators (jobs):
- ENERCON
- Vestas
- Acciona
- Volkwind

* Distribution of jobs on the value chain, as estimated based on data provided by industry.

NB: Non-exhaustive list of logos
Multi-site companies
The wind industry: regional maps

Grand Est

1,679 FTEs | 3,528 MW

Key figures for wind energy jobs (2018):
- Number of wind jobs: 1,679
- Regional wind capital (FTEs): Nancy
- Top wind employers:

Distribution of jobs on the value chain*:

1. Planning & Design
2. Component manufacturing
3. Engineering & Construction
4. Operations & Maintenance

Key figures for wind farms (mid-2019):
- Grid-connected wind farm capacity: 3,528 MW
- Number of wind farms: 259

Top developers (MW):

Top operators (jobs):

* Distribution of jobs on the value chain, as estimated based on data provided by industry

NB: Non-exhaustive list of logos

Multisite companies
The wind industry: regional maps

Hauts-de-France

1,885 FTEs | 4,111 MW

Key figures for wind energy jobs (2018):
- Number of wind jobs: 1,885
- Regional wind capital (FTEs): Compiègne – Le Meux
- Top wind employers:

Distribution of jobs on the value chain*:

Planning & Design: 374
Component manufacturing: 409
Engineering & Construction: 563
Operations & Maintenance: 539

Key figures for wind farms (mid-2019):
- Grid-connected wind farm capacity: 4,111 MW
- Number of wind farms: 316

Top developers (MW):
- Enercon
- Vestas
- Siemens Gamesa

Top operators (jobs):
- Engie
- Boralex
- H2Air

N.B.: Non-exhaustive list of logos
Multisite companies

* Distribution of jobs on the value chain, as estimated based on data provided by industry
The wind industry: regional maps

Île-de-France

5,242 FTEs | 51 MW

Key figures for wind energy jobs (2018):
- Number of wind jobs: 5,242
- Regional wind capital (FTEs): Paris
- Top wind employers:

Key figures for wind farms (mid-2019):
- Grid-connected wind farm capacity: 51 MW
- Number of wind farms: 6

Distribution of jobs on the value chain*:
- Planning & Design: 1,819
- Component manufacturing: 618
- Engineering & Construction: 1,162
- Operations & Maintenance: 1,226

Top developers (MW):
- Vestas
- Nordex
- Acciona

Top operators (jobs):
- EDF
- WPI

* Distribution of jobs on the value chain, as estimated based on data provided by industry

Multisite companies

NB: Non-exhaustive list of logos
The wind industry: regional maps

Normandy

694 FTEs | 853 MW

Key figures for wind energy jobs (2018):
- Number of wind jobs: 694
- Regional wind capital (FTEs): Cherbourg
- Top wind employers:

Distribution of jobs on the value chain*:

149
299
177
69

Key figures for wind farms (mid-2019):
- Grid-connected wind farm capacity: 853 MW
- Number of wind farms: 86

Top developers (MW):
- SENVION
- NORDEx
- ACCIONA
- INGEGEN
- 3. Engineering & Construction
- Fixed-bottom offshore wind farm
- Maintenance facility

Top operators (jobs):
- ENEE
- EDF
- DEKRA
- 1. Planning & Design
- Component manufacturing
- Operations & Maintenance

NB: Non-exhaustive list of logos
Multisite companies

* Distribution of jobs on the value chain, as estimated based on data provided by industry
The wind industry: regional maps

Nouvelle-Aquitaine

1,086 FTEs | 1,042 MW

Key figures for wind energy jobs (2018):
- Number of wind jobs: 1,086
- Regional wind capital (FTEs): Bègles
- Top wind employers:

Distribution of jobs on the value chain*:

<table>
<thead>
<tr>
<th>Planning &amp; Design</th>
<th>Component manufacturing</th>
<th>Engineering &amp; Construction</th>
<th>Operations &amp; Maintenance</th>
</tr>
</thead>
<tbody>
<tr>
<td>354</td>
<td>154</td>
<td>450</td>
<td>126</td>
</tr>
</tbody>
</table>

Key figures for wind farms (mid-2019):
- Grid-connected wind farm capacity: 1,042 MW
- Number of wind farms: 99

Top developers (MW):

Vestas

Top operators (jobs):

ENERCON

*: Distribution of jobs on the value chain, as estimated based on data provided by industry.
The wind industry: regional maps

Occitanie

1,819 FTEs | 1,535 MW

Key figures for wind energy jobs (2018):
- Number of wind jobs: 1,803
- Regional wind capital (FTEs): Montpellier
- Top wind employers:

Distribution of jobs on the value chain*:
- Planning & Design: 618
- Component manufacturing: 204
- Engineering & Construction: 424
- Operations & Maintenance: 557

Key figures for wind farms (mid-2019):
- Grid-connected wind farm capacity: 1,535 MW
- Number of wind farms: 130

Top developers (MW):

Top operators (jobs):
* Distribution of jobs on the value chain, as estimated based on data provided by industry
The wind industry: regional maps

Pays de la Loire

1,796 FTEs | 918 MW

Key figures for wind energy jobs (2018):
- Number of wind jobs: 1,796
- Regional wind capital (FTEs): Nantes
- Top wind employers:

Distribution of jobs on the value chain*:

<table>
<thead>
<tr>
<th>Planning &amp; Design</th>
<th>Component manufacturing</th>
<th>Engineering &amp; Construction</th>
<th>Operations &amp; Maintenance</th>
</tr>
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<tbody>
<tr>
<td>362</td>
<td>817</td>
<td>262</td>
<td>355</td>
</tr>
</tbody>
</table>

Key figures for wind farms (mid-2019):
- Grid-connected wind farm capacity: 918 MW
- Number of wind farms: 106

Top developers (MW):
- Vestas
- Enercon
- Senvion

Top operators (jobs):
- Energie TEAM
- Engie Green
- ABO Wind

* Distribution of jobs on the value chain, as estimated based on data provided by industry

NB: Non-exhaustive list of logos
Multisite companies

1. Planning & Design
2. Component manufacturing
3. Engineering & Construction
4. Operations & Maintenance

Wind farm
Fixed-bottom offshore wind farm
Floating offshore wind demonstrator
Maintenance facility

NB: Non-exhaustive list of logos
Multisite companies
The wind industry: regional maps

Sud-Provence-Alpes-Côte d’Azur

704 FTEs | 61 MW

Key figures for wind energy jobs (2018):
- Number of wind jobs: 704
- Regional wind capital (FTEs): Aix-Marseille
- Top wind employers:

Distribution of jobs on the value chain*:

<table>
<thead>
<tr>
<th>Planning &amp; Design</th>
<th>Component manufacturing</th>
<th>Engineering &amp; Construction</th>
<th>Operations &amp; Maintenance</th>
</tr>
</thead>
<tbody>
<tr>
<td>234</td>
<td>113</td>
<td>237</td>
<td>120</td>
</tr>
</tbody>
</table>

Key figures for wind farms (mid-2019):
- Grid-connected wind farm capacity: 61 MW
- Number of wind farms: 9

Top developers (MW):
- Vestas
- Nordex
- Acciona
- Enercon

Top operators (jobs):
- res
- Voltalia
- juwi

* Distribution of jobs on the value chain, as estimated based on data provided by industry

NB: Non-exhaustive list of logos
Multisite companies

Wind farm
Pilot floating wind farm
Appendixes

B. Participants in the wind industry by category
Value chain participants, by category

Developer and/or operator

**Wind power jobs**
- Total number of wind power jobs: **3,464**
- Number of companies: **146**

**Typical profile**
- Majority business type: **VSE**
- Average year of foundation: **2004**

**Wind power activities**
Distribution of wind jobs:

- **Planning & Design**
- **Component manufacturing**
- **Engineering & Construction**
- **Operations & Maintenance**

**Top 10 wind job employers**
1. **EDF renouvelables**
2. **ENGIE**
3. **Valorem**
4. **RES**
5. **BORALEX**
6. **Quadran**
7. **ABO Wind**
8. **Wpd**
9. **Edp renewables**
10. **Capgemini invent**

Number of businesses by wind power group

- **VSE (<10 employees)**: 56%
- **SME (10–250 employees)**: 49%
- **ISE (250–5,000 employees)**: 46%
- **Large enterprise (or subsidiary)**: 0%

- **0–10**: 83
- **10–30**: 28
- **30–50**: 25
- **50–100**: 6
- **>100**: 4
Value chain participants, by category

Turbine manufacturer / maintenance

**Wind power jobs**
- Total number of wind power jobs: 2,084
- Number of companies: 35

**Typical profile**
- Majority business type: SME
- Average year of foundation: 2007

**Wind power activities**
Distribution of wind jobs:

- Planning & Design: 34%
- Component manufacturing: 23%
- Engineering & Construction: 64%

**Top 10 wind job employers**

1. Enercon
2. Vestas
3. Acciona
4. Senvion
5. Siemens
6. GE
7. POMA
8. Leitwind
Value chain participants, by category

Component manufacturing

Wind power jobs
- Total number of wind power jobs: 4,320
- Number of companies: 232

Number of businesses by wind power group

<table>
<thead>
<tr>
<th>Group</th>
<th>Number</th>
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<tbody>
<tr>
<td>0–10</td>
<td>161</td>
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<tr>
<td>10–30</td>
<td>27</td>
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<tr>
<td>30–50</td>
<td>24</td>
</tr>
<tr>
<td>50–100</td>
<td>10</td>
</tr>
<tr>
<td>&gt;100</td>
<td>6</td>
</tr>
</tbody>
</table>

Typical profile
- Majority business type: SME
- Average year of foundation: 1985

Wind power activities
Distribution of wind jobs:

<table>
<thead>
<tr>
<th>Category</th>
<th>Percentage</th>
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<tbody>
<tr>
<td>Planning &amp; Design</td>
<td>24%</td>
</tr>
<tr>
<td>Component manufacturing</td>
<td>2%</td>
</tr>
<tr>
<td>Engineering &amp; Construction</td>
<td>16%</td>
</tr>
<tr>
<td>Operations &amp; Maintenance</td>
<td>58%</td>
</tr>
</tbody>
</table>

Top 10 wind job employers

<table>
<thead>
<tr>
<th>Rank</th>
<th>Company</th>
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<tbody>
<tr>
<td>1.</td>
<td>GE Energy</td>
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<td>Schneider Electric</td>
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<td>3.</td>
<td>Chantiers de l'Atlantique</td>
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<tr>
<td>4.</td>
<td>ROLLIX</td>
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<td>5.</td>
<td>Mersen</td>
</tr>
<tr>
<td>6.</td>
<td>Hutchinson</td>
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<tr>
<td>7.</td>
<td>LM Wind Power</td>
</tr>
<tr>
<td>8.</td>
<td>Enercon</td>
</tr>
<tr>
<td>9.</td>
<td>SDMO</td>
</tr>
<tr>
<td>10.</td>
<td>Ideol</td>
</tr>
</tbody>
</table>
Value chain participants, by category

Civil and electrical engineering / Logistics

Wind power jobs
- Total number of wind power jobs: **4,011**
- Number of companies: **239**

Typical profile
- Majority business type: **SME**
- Average year of foundation: **1999**

Wind power activities
Distribution of wind jobs:

Top 10 wind job employers

1. Enedis
2. Eurovia
3. Omexom
4. Rte
5. Spie
6. Colas
7. Engie
8. Tech Inter
9. Holcim
10. AlteAd
Value chain participants, by category

Maintenance (excluding manufacturers)

### Wind power jobs
- Total number of wind power jobs: **1,502**
- Number of companies: **72**

### Typical profile
- Majority business type: **SME**
- Average year of foundation: **1992**

### Wind power activities
**Distribution of wind jobs:**
- **Planning & Design**: 19%
- **Component manufacturing**: 26%
- **Engineering & Construction**: 55%
- **Operations & Maintenance**: 19%

### Number of businesses by wind power group
- 0–10: 43
- 10–30: 10
- 30–50: 13
- 50–100: 4
- >100: 2

### Top 10 wind job employers
1. **EDF RENOUVEAUX**
2. **Soleo Energies**
3. **CORDIAL**
4. **VEOLIA**
5. **Groupe QualiConsult**
6. **VALEMO**
7. **Atalante Marine Services**
8. **ENERIA**
9. **Net-Wind**
10. **Baurès**
Value chain participants, by category

Engineering consultancy & Expertise

Wind power jobs

- Total number of wind power jobs: 2,213
- Number of companies: 222

Number of businesses by wind power group:

<table>
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<th>Group</th>
<th>Count</th>
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<td>6</td>
</tr>
<tr>
<td>&gt;100</td>
<td>1</td>
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Wind power activities

Distribution of wind jobs:

- Planning & Design: 36%
- Component manufacturing: 15%
- Engineering & Construction: 48%
- Operations & Maintenance: 1%

Top 10 wind job employers:

1. DEKRA
2. biotope
3. MATHIS technologies
4. 2W
5. Eole
6. AKKA
7. MARC
8. WIND
9. Tractebel
10. Sofresid
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Cover: Enercon, GE, Nordex-Acciona, Siemens Gamesa, Poma Leitwind, Senvion, Vestas

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<td>Poma Leitwind</td>
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<tr>
<td>Page 152</td>
<td>GE</td>
</tr>
<tr>
<td>Page 160</td>
<td>Siemens Gamesa</td>
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3E
3F
B2 Consulting
B.2 France
ABF
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ABES
ABO WIND
ACCO
ACFI GESTION
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GAS NATURAL FENOSA
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GREEN ACCESS
GREENSOLVER
GROUPES ÉTAHRT
GROUPE VALECO
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HAWK
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KELLER FONCTIONNEMENT SPECIALS
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LES VENTS MEUSES DU SUD
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LN WIND POWER
LOUIS DREYFUS ARMATEUR
LUA AVOCATS
LYCEE DHIOUDA
MAERTS
MÄUSER
MÄUSER ENGINEERING
MOAZES ALTER & GO CONCERTATION
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MÉTAMÈRE
METROIL
MG2
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NOTUS ENERGIE FRANCE
NOWOCZESNE
NTR WIND MANAGEMENT DAC
OBESTA
OMICRON RENÉWABLE ENERGIES
ORENORM
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POLE MÉDÉE
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The team behind the 2019 Observatory

- Matthieu Monnier
  - Head of FEE’s Industry, Offshore, and Territory (EU and CR) Division

- Cécile Maisonneuve-Cado
  - Vice-president of FEE’s Industry Commission

- Sébastien Billeau
  - ADEME co-ordinator

- Raphaël Cretin-Pablo
  - Analyst

- Julien Cossé
  - Energy & Utilities director

- Marianne Boust
  - Energy & Utilities director

- Alexandra Bonanni
  - Head of the Energy Strategy Lab

- Pierre-Henri de La Codre
  - Energy & Utilities consultant

- Clément Naullet
  - Energy & Utilities junior consultant