Wind Observatory 2021

Capgemini invent | France Energie Eolienne

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

September 2021

Foreword

Why are we developing wind power in France?

The fierce debate around this symbol of the ecological transition requires returning to the fundamentals.

I have a simple answer: climate disruption.

It is clearly out of the question to continue to rely on fossil fuels to generate our electricity. That is precisely why France is closing down its last coal-fired power plants.

It is also impossible to simply settle for the power generation sources that we are currently using. If we want to be able to do without the fossil fuels that still amount to two thirds of our final energy consumption, we'll have to engage in the massive electrification of our power use – in transport, housing, industrial processes, etc. Even if we intensify our efforts in terms of energy savings, demand for electricity will inevitably continue to grow in the coming years, which implies the need to rapidly boost our power generation capacities in order to preserve our energy sovereignty.

Finally, it would be preposterous to stake everything on just nuclear power. Beyond the debates that are inherent to this power generation method, we have an immediate need for zero-carbon energy, and yet the time required to build a next-generation nuclear power plant is measured in decades. We must also anticipate the end of life of a certain number of reactors. A realistic energy policy is therefore to be achieved through the immediate mass deployment of renewables – and wind power in particular.

There's nothing ideological about this, unless we were to suggest that fighting against climate disruption and the security of our energy supply were secondary.

The pandemic crisis we have been living through for many months has further demonstrated how strategically important having a diversified electricity mix is for maintaining our security of energy supply. Wind power has contributed to mitigating the impact of the downtime of several nuclear installations where maintenance operations had had to be postponed during the pandemic, for example.

Foreword

In 2020, wind power thus amounted to almost 8% of France's electricity generation, third only to nuclear power and hydropower. With an additional wind power capacity of 1 GW in 2020, our installed capacity had thus reached almost 18 GW by mid-2021.

This rapid development is also translating into an increase in economic activity in the country, with a 12% growth in wind jobs in France, amounting to 2,400 new jobs created in 2020, despite the health crisis. The wind industry now provides 22,600 jobs in mainland France, 5,200 of which are related to offshore wind.

These benefits of wind power are well known to our fellow citizens. That is why an overwhelming majority have a positive outlook when it comes to onshore wind.[1]

And it is precisely because wind power is vital for our energy future and because the French people understand this – that it is our responsibility to both combat misinformation against it and listen closely to the genuine concerns of certain local residents living in the vicinity of wind farms.

First and foremost, it is important to set the record straight and not indulge in stereotyping. That is why my Ministry published a True/False document for onshore wind, that is accessible to all. It is true that wind farms aren't completely devoid of impact – no power generation method is – and that is precisely why they are subject to stringent rules in terms of siting, operations, and dismantling. In fact, tighter regulations have been in place since 2020, in particular regarding dismantling requirements. However, it is simply not true that wind power doesn't effectively address climate disruption, that wind turbines only operate 25% of the time, that they aren't recyclable, or that there are gigantic blade graveyards in France. We cannot allow the opposition to wind power to base its arguments on misinformation.

1. According to the survey conducted at the end of 2020 by Harris Interactive for France Énergie Éolienne, 76% of French citizens have a positive image of wind power.
2. https://www.ecologie.gouv.fr/sites/default/files/21088_VraiFaux_E%CC%81olien_terrestre%20%281%29.pdf

Foreword

Of course, wind power cannot be deployed if France's regional and local authorities do not fully take up the issue of the energy transition. Acting on this objective, the government has created, under the Climate and Resilience Law, regional energy committees, which will be tasked with promoting cooperation, especially with regional and departmental authorities, on energy matters within the region, as well as with setting regional objectives for renewable energy development. This law also strengthens the role of mayors in fostering stakeholder dialogue, by requiring that the non-technical project impact analysis statement be sent to mayors before filing a permission application, so that they can in turn submit their observations to the project initiator, who will be required to respond.

In order to foster stakeholder dialogue on wind projects, I also instructed Prefects to map areas that are suited to onshore wind development, in concert with local officials. I highlighted the need for extensive dialogue with residents, local officials, and civil society groups from the early phases of projects in order to account for issues related to landscapes and the environment from the design stage. I am adamant that the industry be exemplary in these matters, which I hold particularly dear, and which are absolutely key to ensuring project buy-in.

The government has also initiated actions so that wind power development is more harmonious and more widely accepted. These actions are a follow-up to the Ecological Defence Council chaired by President Emmanuel Macron in December 2020. The various decisions taken on that occasion include measures aiming to reduce any disturbances (stronger requirements in terms of recycling, ongoing experimentation with warning beacons, etc.), establishing a network of advisers on wind power and photovoltaic energy within the territories (starting this autumn) in order to inform and provide technical support to regional and local authorities, and formalising best practice guidelines. Finally, my Ministry has started working with all stakeholders to promote and simplify grassroots projects to the greatest possible extent.

The year 2021 marks a new impetus for wind power development, with the publication of the specifications for the 2021–2026 period, and the launch of the first period of the new onshore call for tenders. This will help support the net creation of more than 9.2 GW of installed wind power capacity over a 5-year period.

Foreword

More specifically concerning offshore wind, the year 2020 was marked by the changes introduced in the Law on the acceleration and simplification of public action and the launch of the competitive tendering procedure for the 1 GW farm off the coast of Normandy. The French government is now pressing ahead and speeding up the development of the wind power industry. It is now holding competitive dialogues for wind farms in Normandy and southern Brittany, and launching public discussions on projects in the Mediterranean and off Oléron.

We will shortly bring the matter before the French National Commission for Public Debate (CNDP) in order to organise stakeholder dialogue regarding a second offshore project in the area defined during the 2019–2020 public debate in Normandy.

Offshore wind projects must also be exemplary and follow stakeholder dialogue and consultation throughout the process, both prior to its decision and during the course of the construction work. Only then can we foster robust growth and success, and be fully engaged in the energy transition towards achieving carbon neutrality.

Our country's energy policy is at a turning point. The debates that we are experiencing today are related to this juncture. In this context, let us remain focused on the essentials and increase our renewable electricity output now, while continuing to deploy exemplary projects.

Barbara POMPILI
Minister for the Ecological Transition

Op-ed

The **2021 edition** of the Observatory is being released in a pivotal year given that it is the last one before the next **presidential election** and the first that will be read by the new regional officials.

It is also being presented at a time when many national and international reports (including by RTE, ADEME, IEA, as well as the European Commission's "Fit-for-55" climate package) demonstrate that wind power isn't just an option, but a necessity to decarbonise the energy mix. Achieving the objectives set out in the National Low-Carbon Strategy (SNBC), namely **cutting our greenhouse gas emissions to one sixth of 1990 values by 2050** will involve, in particular, eliminating fossil fuels from our energy consumption (they still represent approximately 70%).

How far are we along that trajectory? The share of wind in electricity generation now amounts to **9% of France's global power mix**. Since 2020, wind power has been the **No.3 source** of electricity in France after nuclear power and hydropower.

These outcomes, achieved after 15 years of extensive work by the 900 companies in the industry that are established in France, confirm the robustness of our fundamentals, both in terms of competitiveness and of industrial capabilities.

In terms of competitiveness, the downward trend in wind power generation costs manifests itself within the winning bid prices in the call for tenders, both for onshore (€60.8 per MWh)[1] and offshore projects (€44 per MWh)[2]. This downward trend provides the wind industry with a competitive advantage over historical sectors burdened by upward trends in their production costs (for example, €110–120 MWh for new nuclear operations).

In terms of industrial capabilities, the wind industry has demonstrated its know-how by installing new wind farms **at a steady pace**, even in the midst of a global pandemic. All the business operating along the value chain (planning & design, component manufacturing, construction engineering, operations & maintenance) are thus in line to deliver the yearly **1,900 MW of onshore wind and 1,000 MW of offshore wind that must be installed by 2028** in order to secure France's energy supply and achieve the country's national and international goals (for instance PPE, SNBC, COP 21).

These sound fundamentals are the result of a sustained, concerted effort on the part of the businesses that make up the French wind power industry. These fundamentals translate into significant social and economic benefits. These include **2,400 jobs created in 2020**, and overall **more than 22,600 jobs in France** (the wind industry is now the top employer in the renewables sector), as well as upwards of **€220m in local tax revenues** that contribute primarily to funding municipalities of less than 100 inhabitants and that have been invaluable in revitalising communities by making public local investments possible (for example, rehabilitating a canteen, creating a micro-childcare facility, or renovating public buildings).

It is therefore only natural that the wind industry, which has become indispensable, approaches the second half of 2021 by taking part in the debate and formulating proposals for 2022 that will allow everyone to be informed of the vision that the industry has on the challenges facing society (for example, employment, training, independence, safety, reindustrialisation, combating social inequality) and on the solutions proposed to support France's energy transition.

We hope you enjoy reading this new edition of the Observatory!

Nicolas Wolff, *President of France Énergie Éolienne*

Cécile Maisonneuve Cado, *President of the Industry Commission at FEE*

1. AO8 (8th call for tenders), RTE, 2021
2. *Deliberation of the French Energy Regulatory Commission (CRE) of 6 June 2019 on the examination of the bids received as part of the competitive dialogue No.1/2016 on offshore wind installations in an area off Dunkirk's coast*

Executive summary

Key figures for 2020

No. 1 employer in the French renewables industry[1]

22,600 jobs as of 31 Dec. 2020, **+12%** compared to 2019

€60.8€ per MWh[3]
The average power price in the last tender (AO8), in April 2021, down 3% compared to February 2020

€220m in tax revenue for municipalities and other local authorities in 2021

No. 2 renewable energy in France's electricity generation mix[5]

An installed total capacity of **17.6 GW[2]** as at Dec. 31, 2020

+ 7% installed capacity compared to 2019

39.7 TWh of electricity generated[6] in 2020, +16% compared to 2019

Wind turbines that are recyclable/reusable on average at rates of **> 90%[7]**

7.9% of France's electricity generation in 2020, up from 6.3% in 2019

1. Latribune.fr
2. FEE study, 2021
3. Latest call for tenders, April 2021, greenunivers.com
4. Computed based on an average level of tax revenues of €12,500 per installed MW
5. www.statistiques.developpement-durable.gouv.fr
6. **RTE**: France's Electricity report of 2020
7. https://www.francetvinfo.fr/economie/energie/temps-de-fonctionnement-et-recyclage-des-eoliennes-qui-dit-vrai-entre-barbara-pompili-et-stephane-bern_4649343.html

The contributions of the wind industry in France in 2020

Economic contributions benefiting everyone

€**220m** in tax revenue in France in **2020**[1]

Local taxes aren't increasing or are decreasing in municipalities hosting one or more wind farms

A sector that contributes to France's reindustrialisation

€5.8 billion in turnover in 2019, for onshore alone[2]

€**768m** in equipment and engineering exports[2]

5 out of 13 European units involved in the production of offshore equipment **are located in France**

Massive buy-in from French citizens

76% of people in the country[3] have a positive image of wind power **(+3%)**

€102.4m collected through crowdfunding to fund renewable energies in 2020[4]

The French government is working on a roadmap aiming to mainstream the principle of shared governance. (civic participation)

Major benefits in terms of public service expansion

The installation of wind farms allows rural municipalities to substantially help improve various public services, such as:

- Road rehabilitation
- Building/renovating cultural and tourist sites
- Deploying fibre-optic networks
- Renovating public lighting systems

1. Estimate based on an average of €12,500 per MW installed
2. Source: Ademe – 2021 Wind power market study
3. Source: Harris Interactive study for FEE, January 2021
4. https://www.greenunivers.com/2021/04/en-2020-le-financement-participatif-des-enr-a-depasse-les-100-me-258108/

The French wind power market in 2020

17.6 GW[1] of total grid-connected capacity

+7% installed capacity compared to 2019

power capacity was installed and connected to the grid

This is equivalent to the electricity use of approximately 8 million households.

477 wind turbines[1] installed in 2020

7.9%[3] of France's electricity generation comes from wind power

3.5 GW[2] in generation capacity for offshore wind projects that have won call for tenders or projects

(The equivalent of the electricity use of approximately 1.5 million households.)

With **1.3 GW** of additional wind capacity, total grid-connected capacity rises to **17.6 GW** at the end of 2020. This 8% increase results in wind power representing **7.9% of France's electricity mix.**

The increase in installed capacity is nevertheless slackening given that it amounted to 1.3 GW in 2019 and even 1.7 GW in 2017!

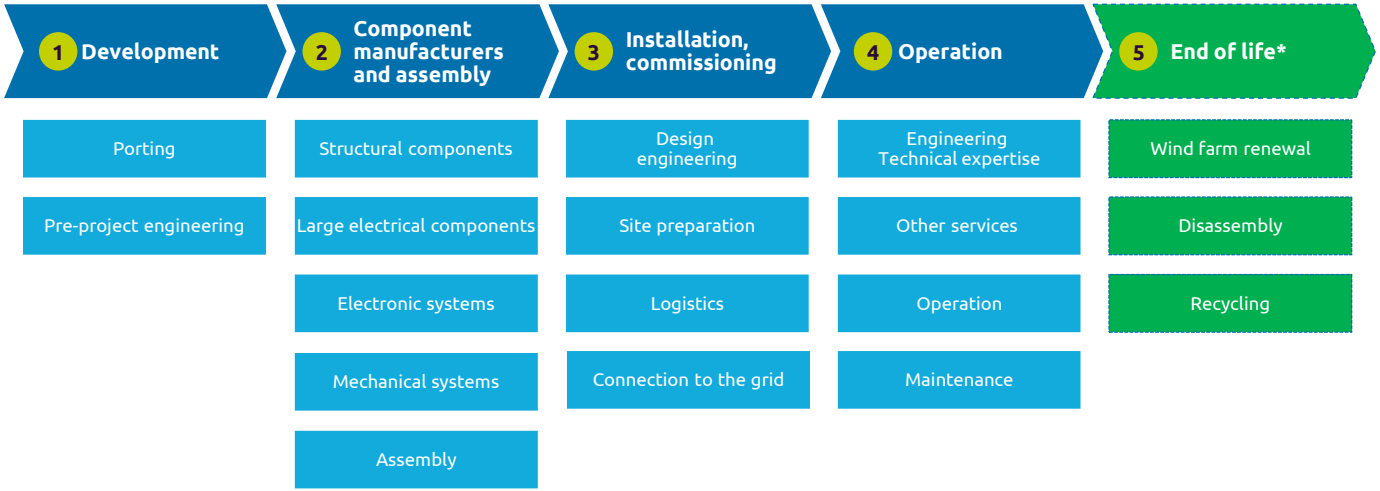
Indeed, though the industry has demonstrated its resilience in the face of the pandemic given that **wind power output increased by 17%** (to 39.7 TWh), **authorisation procedures** for ongoing projects have experienced **significant delays**, out of phase with the PPE's trajectories.

39.7 TWh electricity generated from wind turbines, amounting to 17.3% more than in 2019.[4]

1. FEE study, 2021
2. 2021 Observatory for Marine Energies
3. RTE – Electricity report for 2020
4. RTE – Electricity report for 2020

Industry overview

Overview of the wind industry value chain



Up to **70% of the value of a wind turbine is acquired in Europe**, which proves that the sector has a strong grounding on the continent.

Source: ADEME - Study on the French wind power sector: assessment, prospective and strategy
* Companies specialising only in this link of the value chain are excluded from calculations

The place of wind power in the French energy mix in 2020

In 2020, wind power amounted to **7.9%** of the French power generation and experienced significant growth: **+17.3%** between 2019 and 2020

Total electricity generation
537.7 TWh
-2 %

Nuclear
335.4 TWh
- 11.6%

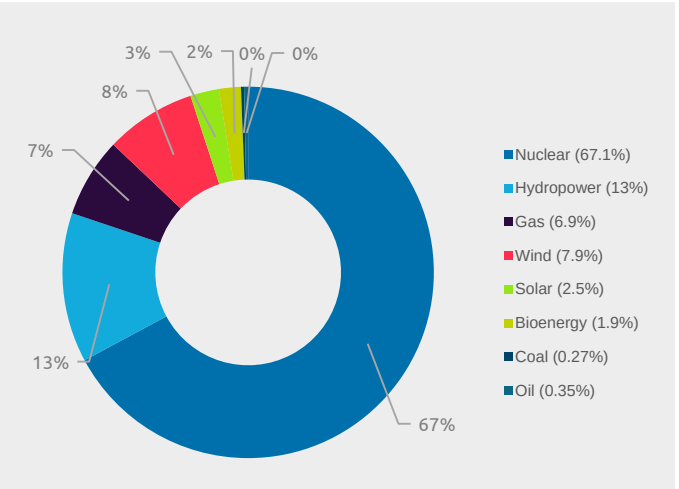
Hydropower
65.1 TWh
8.4%

Wind
39.7 TWh
17.3%

Solar
12.6 TWh
2.3%

Bioenergy
9.6 TWh
- 0.8%

Thermal
37.6 TWh
- 10.6 %



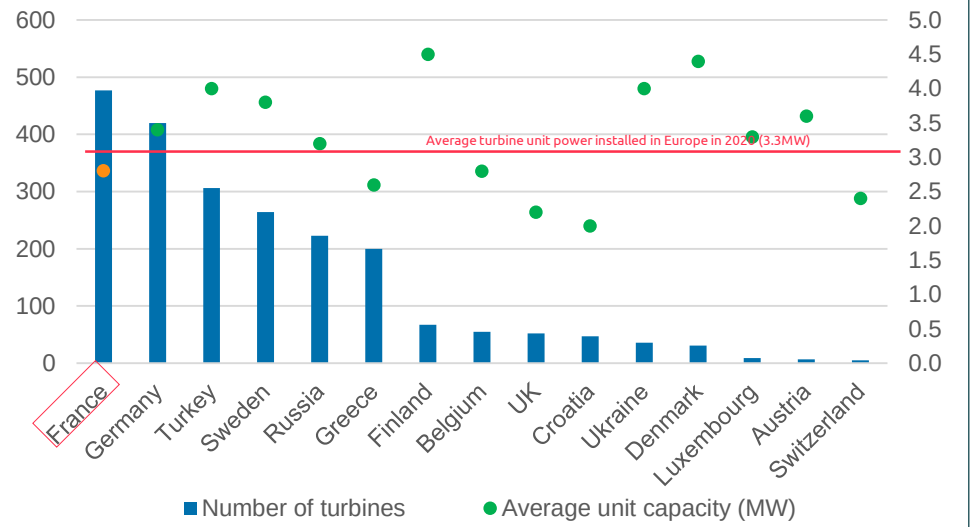
As wind power generation increased by more than **17%** year-on-year in France in 2021, wind power has the highest growth rate among energy sources. Though the figure is satisfactory, it must nevertheless be qualified given that during the pandemic electricity generation was lower than usual.

Source: RTE – Electricity report for 2020

Onshore technologies are continuing to make progress

Among European countries, France installs the highest number of turbines, but with a lower installed capacity

Average unit capacity & number of turbines in European countries in 2020 (onshore)



The unit power of wind turbines installed in France in 2020 nevertheless remains **among the lowest** on the European continent (2.7 MW compared with a 3.3 MW average), though it ranked No. 1 in terms of the number of wind turbines installed in 2020 (with 477 units).

This is due to the strong regulatory constraints, further increased in 2021, **which restrict the potential cost decreases for wind power in France.**

Yet, larger and, therefore, more powerful wind turbines, would help lower the number of installed turbines and therefore also lower electricity prices for the community.

Sources: Wind energy in Europe in 2020, *Trends and statistics* (2020)

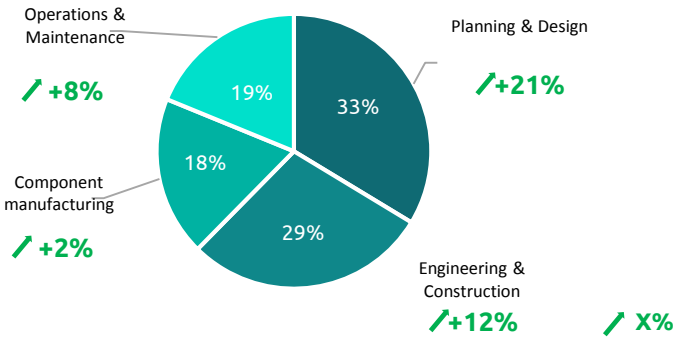
Jobs in wind power in France in 2020

22,600 jobs at the end of 2020

+24% wind power jobs in the **Pays de la Loire** region

12% increase in wind jobs in **2020**

Breakdown and variation of FTEs on the value chain:



In 2020, **wind power jobs have continued increasing at a significant pace**, with a growth rate of 12% and a total of 22,600 direct and indirect jobs in France as at 31 December 2020.

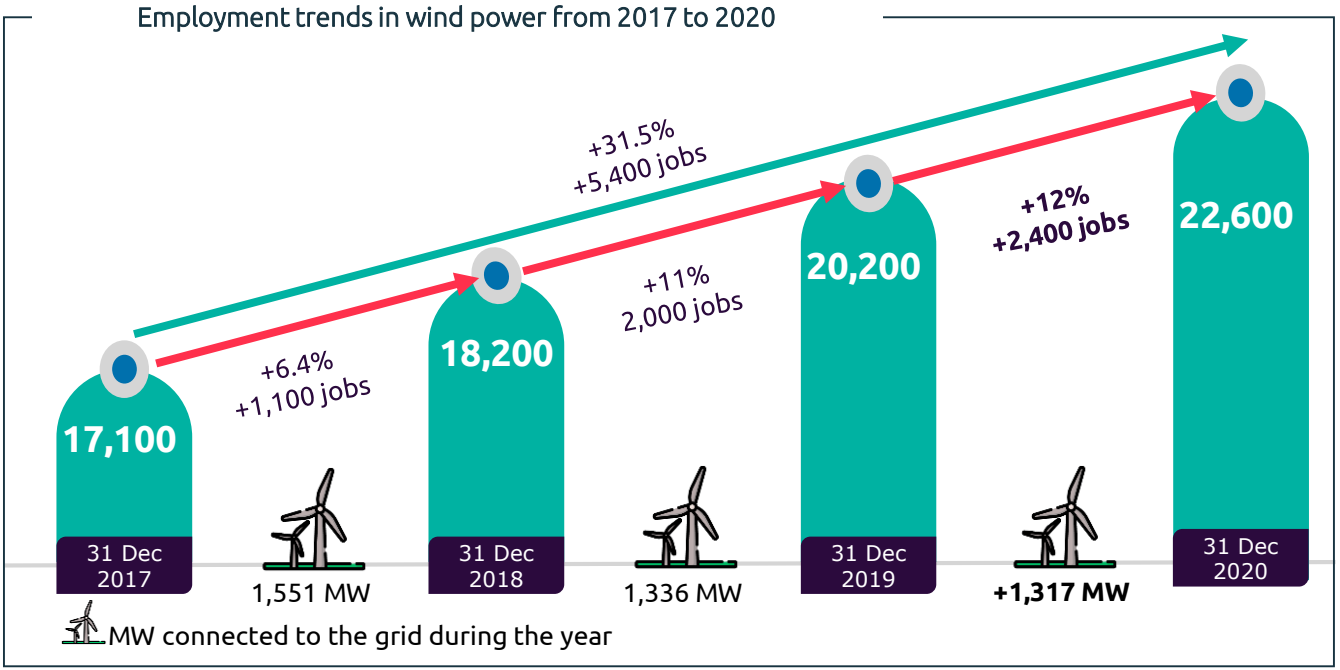
Though the pandemic hasn't impacted the overall momentum, it has nevertheless weighed on the authorisations granted for the construction of the wind farms and has hampered growth in activities related to operation and maintenance, and especially those related to component manufacturing. For the latter category, offshore has been instrumental to maintaining growth.

As in 2019, offshore wind is the sector that boosts job growth in the French wind industry. This trend is largely due to the start of the construction of the Saint-Nazaire, Fécamp and Saint-Brieuc farms. Accounting for more than 20% of all counted wind jobs, offshore wind represents approximately 5,200 jobs in 2020. Job growth is set to continue with more job creation in offshore wind in Normandy (in the industrial clusters in Le Havre and Cherbourg).

Growth rate by link in the value chain (2019–2020)

Job growth in wind power in France in 2020

The number of wind jobs is on the increase for the 7th year in a row



Source: FEE study, data processing by Capgemini Invent

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Table of contents

Table of contents

The contributions of the wind industry to French society

Capgemini invent

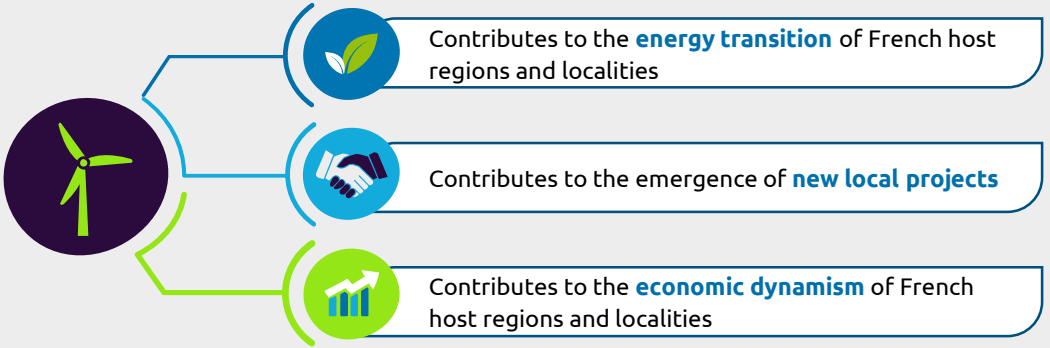
France Energie Eolienne

Economic and fiscal benefits for local authorities

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

Wind energy acts as a catalyst for the energy transition of French regions. Many local authorities (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 often **brings about promising local projects**, including biomass boilers, the rehabilitation of public buildings and tourist locations, road rehabilitation, preservation of public services, creation of short food supply chains, and so on.

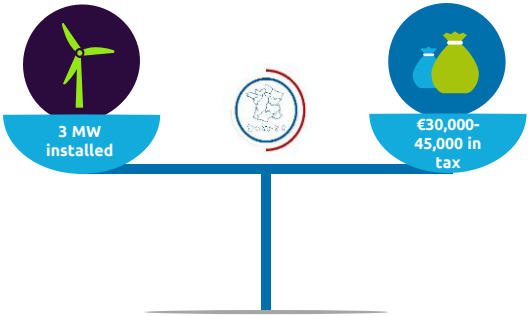


*EPCI = Établissement Public de Coopération Intercommunale – local public service companies

Economic and fiscal benefits for local authorities

... and contributes to the budget of local authorities

Among their economic windfalls, wind power installations generate a variety of **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 installed MW per annum (on average €7,500 for the locality, while the département and the region together receive €4,500)**; they are redistributed between the different local authorities mainly based on the tax regime of the EPCI (pub the project site.



Zoom in on IFER (the flat tax on network infrastructure companies)

The proceeds from the **IFER** are 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):

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

Economic and fiscal benefits for local authorities

Substantial tax revenues enabling municipalities to lower local taxes, borrow money, or fund projects

TESTIMONIALS BY LOCAL OFFICIALS

Daniel David, Mayor of Benet (Vendée)

"The two local wind farms bring in about **€200,000** to the Benet community **every year**."

"**The municipality had been intent on redeveloping the town centre and making the roadway safer for the past fifteen years** and the revenues from the wind farm have finally made this possible."

Armelle Devillard, Mayor of La Chapelle-au-Mans (Saône et Loire)

Jean-Louis Portal, Mayor of Ally (Haute-Loire)

"Since the wind farm has been installed, **we haven't faced any more issues in securing credits from banks**. This has enabled us to generate clean energy all the while providing valuable financial security for developing the municipality and its vicinity."

Examples of fiscal returns

Number of turbines	Average tax resources (€ per year)*	Distribution**
5	€ 125,000	• Localities/EPCI: €85,375 • Département: €35,250 • Region: €4,375
10	€ 250,000	• Localities/EPCI: €170,750 • Département: €70,500 • Region: €8,750
15	€ 375,000	• Localities/EPCI: €256,125 • Département: € 105,750 • Region: €13,725

These revenues generated by the installation and operation of the wind farms in the territory are long standing and last for an average of **20–25 years**.

** €12,500 per MW estimate*
*** Distribution based on the IFER standards*

Expanding public services

The tax revenues from wind operations contribute to improving public service through different means

Improving healthcare services

- Financing medical venues in the municipality bringing together doctors, nurses, physiotherapists, podiatrists, and so on – *(Miraumont | Somme)*
- "Welcoming new doctors has improved the living conditions of our constituents" *(Benet | Vendée)*

Building or rehabilitating infrustructure

- Building and managing a nursery – *(Saint-Etienne-de-Lugdarès | Ardèche)*
- Maintaining the listed historic church *(Savières | Aube)*

Establishing new social structures

- Creating housing that is accessible to people with reduced mobility – *(Dampierre-sur-Moivre | Marne)*
- Opening of a community centre including a library and a media library – *(Avignonet-Lauragais | Haute-Garonne)*
- The municipality provides a living residence for 61 individuals with disabilities – *(Saint-Etienne-de-Lugdarès | Ardèche)*

Sources: "Quotes from elected officials", France Énergie Éolienne

Expanding public services

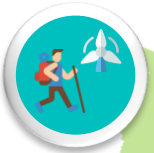
The wind farms can contribute to developing local tourism in various ways

Renovation of monuments to transform them into tourist accommodation

- Thanks to the tax revenues derived from the wind farms, the town of Ally (Haute-Loire) has been able to **rehabilitate 3 former windmills** that can be visited. Certain parts of the building were furthermore **transformed into holiday getaways**
- Renovation of an **antimony mine** in the town of Ally to welcome visitors

Tourism around renewable energies

- The town of Fitou, in the Aude département, plans to **rehabilitate a former Lafarge plant** to create a site combining **tourism** and **renewable energies**
- Each year, the town of Ally welcomes **school field trips** on the topic of renewable energies.



Sport tourism

- Sainte-Colombe in the Yonne département - creating **hiking trails** around the wind farms to combine sports and renewable energies
- In the Somme département, wind power has allowed the creation of a 20 km **hiking trail** around the wind turbines, with information boards on **biodiversity**

Sources: "Quotes from elected officials", France Énergie Éolienne

Consolidating French industry locally

The wind industry is a significant and increasing contributor to the French industrial sector

A rapidly expanding French wind power market...

The turnover of the wind power industry is expanding continuously. In 2019, it amounted to **€5.8b** – twice as much as in 2013.

For the sake of comparison:

This is roughly twice as much as the turnover of the small household appliance industry in France, which represented €**3.7 billion** in 2020

LM Wind Power's factory in Cherbourg (Manche)
Photo: LM Wind Power

... thanks to a highly advanced French know-how

The prevalence of French know-how is reflected by the fact that **5 out of 13 facilities** for the production of offshore wind power equipment in Europe.

In 2019, the value of exports of equipment and engineering amounted to **€768m**.

Certain companies located in France are global leaders in component manufacturing, as for example **Rollix** for bearings and **Schneider Electric** for electrical equipment.

Sources: ADEME, CNEF

Consolidating French industry locally

The wind power industry creates many non-relocatable local jobs as a result of the establishment of specialized wind turbine component manufacturers

Much of the activity generated by the wind industry happens directly *in situ* and therefore results in the **creation of long-term non-relocatable jobs in the regions**.

Jobs related to **engineering and construction are experiencing high growth (+14% in 2020).** This major thrust leads us to believe that the weight of the wind industry will continue to grow in France.

The growth in wind power brings about the creation of specialized, innovative companies. This is the case, for example, of Avent Lidar Technology, which is specialized in the manufacturing of technological components for measuring wind speed (for instance using LiDAR technology).

Offshore wind is now primarily responsible for this growth in wind jobs. It is driven by the huge, growing investments in offshore wind. During the 1st semester of 2020, this investment amounted to **$35 billion globally, representing 319% year-on-year growth**.

Sources: energiesdelamer.eu, BloombergNEF

Public buy-in on wind power in France

75% of French people living in the vicinity of wind farms have a positive attitude towards wind power (+3% compared to 2018)

79% of French people
consider that wind power has a major role to play in the energy transition

2 out of 3 French citizens
consider that a wind farm installation in their local area would be a positive thing

More than 85% of the French
consider that wind power is a clean and inexhaustible energy source.

91% of respondents aged 18–34
have a positive image of wind power

Sources: Harris Interactive, 2020; GreenUnivers – "Barometer of the crowdfunding of renewable energies", IRSN barometer 2020

Public buy-in on wind power in France

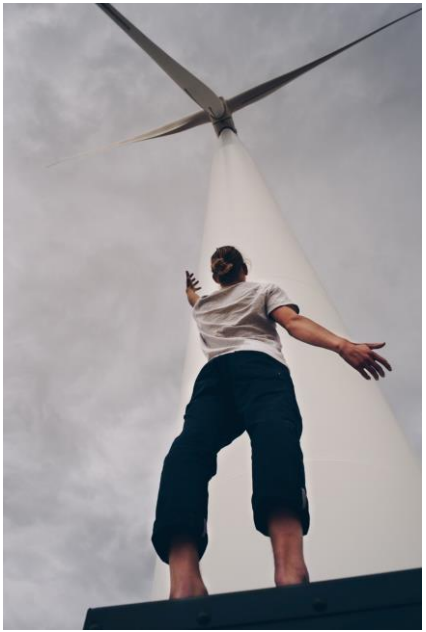
Renewable power generation projects involving citizens in the decision process and as investors are proliferating in France

There are now upwards of 200 power generation projects with the long-term involvement of residents* and local authorities in terms of governance and financing.

This civic energy – where decision-making, financing and initiatives stem from grassroots initiatives – leverages the local natural resources of the territories involved. It also helps improve citizen buy-in to the project and to the energy transition.

In partnership with FEE, the French government is thus currently working on **creating a roadmap to encourage this civic involvement,** through the **principle of shared governance of wind projects** in particular.

In France, **€102.4m**** have been collected through crowdfunding initiatives in order to fund renewable energies in 2020



*https://www.ecologie.gouv.fr/developpement-des-energies-renouvelables-barbara-pompili-visitera-parc-eolien-citoyen-lhyrome-dans
**https://www.greenunivers.com/2021/04/en-2020-le-financement-participatif-des-enr-a-depasse-les-100-me-258108/

The French wind power market in 2020

Capgemini invent
France Energie Eolienne

The French wind power market – Introduction

The French wind power market plays a major part in achieving carbon neutrality and must pick up speed in order to meet the objectives of the PPE

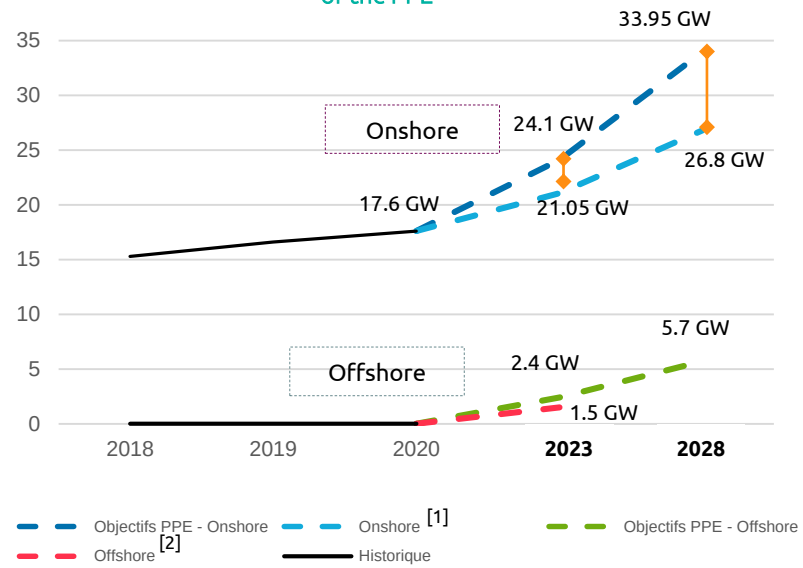
France's 2050 carbon neutrality objective has been laid out by the PPE (published in April 2020). It sets the objectives of the country's energy transition up to 2028, with a **45% increase in wind power capacity over 3 years, up to 24.1 GW**.

However, with only 1,105 MW connected to the grid in 2020 and a cumulative capacity of 17.6 GW, France is failing to reach the cruising speed that it set out, i.e., an annual increase in installed wind power capacity of **2,000 MW**.

The same applies to the 34 GW objective for grid-connected cumulated capacity by 2028, which also seems hard to achieve given the regulatory constraints that are still weighing on the industry and the impact of the pandemic crisis on commissionings. This is a most regrettable state of affairs as **France happens to be the European country that commissioned the highest number of wind turbines in 2020**.

Offshore wind is no exception given that in a best case scenario, only 1.5 GW should be newly installed by 2023, instead of 2.4 GW as initially planned for in the PPE.

Objectives in terms of installed capacity in GW versus the objectives of the PPE



[1] *The projections for 2023 and 2028 were computed based on the average growth rate in previous years.*

[2] *The projection for 2023 was made based on the schedule for the installation of the offshore farms under development*

Source: PPE implementing decree, published in the French official gazette on April 23, 2020 & SDES 2020

PPE: Multiannual Energy Programming (*Programmation Pluriannuelle de l'Énergie* – PPE).

The French wind power market in 2020

17.6 GW[1] of total grid-connected capacity

+7% installed capacity compared to 2019

1,3 GW[1] installed and grid-connected capacity in 2020

This is equivalent to the electricity use of approximately 8 million households.

477 wind turbines[1] installed in 2020

7.9%[3] of France's electricity generation comes from wind power

With **1.3 GW** of additional wind capacity, total grid-connected capacity rises to **17.6 GW** at the end of 2020. This is an 8% increase that results in wind power representing **7.9% of France's electricity mix.**

The increase in installed capacity is nevertheless slackening given that it amounted to 1.3 GW in 2019 and even 1.7 GW in 2017!

Indeed, though the industry has demonstrated its resilience in the face of the pandemic, given that **wind power output increased by 17%** (to 39.7 TWh), **authorisation procedures** for ongoing projects have experienced **significant delays**, out of line with the PPE's trajectories.

3.5 GW[2] in generation capacity for offshore wind projects that have won call for tenders or projects

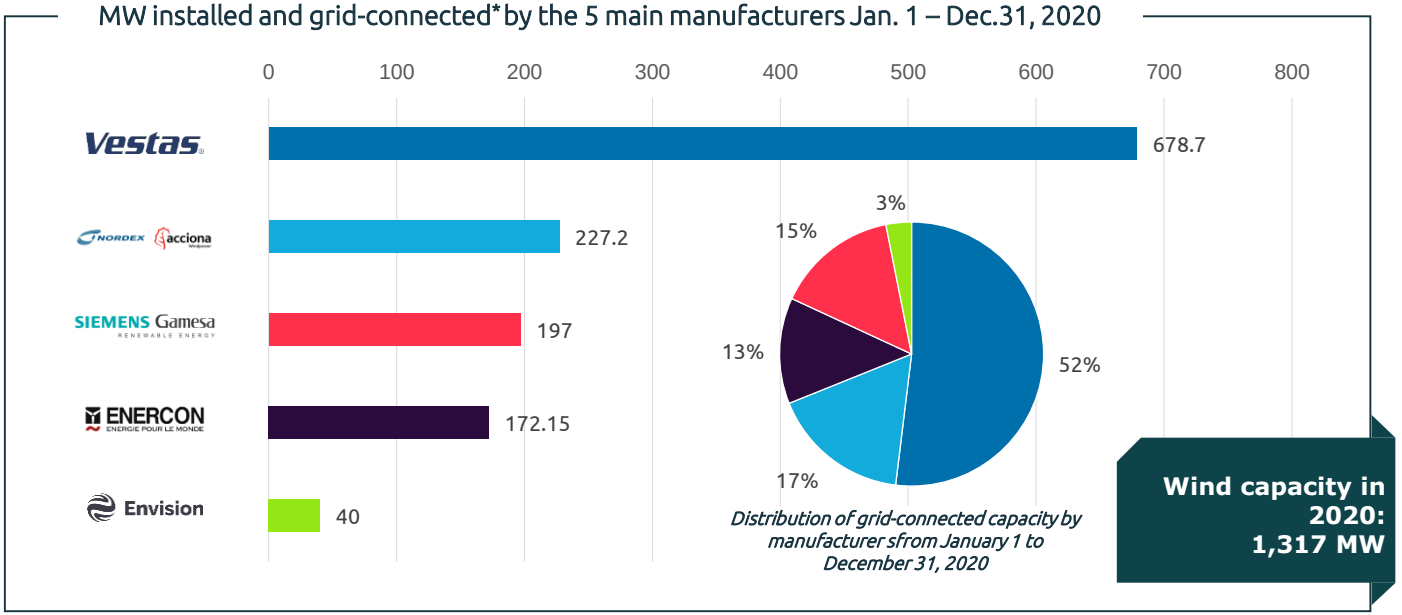
(The equivalent of the electricity use of approximately 1.5 million households.)

39.7 TWh electricity generated from wind turbines, amounting to 17.3% more than in 2019.[4]

1. FEE study, 2021
2. 2021 Observatory for Marine Energies
3. RTE report
4. WindEurope, "Wind energy in Europe in 2020"

Overview of the French wind market

1.3 GW of wind power capacity was installed in France in 2020

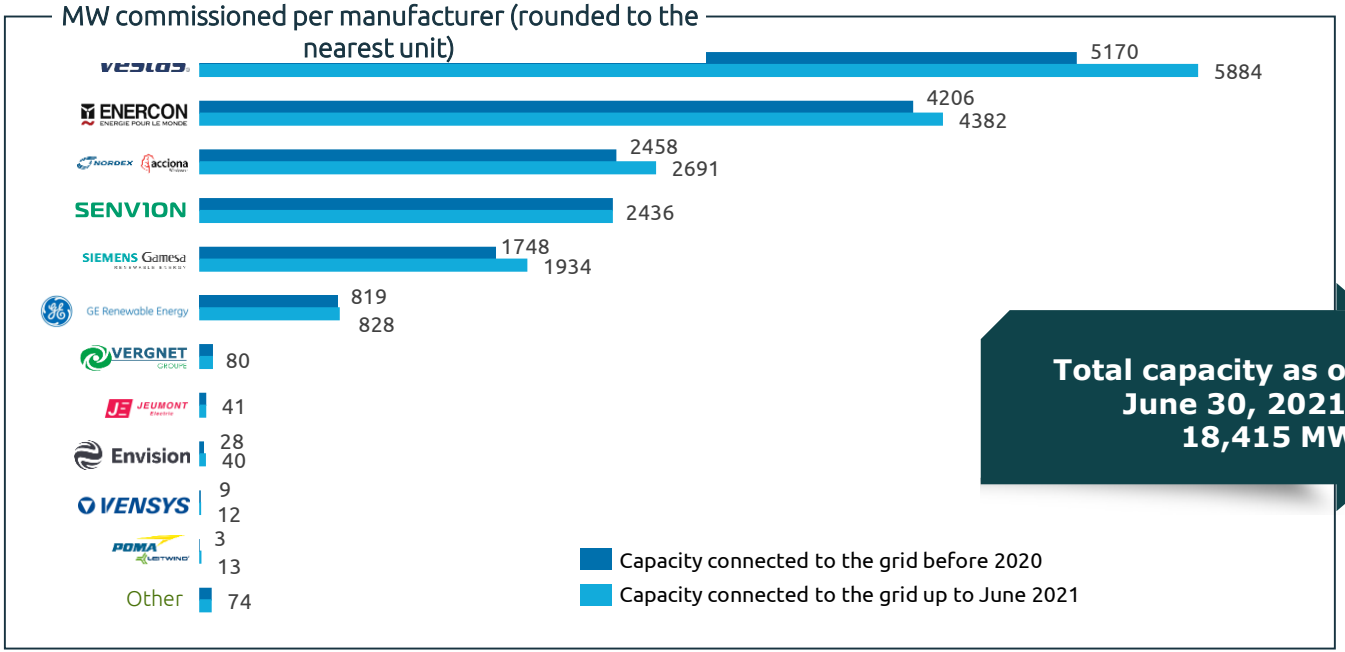


Source: FEE study, 2021

** The data on installations and connections to the grid may differ from those reported by RTE due to differences in the way grid-connection contracts are treated*

Overview of the French wind market

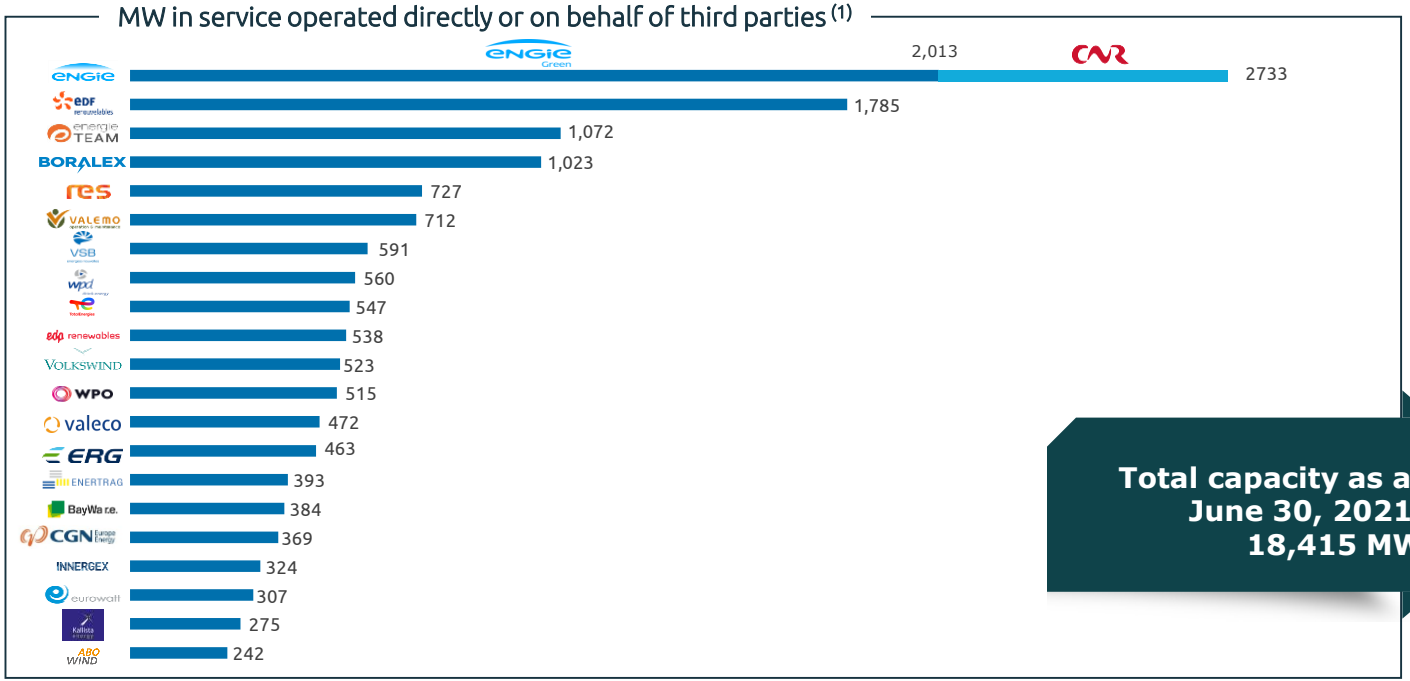
As of 30 June 2021, there is a total grid-connected capacity of 18.4 GW in France



Source: FEE study, 2021

Overview of France's installed capacity

19 operators manage more than 300 MW of wind capacity each



Source: FEE study, 2021

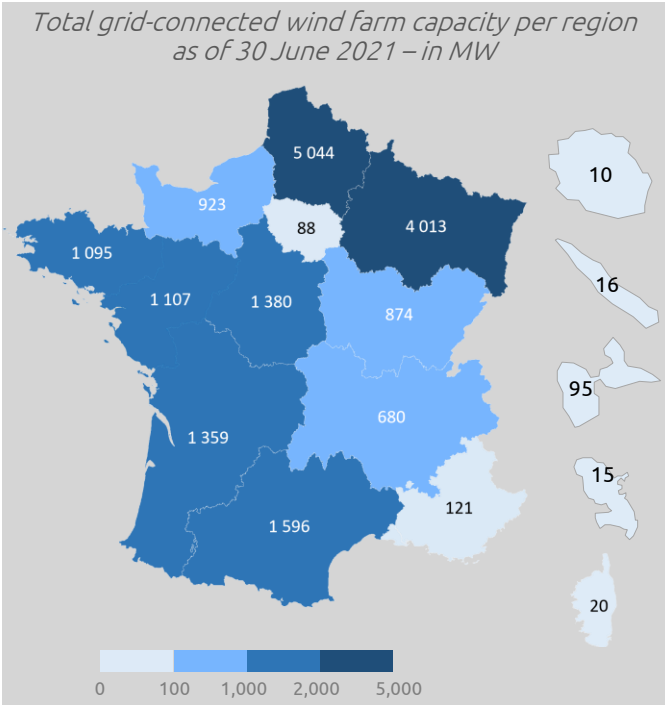
CNR 592 MW of which are operated by Energieteam , 128 MW by Engie Green, and the rest by third parties.

(1) Data from the FEE database as of June 30, 2021; figures are rounded to the nearest unit; data for the last semester are consolidated on the following semester

Overview of the wind power market by region

The current distribution of installed MW attests to the dominance of the north-east and west of France

Total grid-connected wind farm capacity per region as of 30 June 2021 – in MW



Source: FEE study, 2021

Wind capacities are distributed over the country, **with more than 1,550 wind farms** featuring 8,905 wind turbines that are located in all regions of mainland France as well as in overseas territories.

Hauts-de-France and **Grand Est** are the top wind regions. These two regions alone represent **50% of France's grid-connected capacity**. Meanwhile, **Occitanie,** the historical birthplace of the French wind industry, **ranks 3rd nationally**.

Other regions continue to progress. For instance, **Nouvelle-Aquitaine** has connected more than **200 MW** to the grid between June 2020 and June 2021.

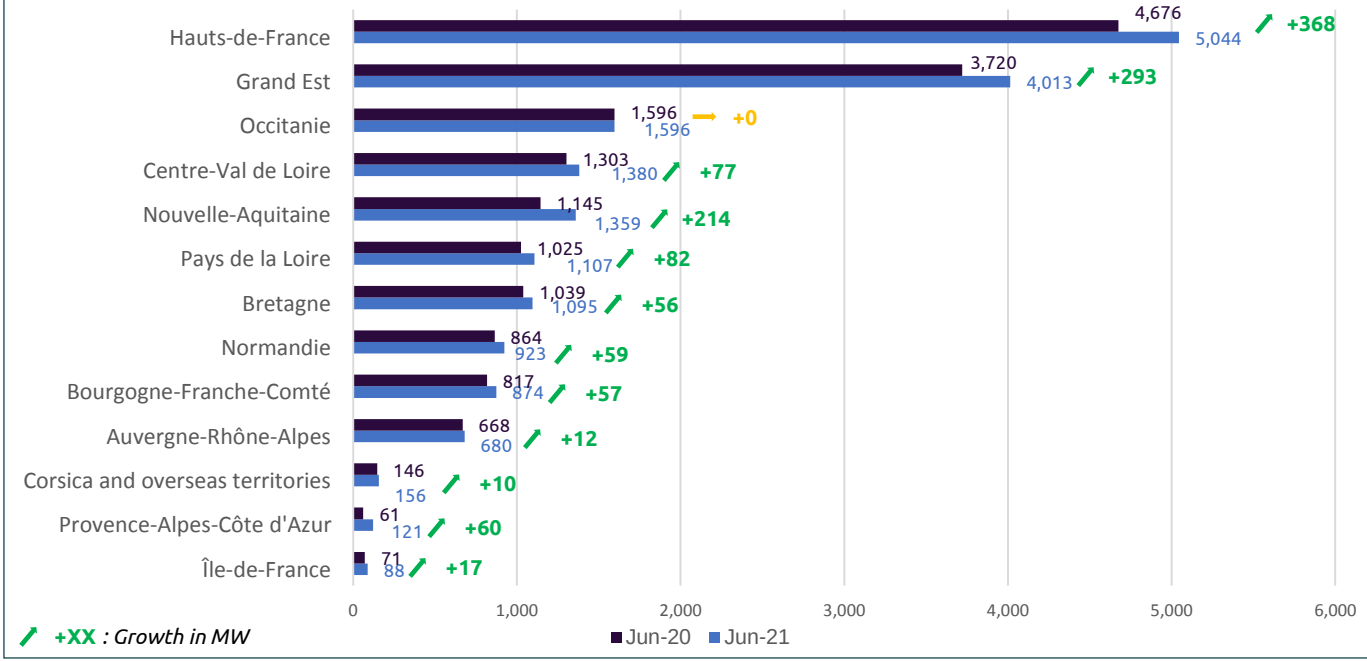
The Grand Est **has now hit the 4 GW mark** in terms of installed wind turbines, which testifies to the **harmonious development** of the sector that is under way throughout the country.

7 regions out of a total of 13 have more than **1,000 MW** of wind power connected to the grid at the end of June 2021

Overview of the wind power market by region

Though grid-connection capacity is increasing throughout the country, growth is the highest in Hauts-de-France and Grand-Est

Growth in grid-connected capacity by region



Source: FEE study, data processing by Capgemini Invent, 2021

The French wind market within the European context

Europe's wind energy sector continues to grow, with strategies that differ for offshore and onshore wind in different countries

Focus on the 15 countries with the highest grid-connected capacity at the end of 2019

Grid-connected capacity (onshore and offshore) in Europe at the end of 2020

Key:

Total grid-connected wind farm capacity – MW

500 5,000 10,000 20,000 30,000

Change in grid-connected capacity in 2020

<10% Stable >10%

	Country	Combined installed capacity at the end of 2019 (MW)	... of which offshore capacity at the end of 2019 (MW)	Growth between 2019 and 2020*	Combined installed capacity at the end of 2020 (MW)	... of which offshore capacity at the end of 2020 (MW)	% of the electricity mix in 2020
1	Germany	61,357	7,445	1,270	62,627	7,689	**27%**
2	Spain	25,808	5	1,456	27,264	5	22%
3	UK	23,515	9,945	652	24,167	10,428	27%
4	France	16,646	2	1,303	17,949	2	9%
5	Italy	10,512	0	340	10,852	0	7%
6	Sweden	8,985	192	1,007	9,992	192	20%
7	Netherlands	4,600	1,118	2,184	6,784	2,611	12%
8	Poland	5,917	0	697	6,614	0	9%
9	Denmark	6,128	1,703	52	6,180	1,703	**48%**
10	Portugal	5,437	8	49	5,486	25	25%
11	Belgium	3,879	1,556	840	4,719	2,261	14%
12	Ireland	4,155	25	196	4,351	25	**38%**
13	Greece	3,576	0	537	4,113	0	15%
14	Austria	3,159	0	51	3,210	0	12%
15	Romania	2,930	0	0	3,029	0	13%

Sources: WindEurope, "Wind Energy in Europe in 2020" (2020), IEA and national energy companies

:* The data on capacity growth in France presented by WindEurope differ from those presented by FEE because they are based on different calculation methods.

In spite of its large area, France's installed capacity only amounts to one third of that of Germany. According to WindEurope, wind power contributes to 16% of the EU's electricity mix, but still only 9% of France's electricity mix.

Sources: Euractiv, "Wind provided 16% of EU electricity in 2020, despite COVID delays"

The French wind market within the European context

Europe's wind energy sector continues to grow, but with stark disparities between countries France is in Europe's No. 4 position in terms of grid-connected capacity

- In Europe, total grid-connected wind power capacity at the end of 2020 was **220 GW**, of which 195 GW was onshore wind and 25 GW offshore wind. This amounts to a 15 GW increase in 2020.
- This grid-connected capacity generated 458 TWh of electricity in 2020 and covers **16%** of Europe's total electricity needs.
- Installed capacity has increased by 15 GW by 2020, amounting to a 7% increase compared to 2019. We need to pick up the speed if Europe is to achieve its stated objective of an additional 105 GW installed between 2021 and 2015.
- The **Netherlands** is the European leader in terms of additional grid-connected capacity, with **1,979 MW grid-connected in 2020, including 1,493 MW in offshore capacity.** Germany comes second with **1,650 MW capacity.** This "powering up" of the Netherlands is largely the result of the emergence of offshore wind farms, which contribute to **75%** of Europe's grid-connected capacity in 2020.
- **Spain is No. 3 in Europe** with 1,400 MW grid-connected in 2020.
- **Sweden and France** complete the ranking of the most dynamic countries in Europe with 1,007 MW and 1,318 MW of new capacity installed in 2020*, respectively.
- **France remains the fourth largest country in Europe** by installed wind capacity, at 18 GW, lagging far behind **Germany**, which keeps its European lead with a total installed capacity of **63 GW**.

Sources: WindEurope, "Wind Energy in Europe in 2019" (2020), RTE Electricity report for 2019
RTE Electrical Balance Sheet 2018
*Installed capacity in France according to WindEurope. The figure adopted by FEE is 1,105 MW.

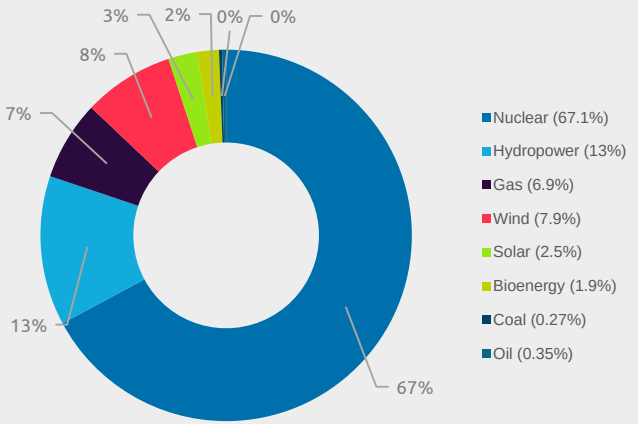
The place of wind power in the French energy mix in 2020

In 2020, wind power amounted to **7.9%** of the French power generation and experienced significant growth: **+17.3%** between 2019 and 2020

Total electricity generation
537.7 TWh
-2 %

Nuclear	Hydropower	Wind
335.4 TWh	65.1 TWh	39.7 TWh
- 11.6%	8.4%	17.3%

Solar	Bioenergy	Thermal
12.6 TWh	9.6 TWh	37.6 TWh
2.3%	- 0.8%	- 10.6 %

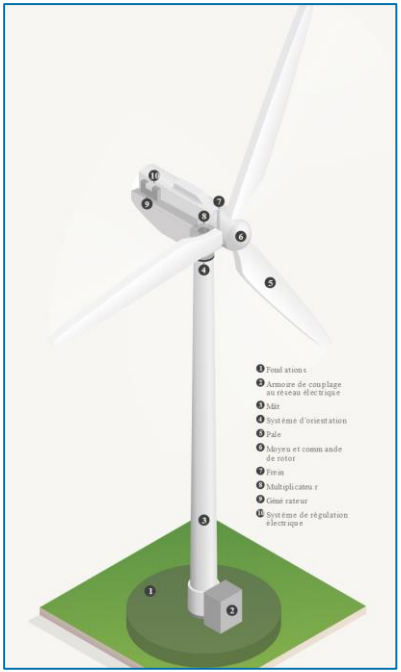


As wind power generation increased by more than **17%** year-on-year in France in 2021, wind power has the highest growth rate among energy sources. Though the figure is satisfactory, it must nevertheless be qualified given that during the pandemic electricity generation was lower than usual.

Source: RTE – Electricity report for 2020

Onshore technologies are continuing to make progress

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



Source: FEE study

The wind, a source to be mastered

The efficiency of wind turbines depends on wind speed and frequency. A site with winds averaging 30 km/h will be approximately eight times more productive than another site with winds averaging 15 km/h. In France, a project is considered economically interesting when the annual average speed at the site is around 21 to 25 km/h.

Other criteria are also taken into account, such as the capacity of the soil to support the foundations and the connection to the power grid.

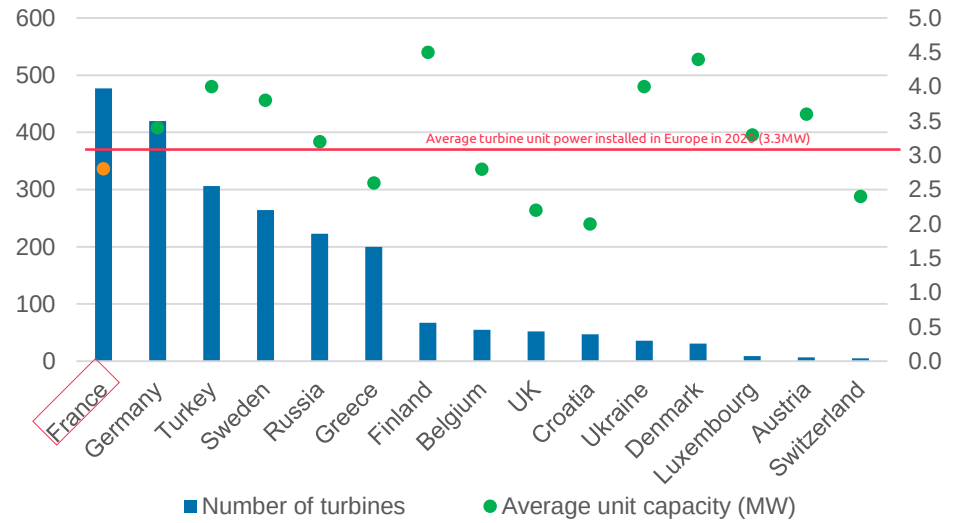
Wind turbines must aim for an optimal rotor size to be able to capture winds that are both strong and continuous.

The larger the diameter of the rotor (5 and 6), the higher the energy captured.

Onshore technologies are continuing to make progress

Among European countries, France installs the highest number of turbines, but with a lower installed capacity

Average unit capacity & number of turbines in European countries in 2020 (onshore)



Sources: Wind energy in Europe in 2020, *Trends and statistics* (2020)

The unit power of wind turbines installed in France in 2020 nevertheless remained **among the lowest** on the European continent (2.7 MW compared with a 3.3 MW average), though it ranked No. 1 in terms of the number of wind turbines installed in 2020 (with 477 units).

This is due to the strong regulatory constraints, further increased in 2021, and **which restrict the potential cost decreases for wind power in France.**

Yet, supersize wind turbines, which are higher and therefore more powerful, would help lower the number of installed turbines and therefore also lower electricity prices for the community.

Onshore technologies are continuing to make progress

There is a trend towards higher turbine capacity, yet it still lags behind the European average (3.3 MW)

Most installed turbines in 2020

	Model	Manufacturer	Unit capacity (MW)	Rotor size / mast height (France)	Installed capacity (MW)
1	V100	Vestas	2–2.2	100m / 80–120m	196
2	SG3.X-132	Siemens Gamesa Renewable Energy	3–3.6	132m / 84–97m	133
3	V136	Vestas	3–3.6	136m / 82–149m	133
4	N131	Nordex / acciona	3–3.9	131m / 84–120m	126
5	V117	Vestas	3–3.6	117m / 80–116m	121
6	N117	Nordex / acciona	2.4–3.6	117m / 91–120m	96
7	V110	Vestas	2–2.2	110m / 80–125m	83
8	E92	Enercon	2.3	92m / 69–138m	83
9	E82	Enercon	2–3	82m / 78–138m	59
10	V126	Vestas	3–3.6	126m / 87–137m	50

Source: FEE study, 2021

X MW Models with a unit capacity higher than the European average

Onshore technologies are continuing to make progress

The most installed turbines in France have generation capacities and sizes that are limited compared to the possibilities offered by manufacturers

Most installed turbines **as of 30 June 2021** (total number)

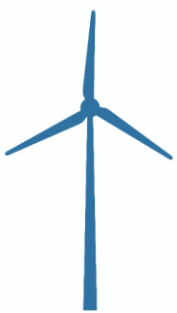
	Model	Manufacturer	Unit capacity (MW)	Rotor size/height	Total capacity (MW)
1	E82	ENERCON	2–3	82m / 78–138m	1699.8
2	V90	Vestas	2–3	90m / 80–105m	1,626
3	MM92	SENVION	2.05	92m / 68–100m	1511
4	E70	ENERCON	2.3	71m / 54–138m	1,452
5	V100	Vestas	2–2.2	100m / 75–120m	1,434
6	N90	NORDEX / acciona	2.5	90m / 65–120m	854
7	N117	NORDEX / acciona	2.4–3.6	117m / 91–120m	720
8	V112	Vestas	3–3.45	112m / 69–119m	701
9	N100	NORDEX / acciona	2.5	100m / 75–100m	685
10	MM82	SENVION	2.05	82m / 59–100m	572

Source: FEE study, 2021

X MW Models with a unit capacity higher than the European average

The higher burden of aeronautical & regulatory constraints

The expected dynamics in terms of increased installed capacity is being held back by restrictions that add to an already highly restrictive environment



		Examples of constraints
Aeronautical constraints:	- Setting up a wind farm is subject to clearance by the Ministry of the Armed Forces when it is located close to a military radar. - In addition, military flight paths prevent the installation of wind turbines on almost 50% of the French territory. This makes it challenging to install wind turbines over a large part of the country, and even more so when more than 150 m high.	In June 2021, the minimum regulatory distance between wind turbines and military radars has gone down from 30 to 70 km. Beneath that distance, clearance from the Ministry of the Armed Forces is required.
Regulatory constraints	In France, the development and renewal of wind farms with larger wind turbines is hindered by regulatory constraints that make it a long and complex process. The French administration is increasingly making use of guidelines, which are instruments of “soft law”.	The section related to landscapes in the French methodological guide on impact assessments was updated in 2020 and increases the burden in reading the recommendations and having landscape studies conducted by specialized consultancies.

Source: FEE study, 2021

Offshore wind

Offshore wind, a booming technology

In 2021, there were **7 awarded offshore projects under development and 4 pilot floating offshore projects in France**. Though construction on offshore projects first started in 2019, the offshore wind sector should represent 10% of grid-connected wind 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 50–60 m and can harness strong coastal winds.
Projected unit capacity: 6-8 MW (AO1/CFT No.1) and up to 12–15 MW (AO3/CFT No.3)

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 depths of 30 to 50 m. Projected unit capacity: 8–10 MW (pilot farms)

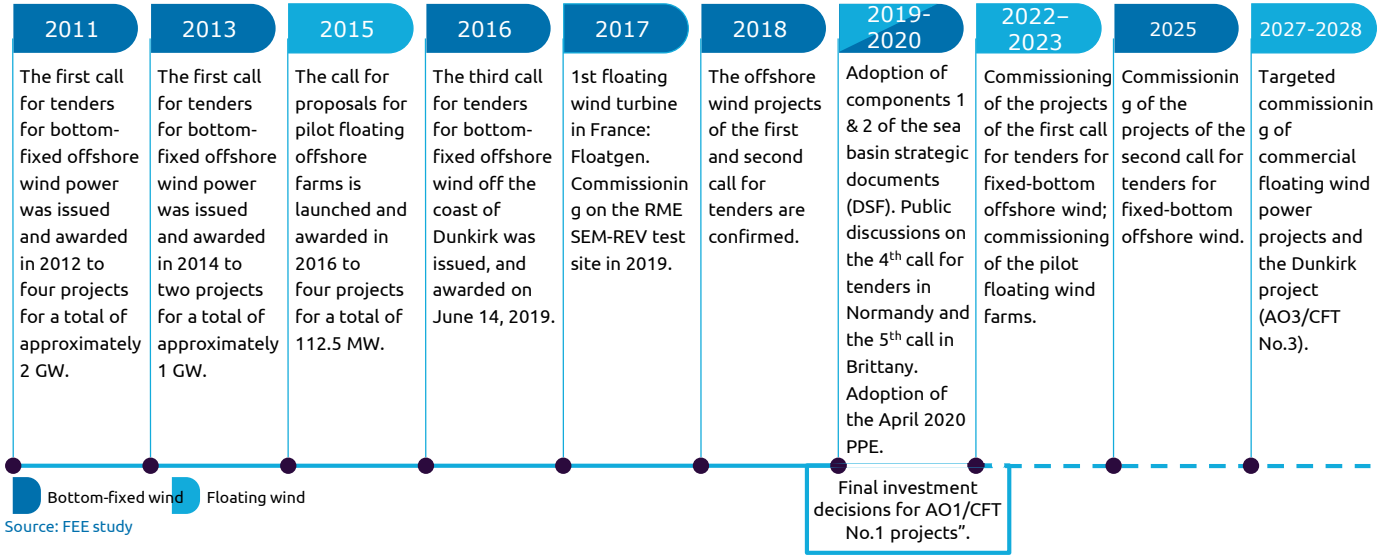
Source: FEE study

Offshore wind power is expected to represent **10%** of grid-connected wind power capacity in France in 2023

Offshore wind

France has drawn up a roadmap for offshore wind power

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. Nevertheless, France is currently less ambitious than its European neighbours: the PPE published in April 2020 provides for a target of 5.2 to 6.2 GW of offshore wind power in service in 2028, while the objective of the British Government for offshore wind is to reach 40 GW by 2030. Germany should surpass its 2020 target of 6.5 GW and is expecting to achieve 20 GW by 2030 and 40 GW by 2040.



Source: FEE study

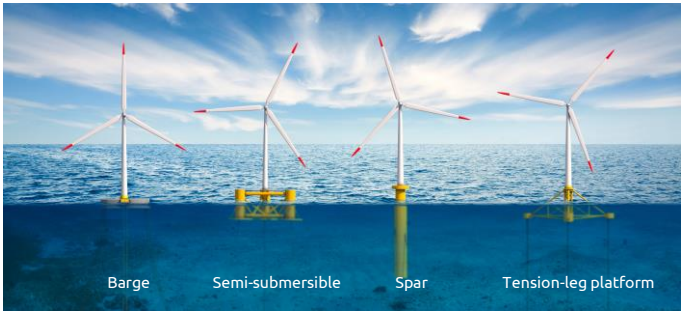
Offshore wind

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, meshed power grid

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 for 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 new markets abroad**. 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 **2021 Observatory for Marine Energies**). The sector expects 15,000 jobs to be related to offshore wind power in France in 2030.

Examples of floating offshore wind installations:

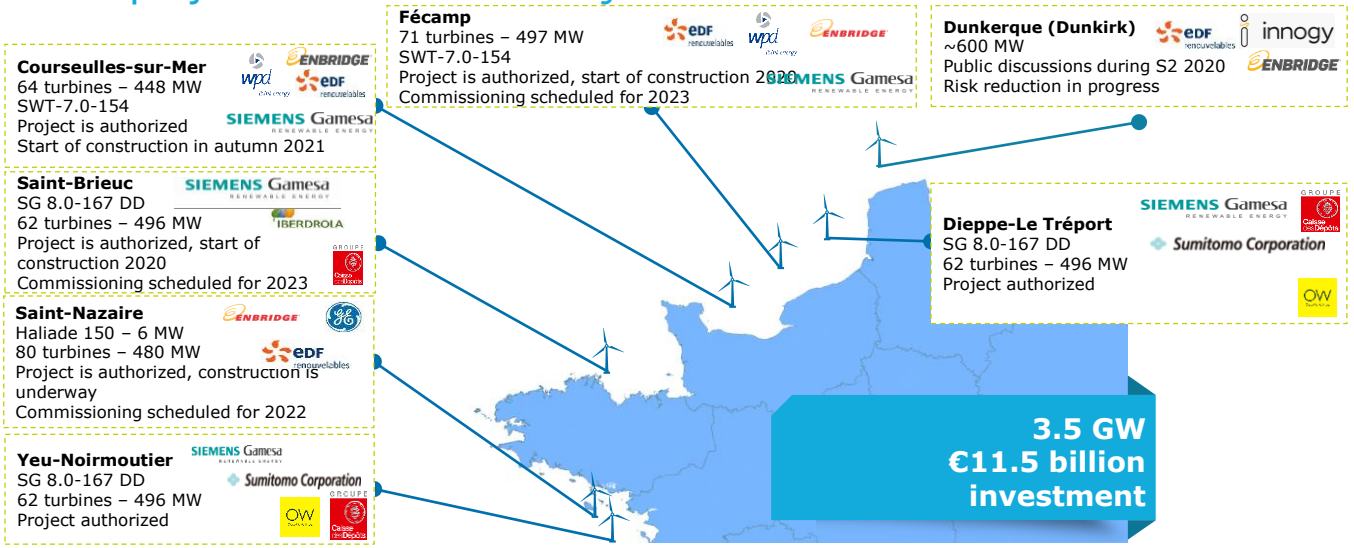


Bottom-fixed wind is the most mature and competitive MRE technology and has projects at advanced stages. Fixed-bottom offshore wind accounts for **90%** of the turnover of the sector.

Source: FEE study, 2021 Observatory for Marine Energies

Offshore wind

After the start of construction in Saint-Nazaire, the Fécamp and Saint-Brieuc projects are now underway



In **Normandy**, the year 2020 saw the construction and connection to the grid of the **Fécamp wind farm**. In 2021, construction work at the **Courseulles** wind farm started, which is soon to be followed by the **Dieppe-Le Tréport** wind farm. A new call for tenders was presented for the attribution of a **1,000 MW** offshore wind farm off the coast of the **Cotentin**.

The **Brittany** region will host the pilot floating wind farm Éoliennes Flottantes de Groix et Belle-Île following the call for tenders organised in early 2021. The project aims to connect **250 MW** to the grid (that will be extended to **750 MW in subsequent years**).

Sources: FEE study, 2021 Observatory for Marine Energies

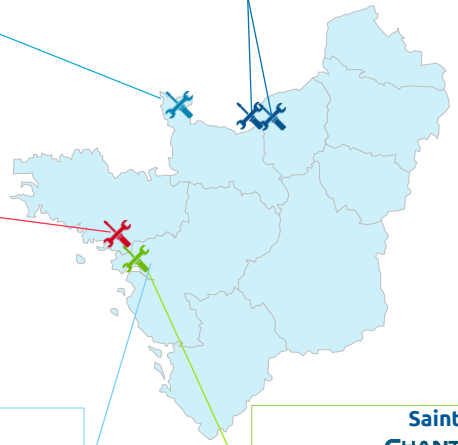
Offshore wind

Offshore wind power is now truly **emerging as an industrial sector** and is set to create and sustain many direct and indirect jobs in France.

Le Havre
SIEMENS Gamesa
Manufacturing of blades, nacelles and generators for offshore wind power
750 direct and indirect jobs by 2022

Cherbourg
GE Renewable Energy
Manufacturing of blades
350 direct jobs created
550 direct jobs by 2021

Montoir-de-Bretagne
GE Renewable Energy
Assembly of 80 nacelles for 6 MW wind turbines for the first French offshore wind farm located in Saint-Nazaire
300 direct jobs
450 direct and indirect jobs by the end of 2020



Nantes
GE Renewable Energy
The site mainly brings together the engineering, purchasing, quality, project management and service departments.
200 direct jobs

Saint-Nazaire
CHANTIERS DE L'ATLANTIQUE
Includes 3 jacket-type foundation production units, transition pieces and electrical substations for the Saint-Nazaire wind farm
200 direct jobs

Fécamp wind farm: start of construction in June 2019; 71 offshore turbines; commissioning in 2023.

Saint-Nazaire wind farm: commissioned in 2022. Manufacturing of nacelles in the GE Renewable Energy plant at Montoir-de-Bretagne.

The Saint-Nazaire Chantiers de l'Atlantique plant will manufacture the electrical substations for the Saint-Nazaire and Fécamp wind farms.

The **GE Renewable Energy** (LM Wind Power) plant located in **Cherbourg** currently produces the longest blades in the world for export projects won in the United States and the United Kingdom.

1,300 jobs created in France by 2022 in factories manufacturing offshore wind turbine components

Source: FEE study

Offshore wind

Focus on the factories of Cherbourg and Le Havre

In November 2019, GE Renewable Energy (through its subsidiary, LM Wind Power) inaugurated its plant in Cherbourg for the construction of blades for offshore wind power. As of mid-2020, the plant has more than 300 employees and will be recruiting 250 more by early 2021.

In June 2020, Siemens Gamesa started construction of its blades and nacelles plant in Le Havre after receiving confirmation for two firm orders in France (Fécamp and Saint-Brieuc). This plant will generate **750** additional **jobs** and should be operational in Q1 2022.

Offshore wind power represents a promising industrial sector as France will soon hold one third of Europe's offshore generation capacity

LM Wind Power's factory in Cherbourg

The largest blade in the world is manufactured at LM Wind Power's Cherbourg factory

3D representation of the Siemens Gamesa Renewable Energy plant in Le Havre

The GE Renewable Energy (subsidiary: LM Wind Power) factory in Cherbourg has already manufactured **the largest blade ever made** (107 metres long) for **the most powerful wind turbine in the world**, developed by GE Renewable Energy and with a demonstrator that is currently installed and operational in Rotterdam for testing purposes–the **12 MW Haliade-X**.

Source: FEE study, LM Wind Power

Offshore wind

€220 million of investment for the development of the MRE* terminal of the port of Brest intended for marine renewable energies

The industrialisation of the offshore wind industry contributes to massive investments in certain French ports. Indeed, the assembly of certain components is done at the dock. To carry out these complex operations, the port infrastructure must be adapted. These investments form part of a long-term goal to establish the know-how of **the French offshore wind industry** and to thus consolidate **its expertise in order to export turbines to Europe and to the rest of the world**.

The Brest port upgrade started in 2017, with the aim of creating a 40 ha polder – an artificial expanse of land reclaimed on the water – dedicated to **marine renewable energies (MREs)**, including **offshore wind power (bottom-fixed and floating) and tidal power.**

The project represents an investment of **€220 million** from the Brittany Region and its partners. The boom in the MRE sector is expected to generate **400 to 500 direct jobs** at the end of the construction phase, **scheduled for 2024**. The Spanish company Navantia has chosen to operate from the port and will set up a jacket foundation pre-assembly unit for the future offshore wind farm in the bay of Saint-Brieuc. This market will mobilize **250 direct jobs over 2 years.**

In addition to the port of **Brest**, the ports of **Cherbourg**, **Le Havre** and **Saint-Nazaire** have also undertaken significant investments to support the development of MREs on the Atlantic coast. The ports of **Marseille-Fos** and **Port-La Nouvelle** on the Mediterranean basin have also followed that approach. France is very dynamic in this promising **sector offering strong growth potential** in Europe and around the world.

Work in progress for the construction of a polder in the port of Brest aimed at attracting activities related to marine energies

Source: FEE study

Offshore wind

€252 million are being invested in extending the port of Port-La Nouvelle, which is intended, among other things, for floating offshore wind activities

In 2016, Occitanie was chosen by the French government as a favourable site for two floating wind farms. It is on the site of the port of Port-La Nouvelle, which is France's No. 3 **Mediterranean port** that wind turbines should be assembled before being installed offshore, and it will also be used for logistics coordination. Out of four floating offshore wind power pilot projects in France, **two are located off Leucate-Barcarès and Gruissan**, facing the Aude coast. They should be launched around **2021-2022**, for a test phase lasting approximately three years.

The port extension works started in the autumn of 2019. The Occitanie region has committed to invest **€252 million** in the extension project which includes the creation of a new port basin and a new wharf for offshore wind power.

Construction work should be completed by **2023**. In total, no less than **3,000 jobs** (either direct, indirect or induced) will be created thanks to the activities that will be established in this port in the Aude département. The first stage of the expansion of the port, launched last September, **already** represents **200** full-time equivalent **jobs**. Ten local companies were selected to carry out this project, and five other local companies are taking part as subcontractors.

In order for the port expansion to be exemplary from an environmental standpoint, the regional authorities have set up several bodies, in particular a scientific committee composed of experts as well as an environmental monitoring committee that brings together local authorities, associations and the fishing industry. It has also mobilized more than **€12 million for environmental compensation purposes.**

Development of the port of Port-La Nouvelle

Development of the port of Port-La Nouvelle

Source: FEE study

Optimize performance

Floating wind

EolMed

Pilot farm at Port-La-Nouvelle

Wind farm context and description

The very first floating offshore wind farm will come into being in **Occitanie** in the town of Port-La-Nouvelle with a planned commissioning in **autumn 2023**. The farm will feature **3 turbines each having a 9.5 MW capacity**.

Two **core elements** are involved in setting up this floating wind farm:
- Steel **floats**
- A connection **hub**

Having a single connection hub for 3 turbines offers many advantages:
- The physical **connection point** is clearly defined.
- The wind turbines are connected in **parallel**.

Various protagonists are involved throughout the value chain:*

Developer	Co-developer	Turbine	Foundations	Crowdfunding
Qair	TotalEnergies	Vestas	BW ideol	enerfip

Source: Vestas * *Non-exhaustive list*

Offshore wind

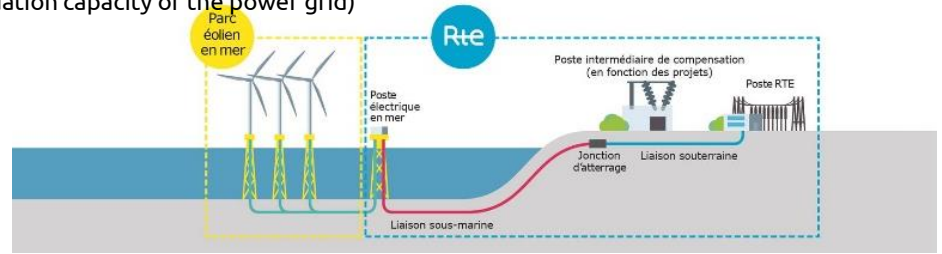
RTE is positioning itself to adapt its network to the challenges of offshore wind power

In France, since 2017, 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 risk mitigation** 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 standardisation 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

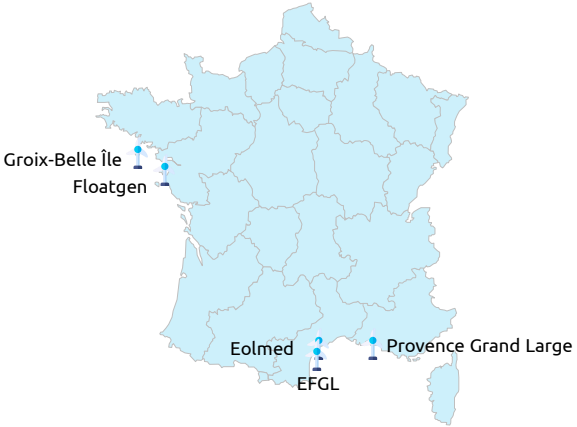
In France, the Mediterranean Sea and the Brittany seaboard have substantial wind power potential for the installation of floating wind farms due to their highly favourable and regular wind regimes as well as its bathymetry (the ocean floors drop very steeply to a depth exceeding 60 m).

The main challenge for floating wind power is to make its cost converge towards that of offshore wind power, hence the need to develop several projects to industrialise the sector and **become more competitive.**

Similar projects are underway throughout **Europe**, which testifies to the importance of the floating offshore wind industry.

Project	Characteristics	Industrial partners
Provence Grand Large	3 turbines – 24 MW	EDF, SBM Offshore, Siemens Gamesa, DCNS, CGN, EDPR, Vinci, Naval Energies, Vestas, Qair, BW Ideal, Eiffage, OW, Vestas
Groix-Belle Île	3 turbines – 28.5 MW	
Eolmed	3 turbines – 30 MW	
EFGL (Floating wind of Golfe du Lion)	3 turbines – 30 MW	

"**80%** of European wind resources are found in areas with depths exceeding 60 m" (Wind Europe)



FLOATGEN, 1st floating wind demonstrator in France, installed in 2018
Objective: to validate the performance of the combination of a wind turbine and a floating foundation
Capacity: 2 MW (Vestas V-80)
Installation location: Le Croisic
Water depth: 33 m
Power generation: 6 GWh in 2019
Consortium:

Source: 2021 Observatory for Marine Energies

Jobs in wind power

Capgemini invent | France Energie Eolienne

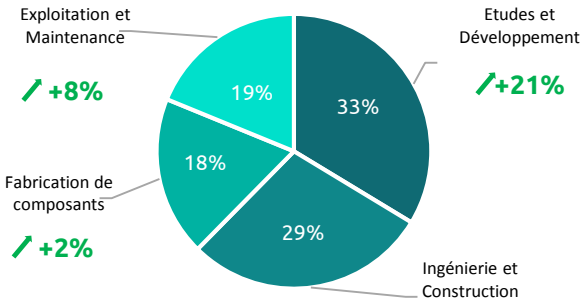
Key facts and figures

22,600 jobs at the end of 2020

+24% wind power jobs in the Pays de la Loire region

12% increase in wind jobs in **2020**

Breakdown and variation of FTEs on the value chain:



Growth rate by link in the value chain (2019–2020)

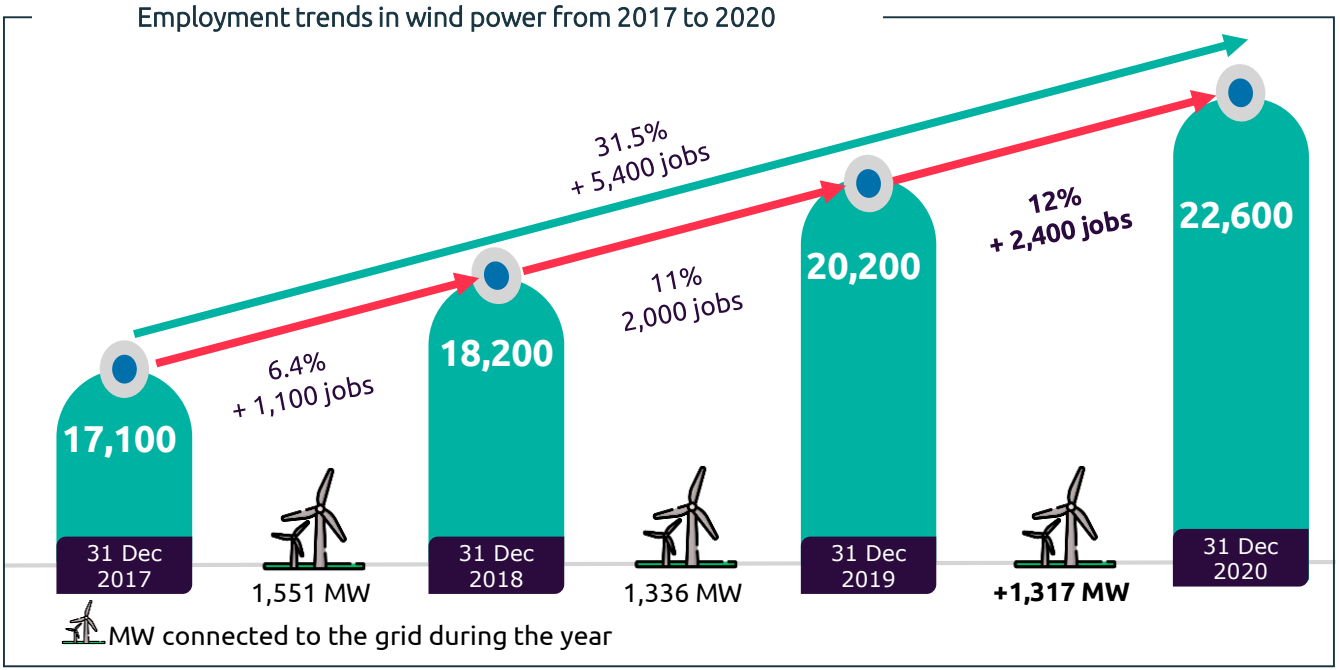
In 2020, **wind power jobs have continued to increase at a significant pace**, with a growth rate of 12% and a total of 22,600 direct and indirect jobs in France as of 31 December 2020.

Though the pandemic hasn't impacted the overall momentum, it has nevertheless weighed on the authorisations granted for the construction of the wind farms and has hampered growth in activities related to operation and maintenance, and especially those related to component manufacturing. For the latter category, offshore has been instrumental to maintaining growth.

Just as in the year 2019, offshore wind is the sector that boosts job growth in the French wind industry This trend is largely due to the start of the construction of the Saint-Nazaire, Fécamp and Saint-Brieuc farms. Accounting for more than 20% of all counted wind jobs, offshore wind represents approximately 5,200 jobs in 2020. Job growth is set to continue with more job creation in offshore wind in Normandy (in the industrial clusters in Le Havre and Cherbourg).

Job growth in wind power in France in 2020

The number of wind jobs is on the increase for the 7th year in a row



Source: FEE study, data processing by Capgemini Invent

Details by link in the value chain

An activity organized along 4 segments

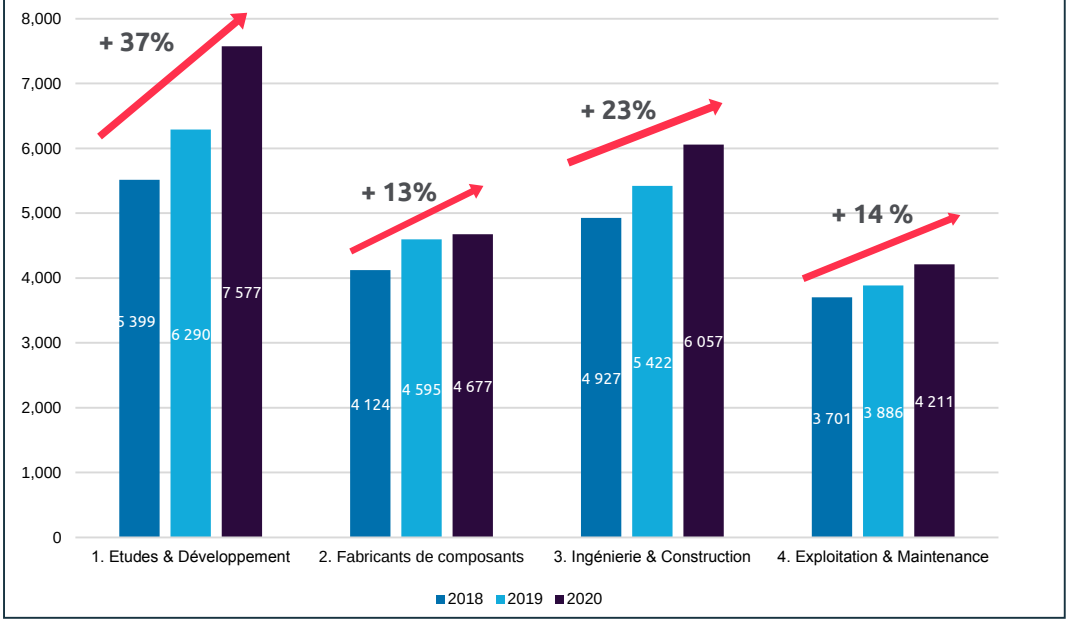
The French wind power industry has businesses operating along the entire value chain, providing wind power jobs within the following key activities:

		% of total jobs 2020
Planning & Design	E.g. engineering consultancies, wind measurement, geotechnical measurement, technical expertise, performance monitoring companies, developers, financial institutions	**33%**
Engineering & Construction	E.g. assembly, logistics, civil engineering, power grid and wind farm electrical engineering, erection, grid connection	**29%**
Operations & Maintenance	E.g. assembly, logistics, civil engineering, power grid and wind farm electrical engineering, erection, grid connection	**19%**
Component manufacturing	E.g. casting parts, mechanical parts, rotor blades, nacelles, masts, yaw drives and bearings, brakes, electrical equipment for wind turbines and the electrical grid	**18%**

Details by link in the value chain

Strong momentum on the "Planning & Design" link, translating the industry's involvement in achieving the objectives set out in the PPE.

Distribution of jobs on the value chain: employment trends in wind power from 2018 to 2020 (rounded off)



Source: FEE study, data processing by Capgemini Invent

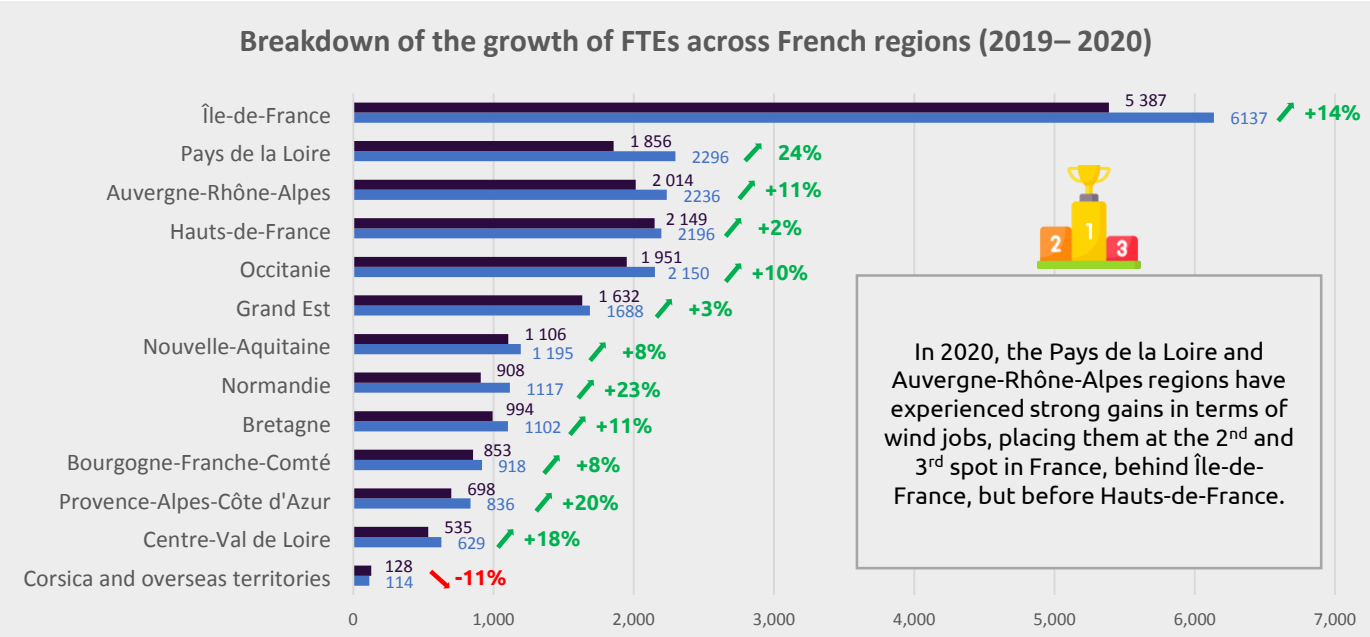
The "Planning & Design" link in the value chain is experiencing the highest growth, with a 37% increase over 2 years.

However, the "Component Manufacturing" link posted only a very slight increase in 2020 (+2%). This trend is primarily driven by the delays in the authorisation process for new wind farms. As a result, orders to suppliers are being postponed.

The Planning & Design link nevertheless remains a growth category thanks to offshore wind.

Breakdown of wind jobs by region

Wind companies are undergoing strong growth in Pays de la Loire and Normandie, thanks in particular to offshore wind



Source: FEE study, data processing by Capgemini Invent

Breakdown of wind jobs by region

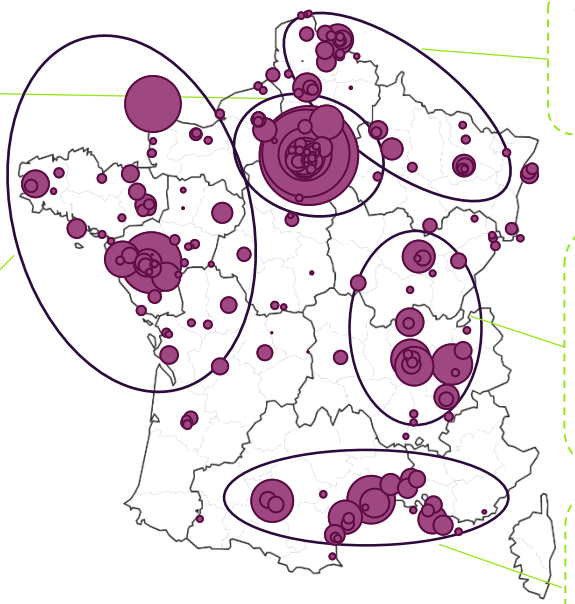
The wind power sector creates pools of employment throughout France and close to local operations

Spatial distribution of wind power labour pools in France

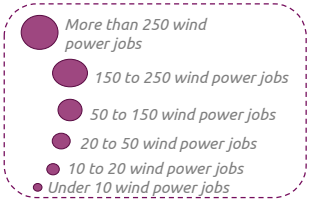
The Paris Basin (**Île-de-France** and part of the **Centre-Val de Loire** region), where many head offices of companies involved in the industry are traditionally based

The Grand Est and Hauts-de-France regions, where wind power is currently progressing rapidly, contributing to local economic vitality

The Greater West (Brittany, Pays de la Loire, Normandy, 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



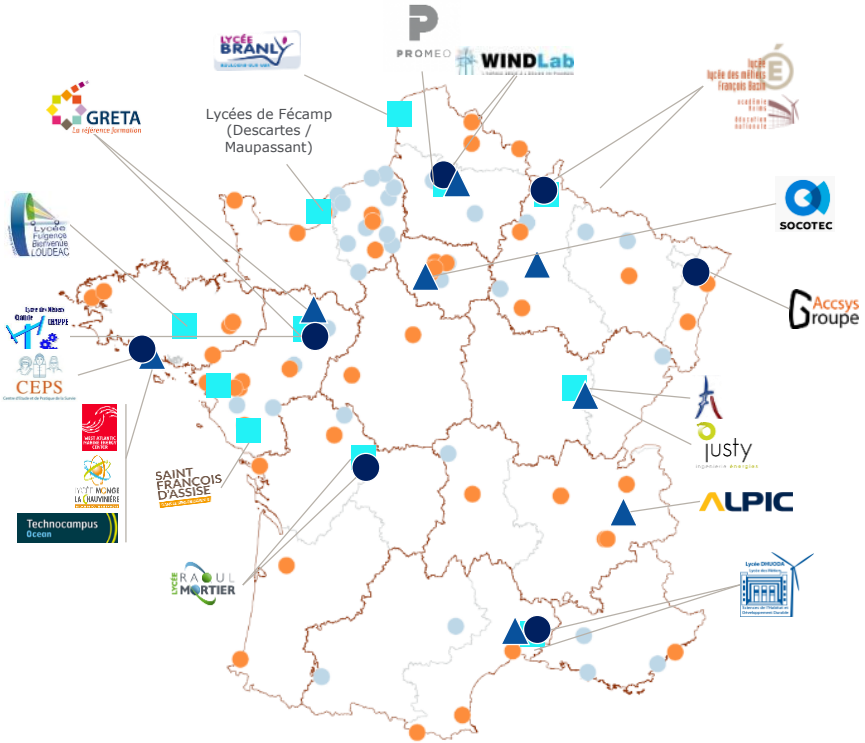
The Mediterranean (Sud-Provence-Alpes-Côte d'Azur and **Occitanie** regions), which is the cradle of the wind power industry and where several historical players are established

Source: FEE study, data processing by Capgemini Invent

Capgemini invent | France Energie Eolienne

Wind energy training programmes

Training institutions in France



Wind energy training programmes

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.

Across the country

These programmes are first supported by the regions that are developing wind power generation. Training centres are therefore usually located near production sites.

Wind energy training programmes

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

d'Aptitude Professionnelle) vocational qualification – specialisation in wind energy or wind energy	**(vocational high school diploma) –** specialisation in wind energy or wind energy	**certification (*Brevet de Technicien Supérieur* – BTS)** specialisation in wind energy or wind energy	***Technologie* (university technology degree – DUT)** specialisation in wind energy or wind energy	***Licence Professionnelle* (bachelor's degree)** specialisation in wind energy or wind energy option
Pre-baccalaureate programmes	Baccalaureate	2 years post-secondary education	2 years post-secondary education	1 year training programme after 2 years of post-secondary education
31 cities	59 cities	28 cities	10 cities	32 cities
51 diplomas	158 diplomas	46 diplomas	16 diplomas	50 diplomas
42 institutions	94 institutions	38 institutions	9 institutions	41 institutions

West Atlantic Marine Energy Center

Wind energy training programmes

Beyond 4 years of post-secondary education, higher education programs are expanding their professional modules

Across the country, there are now:

- More than 70 training programmes
- 25 cities
- In more than 40 universities or Grandes Écoles
- Several hundred graduate students per year

West Atlantic Marine Energy Center

Examples of Universities and Grandes Écoles

icam, MINES ParisTech, CentraleSupélec, GRENOBLE ÉCOLE DE MANAGEMENT, ENSTA Bretagne, INSA, Université de Poitiers, INP ENSIACET, POLYTECH NANTES, ARTS ET MÉTIERS, UNIVERSITÉ DE NANTES, CENTRALE NANTES, AgroParisTech Talents d'une planète soutenable

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

Key modules

Specialized Master's degree
"Experts in renewable energy projects and production"
Energy and the environment, renewables and energy management, technologies employed in renewables, renewable energy systems design

Partners

ADEME, cea, BOUYGUES CONSTRUCTION, EDF, transénergie, SUNPOWER, ENGIE Green

Career opportunities

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

ENSTA Bretagne

Key modules

Specialized Master's degree
"Experts in Marine Renewable Energies"
Systems engineering; marine resources; economic, environmental and legal aspects

Partners

GROUPE NASS & WIND, Sabella, SOFRESID ENGINEERING

Career opportunities

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

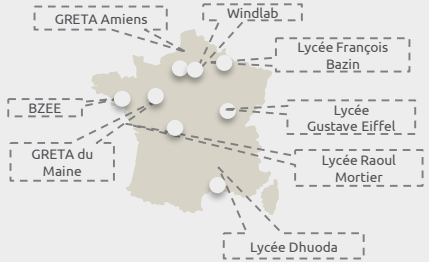
Wind energy training programmes

Two international training programmes providing certification are available in France

BZEE - 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

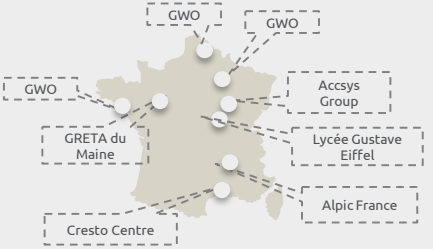


Eight accredited institutions in France

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.

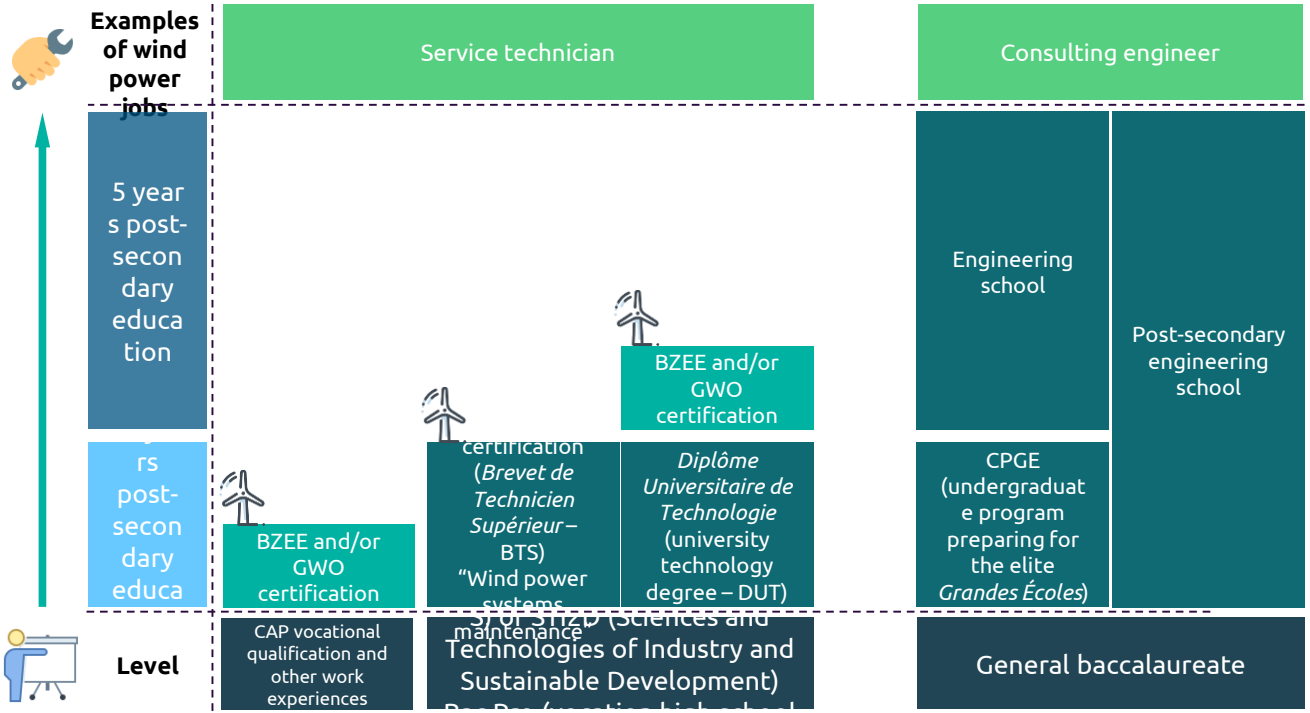


Eight accredited institutions in France

Wind energy training programm

Jobs in the industry often offer rapid career advancement and diverse career opportunities

Sample student itineraries



Wind energy training programmes

Zoom in on the Bazin (Charleville Mézières) & Dhuoda (Nîmes) high schools

LYCÉE FRANÇOIS BAZIN

- BTS technician work-study programme & BZEE and GWO certification
- Each year, the high school trains **16 students** in the case of the FCIL and **12 students** for the BTS
- Entering strong partnerships with the major players in the wind industry
  - Signing of a partnership with **EDF Énergies Renouvelables** as part of the construction of a 61-turbine wind farm in the Ardennes
- Since the training centre was opened in 2007, **500–600 students** have graduated

3 months after graduation, **90% of students find employment**

LYCÉE DHUODA
SCIENCES • NUMÉRIQUE
GÉNIE CIVIL • ÉNERGIES

- BTS technician work-study programme & BZEE and GWO certification
- Each year, the high school trains **90 students** in the BTS programme and **200 students** for the IUT
- The technical school is considering providing specific training programs geared towards offshore wind, in particular to train students to work at sea and navigate the risks involved.
- Soon there will be a possibility to follow co-op education thanks to the RNCP degree certification

Approximately **85% employment insertion** after completing the various degrees and certifications

Wind energy training programmes

Zoom in on the Vestas campus

The Vestas campus will open its doors in 2021 in order to provide students with training to become **advanced technicians in wind power maintenance**. The unique aspect of this co-op program is that it is particularly geared towards **early school leavers, those wanting to pursue short tracks, or young adults seeking job retraining.**

Prerequisites

- **Training:** Technical baccalaureate (maintenance, automobile mechanics, electrical engineering) or CAP (vocational qualification)/BEP (occupational studies)
- Driver's licence
- Elementary English

Skill set developed

- Mechanics
- Electricity
- Electrical engineering
- Hydropower
- English
- Workplace safety

Cohorts

1st cohort:
9 students
Date: 20/09/2021

Followed by two cohorts per year

Location

- **Theoretical background:** Reims (51)
- **Practical training:** on the various wind farms in Troyes (10), Langres (52), Reims (51), Nancy (54), or Saint Quentin (02) – at the student's discretion

Professionalisation contract

Intermittent 12-month professionalisation contract, with a possible permanent contract offered by Vestas at the end (subject to passing the year)

Wind energy training programmes

Zoom in on the ENERCON Training Center in Meux (Oise)

ENERCON's Meux Training Center in Oise (60 – Hauts-de-France) has been open since January 2017.

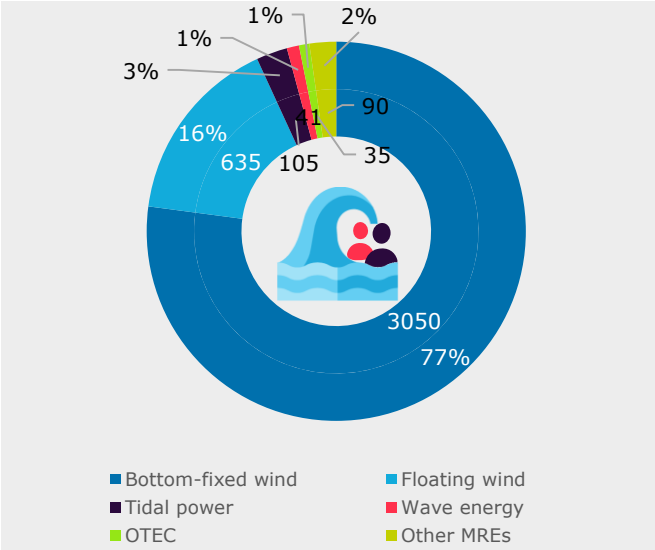
The roughly 1,400 m² space is dedicated to maintenance technicians and can accommodate 600 trainees per year. Most of them are trained on electrical and mechanical accreditations.

The 7 instructors in the training body focus on upgrading the skills of ENERCON staff and compliance with wind power-related regulations. Most training programs thus deal with the topics of security, electricity, and mechanics.

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 in the Skills Investment Plan (2018–2022), which provides for the introduction of 10,000 training courses in green jobs.

Focus on the Observatory for Marine Energies (*Observatoire des énergies de la mer*)

Jobs in offshore wind and their place in MREs*



* MREs: Marine renewable energies
Source: Observatory of marine energies 2021, C2 strategies for the French maritime cluster

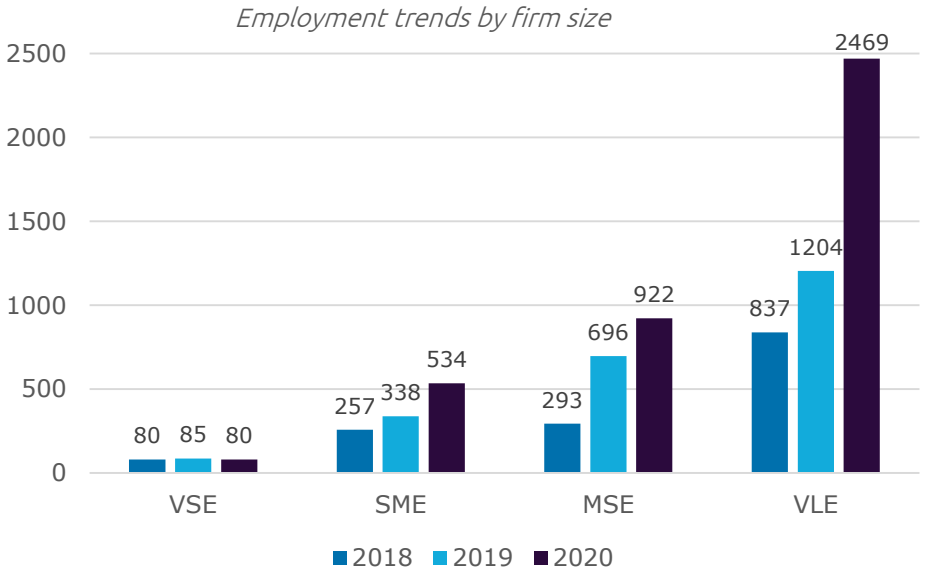
At the end of 2020, **93% of all FTEs in MREs were in offshore wind**, i.e. a total of **3,685* FTEs** out of 3921 (77% in fixed-bottom offshore wind and 16% in floating offshore wind, or, in other terms, 3,050 FTEs and 600 FTEs respectively).

The number of FTEs have seen a marked increase compared with the end of 2019, with a gain of 1,400 FTEs for bottom-fixed offshore wind and 227 FTEs for floating offshore wind.

Fixed-bottom and floating offshore wind being the most mature and competitive technologies in the industry with projects at advanced stages, these logically account for almost the entirety of FTEs and turnover. **The turnover** relating to **floating wind power** has **increased by 20% over the past year thanks to France's pilot projects.**

Focus on the Observatory for Marine Energies (*Observatoire des énergies de la mer*)

The offshore wind sector concerns all French companies, from very large companies to start-ups



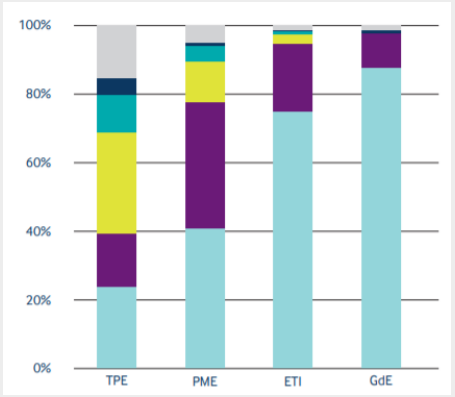
Source: Observatory of marine energies 2021, C2 strategies for the French maritime cluster

Jobs are consolidating around SMEs and large companies

Focus on the Observatory for Marine Energies (*Observatoire des énergies de la mer*)

Breakdown of FTEs in offshore wind by company size

Breakdown of FTEs by technology and company size



Source: Observatory of marine energies 2021, C2 strategies for the French maritime cluster

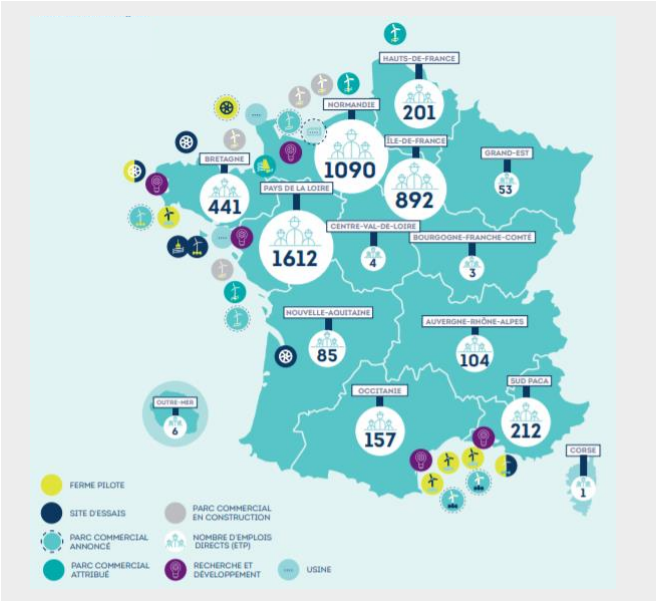
More than **90% of hires made in 2020 by large companies (VLEs) and mid-sized companies (MSCs) concern offshore wind**, three-quarters of which are for bottom-fixed wind. The enthusiasm of large companies demonstrates the maturity of the offshore wind industry and the confidence of businesses in the growth of the market.

Conversely, very small enterprises (VSEs) are not very present in bottom-fixed wind, in particular because of the high capital requirements to enter the industry. VSEs are more geared towards emerging sectors such as tidal power and wave energy, in which many innovations are brought about by start-ups.

Finally, SMEs have a strong presence in floating wind, which is a sign of the advances surrounding that technology.

Focus on the Observatory for Marine Energies (*Observatoire des énergies de la mer*)

Breakdown of FTEs in marine energy in France



Generally speaking, **FTEs are up in all regions**, particularly in **Pays de la Loire**. The region recorded the largest increase with an additional **507 FTEs (45%)**. **Normandy** has recorded a similar increase and therefore becomes the second French region for employment in MREs

Brittany and Île-de-France have also experienced significant increases.

These increases are mainly due to the boom in **bottom-installed offshore wind power**: with the onset of construction at the Saint-Nazaire and Saint-Brieuc offshore wind farms, but also, for instance, at the Cherbourg blade factory and the nacelle factory in Montoir-de-Bretagne.

Source: Observatory of marine energies 2021, C2 strategies for the French maritime cluster

The full report of the Observatory of Marine Energies is available online at www.merenergies.fr

Driving the industry forward

The industry is driven by a variety of stakeholders that can be grouped into 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-Atlantic and Mediterranean.

- PÔLE MER Bretagne Atlantique
- Technopole Brest-Iroise
- EMC2
- DERBI
- PÔLE MER Méditerranée
- Capenergies
- Tenerrdis

Clusters

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

- Cluster Maritime Français (the French Maritime Cluster)
- MEDEE
- Ouest Normandie Énergies Marines
- France Énergies Marines
- Neopolia
- Technocampus Ocean, West Atlantic Marine Energy Center
- Cluster Éolien Aquitain
- CEMATER

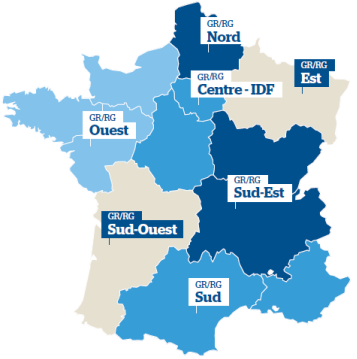
Other relevant actors

Professional unions and federations that, like France Énergie Éolienne, bring together wind industry professionals, including:

- FNTP
- FNTR
- UFL
- Cluster Maritime Français (the French Maritime Cluster)
- Gimélec
- EVOLEN
- SER

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).

Key:

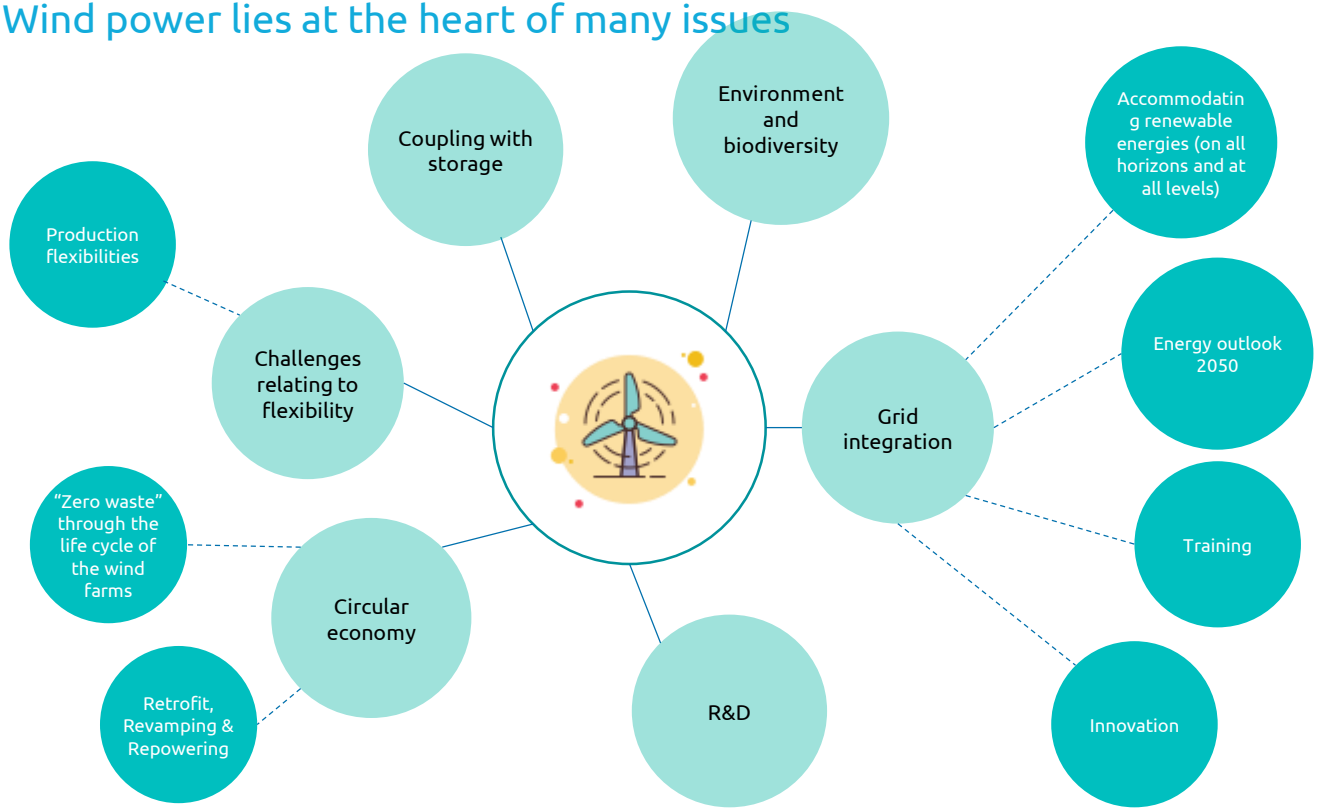
- *Competitiveness cluster*
- *Cluster*
- *Other relevant actor*
- *France Énergie Éolienne*

The major challenges of wind power between now and 2030

Capgemini invent | France Energie Eolienne

Overview of the key challenges

Wind power lies at the heart of many issues



The wind industry is ready to build a Wind Deal

Wind power is a key solution for France and Europe to address the environmental, social and economic challenges of the future

Beyond the emergency measures taken in the face of the COVID-19 crisis, it is crucial that the wind industry be included in the green economic recovery plan that is being considered by the French government, by proposing a Wind Deal within the broader context of the French and European Green Deal.

FEE PROPOSED MEASURES

For the wind industry

- Implementing **SDDR 2019, the ten-year network development plan** (*Schéma décennal de développement du réseau*)
- Appointing a **national co-ordinator for wind development**
- Introducing of **carbon taxing** with a price floor
- Supporting the expertise and competencies of French businesses in their key clusters, including the **French Tech**
- **Ceasing to add new constraints** to wind development

For onshore wind

- Optimising **spatial constraints** to release spaces
- Expediting the **renewal** of existing farms
- Ensuring the stability and predictability of **pricing and attribution mechanisms**
- Improving the effectiveness and compliance with promised delivery dates for the **appraisal process**
- Defining norms and standards at a European level in order to increase the industry's efficiency
- **Setting regional objectives and targets** for rolling out the PPE
- Supporting the **integration of wind power** in the grid and the European market thanks to innovation (digitalisation, automation)

For offshore wind

- **Massively recruiting staff and increasing the expertise** of the Directorate-General for Energy and Climate of the Ministry for the Ecological Transition
- **Planning the medium and long-term deployment** of offshore wind across all of France's seaboards, in accordance with the adoption of a long-term objective (2050), as set out by CiMER in January 2021.

Grid integration – 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 over 95% of the French mainland territory, 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 able to accomodate fives 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

Grid integration – at all levels

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

Local

At a local level, carrying out grid connection work, fostering **dialogue with local authorities** and contributing to the **consultation** phases of projects with a strong local component.

Regional

At a regional level, 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, and thanks to their day-to-day implementation.

Grid integration – at all levels

… as well as 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.

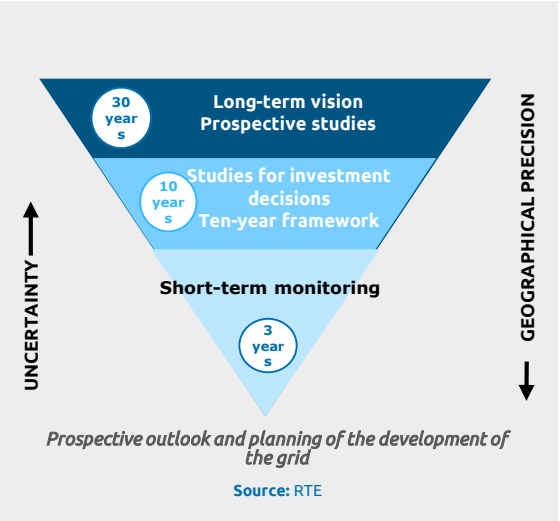
The initial prospective outlook is then gradually refined as further in-depth studies are conducted on the projects and **increasingly specific assumptions regarding the key determinants are taken into account.**

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 S3REnR (*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 a comprehensive study of the changing dynamics between power generation and use. **Its next long-term edition will run until 2050 and will study contrasting scenarios, in particular a scenario with a 100% renewable energy mix. These scenarios are largely drafted in a concerted manner.** In January 2021, RTE also published a joint study with IEA on the conditions required for a power system with a high share of renewables in France towards 2050.

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 **S3REnR** regional schemes are key to identifying and anticipating needs on the grid and thus realising the ambitions for renewable energy development set out by the region prefects on a ten-year forecast horizon (see the following pages for further details).



Prospective outlook and planning of the development of the grid

Source: RTE

Grid integration – 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 that has been 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:

- **3 years**: 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.
- **10 years**: it points out the main transport infrastructure that will have to be constructed or modified, and provides a timeline for these investment projects.
- **longer term**: the last edition, published in 2019, 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 needs for adaptation 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 broadly involved stakeholders in the drawing-up of the 2019 plan via a formal consultation that was organized in May 2018.

The SDDR is subject to approval by CRE. The French Energy Regulatory Commission (CRE)'s public consultation on the SDDR ended on June 8. CRE then deliberated in the summer of 2020 and declared itself in favour of the basic principles of the SDDR, which aim to optimize the costs of adapting the grid to the energy transition. In its analysis, it promotes the use of flexibilities, presented in the document.

France Énergie Éolienne stresses that the SDDR must make it possible to support the actors in the energy transition by providing a clear roadmap for the restructuring of the electricity grid over the long term.

Grid integration – 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 (in principle by 2030 for the next 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, in accordance with ordinance No. 2019-501, the prefects of each region will set the accommodation capacities of the new schemes, taking into account the national renewable energy development objectives defined by the PPE, the regional ambitions defined in the SRADDETs, as well as the development dynamic of renewable energies in the region, pursuant to the conditions defined by decree No. 2020-382 of March 31, 2020 and included in the French energy code.

RTE is already working with the regions to develop these new plans. Nouvelle-Aquitaine's revised scheme came into effect on 10 February 2021, following the approval of the *quote-part* financing by the Prefect. The revision work is continuing in many regions, especially in Grand Est, AURA, Provence-Alpes-Côte d'Azur and Bourgogne Franche-Comté, for which the various phases of public consultation took place in late 2020 and early 2021, the *quote-part* share being slated for approval in the first quarter of 2022. All the regions involved in the revision process now have objectives set by the prefect, with the exception of Pays de la Loire.

Pending the approval of the revised schemes, grid operators are to implement the scheme adaptations that will reduce the local overloads identified in the networks.

The S3REnRs are not sufficient to cover the full needs of the grid in order to accommodate renewable energies as major transmission and inter-regional structures are not included. Hence the need to implement the SDDR, which covers all the needs that would make it possible to achieve a grid designed for a diversified mix by 2025.

Grid integration – at all levels

To date, the 20 S3REnR schemes represent a grand total of 30.4 GW accommodation capacity of renewable energy across the country...

Key data for 2020

- Total accommodation capability reserved for renewable energies: 30.4 GW
- Total investment in the accommodation of renewable energies in the regional S3R schemes amount to €1,157m in infrastructure development and €308m in infrastructure enhancement.

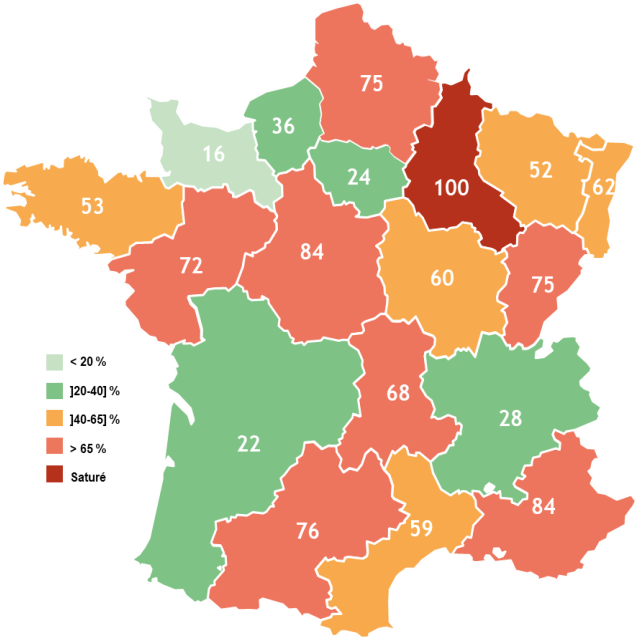
Total investment in the accommodation of renewable energies in the regional S3REnR schemes as of the end of 2020

- Works on the Enedis network: €267m spent on infrastructure development and €27m on infrastructure enhancement
- Works on the RTE network: €88m spent on infrastructure development and €113m on infrastructure enhancement

It should be recalled that the creation of the S3REnR are funded by producers through the "quote-part" mechanism: At the end of 2020, the monies spent by the grid operators for the S3REnR infrastructure development amount to almost twice the amounts perceived through the "quote-part" financing collected from producers (€483m vs. €276m).

Grid integration – at all levels

... Nevertheless, there are still significant disparities in the use of reserved allocation capacities as of mid-2021



Champagne-Ardennes: saturated since September 2020

Rapid growth in the number of projects being commissioned and developed: **+48%** over the course of a year in Alsace and **+25%** in Champagne-Ardenne and Languedoc-Roussillon

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Adaptations underway in 7 regions: PACA, Midi-Pyrénées, Rhône-Alpes, Languedoc Roussillon, Bretagne, Centre-Val de Loire and Hauts-de-France

Grid integration – at all levels

INSAS aims to speed up grid connection

A working group launched in 2018 within the Committee of users of the electricity transmission network (CURTE) on the **acceleration and anticipation of adaptations** to the grid that will be required for the development of renewable energies has led to the establishment of **INSAS** (the national instance for monitoring and improvement of S3REnR), which brings together the **federations of producers, grid 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*).** The aim of **INSAS** 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.

Several concrete achievements resulted from this WG and were placed under the responsibility of the national authority:

- **Launch of the construction of a collection platform for potential renewable energy sources**

This tool, which is currently being defined by RTE in close collaboration with DSOs and professional federations, will collect information regarding potential renewable energy sources to be integrated over the course of the development and life of the S3REnRs. The data will directly proceed from producers, while respecting the level of confidentiality that they will have defined themselves. **This tool will thus make it possible to improve the robustness of the wind resources included** and therefore the relevance of the necessary adaptations to the public networks.

- **Preparing 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. The decree of March 2020 also included the methods of financing for these studies in the framework of S3REnR. An operational procedure for the implementation of the anticipation of studies and administrative procedures is being finalized within INSAS.

- **Establishment of a working group on the opportunity to set up a new technical level on public grids**

The working group started working on global technical and economic analyses of new network structures **in order to assess the advisability of developing a new level to facilitate connecting renewable energies to the grid.**

Technical conditions for a power system with a high share of renewables

IEA–RTE report: intermediary deliverable on the technical feasibility preparing RTE's prospective study "Energy Futures 2050"

The study was commissioned in 2019 by the Ministry for the Ecological Transition and conducted together with IEA. It examines **the technical feasibility of energy mixes including high and very high shares of variable renewables**. The report outlines four strict cumulative conditions that the public policies must take into account should the choice be made to aim for a high share of renewable energies by 2050:

- **Evening out the variability of renewable energies,** which will require substantial sources of carbon-free flexibility, such as storage, peak generation units, demand-side flexibility, and so on.
- **Maintaining frequency**, which will involve developing new technical solutions that will have to be incorporated at the manufacturing stage of renewable energy generation infrastructure, as soon as very high instantaneous generation shares are achieved.
- **The ability to provide for reserves and margins** to managed the grid in real time.
- **Reconfiguring the power distribution transmission grid**, which will have to adapt to the changes in energy flows and the new location of power generation units.

The RTE-IEA report is available on rte-france.com

This study highlights the need for testing and large-scale deployment of technological solutions. The related industrial challenges will be commensurate to the share of renewable energies considered at that time horizon, but will imply in all scenarios an **ambitious roadmap binding both the public authorities and industry players**.

This publication marks an important milestone that forms part of a broader agenda aiming to draw up and compare long-term scenarios regarding the transformation of the electrical system in order to achieve carbon neutrality in 2050.

Main findings of the RTE-AIE study

A system based largely on renewables is technically viable under a set of stringent cumulative conditions

First-order technical conditions

1 Balancing the variability of renewables

The massive integration of variable renewable energies requires developing a combination of flexible solutions (interconnections, demand flexibilities, storage, hydrogen, etc.)

Challenges: **technical** (scaling up), **economic** (incorporating the cost of flexibilities to the full cost of renewable energies for an equivalent comparison of the service performed)

2 Largely reconfiguring the power distribution grid

The main lines of the French grid (north-to-south and east-to-west) should be resized starting in 2030, probably including greenfield developments

Challenges: **environmental and social** (area occupied by the power generation, network and storage)

Second-order technical conditions

3 Ensuring system stability

A system relying solely on wind power and photovoltaic energy is possible: there are solutions to maintain frequency, though some are still in the R&D phase.

Challenge: **technical** (R&D, scaleup)

4 Enhancing the operational reserves of the system

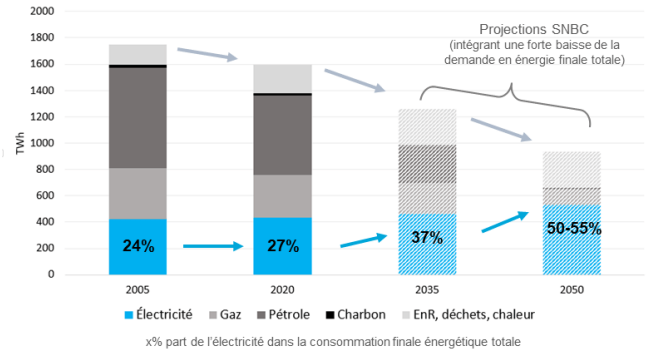
Improve the quality of renewable energy production forecasts and develop new solutions to mitigate uncertainty (for instance, electric car batteries)

Challenge: **technical** (R&D, scaleup)

“Energy Futures 2050”

RTE is pondering 2050 scenarios for its *Bilan prévisionnel* forecast in the course of a research and concertation program on an unprecedented scale

Consommation finale énergétique et part de l'électricité en France métropolitaine



Source: RTE

This study aims to describes the characteristics, challenges, and key milestones of the power systems compatible with **achieving carbon neutrality in 2050**. This will involve systematically switching from fossil fuels to carbon-free energies, especially in the transport, construction and industrial sectors.

Consistent with global and European scenarios, **the share of electricity in the overall energy mix is set to increase substantially**. In France’s case, the main challenges will be to increase the generation of carbon-free electricity, all the while gradually replacing power generation units that will reach end-of-life within the next thirty years.

The study compares **two major families of scenarios**: with or without new nuclear installations, which could lead to scenarios with power systems with 100% renewable energy sources by 2050. They will be supplemented by variations involving different assumptions regarding reindustrialisation, consumption, and hydrogen development for instance, as well as numerous sensitivity analyses.

The scope of the analyses are the result of an unprecedented “concertation” process that ended with a public consultation in the spring of 2021, for which more than 4,000 contributions by experts and citizens were received.

These results, which will be published in Autumn 2021, will be presented along four analytical dimensions: **technology, economics, environment, and society**.

Integrating renewables – Focus on hydrogen

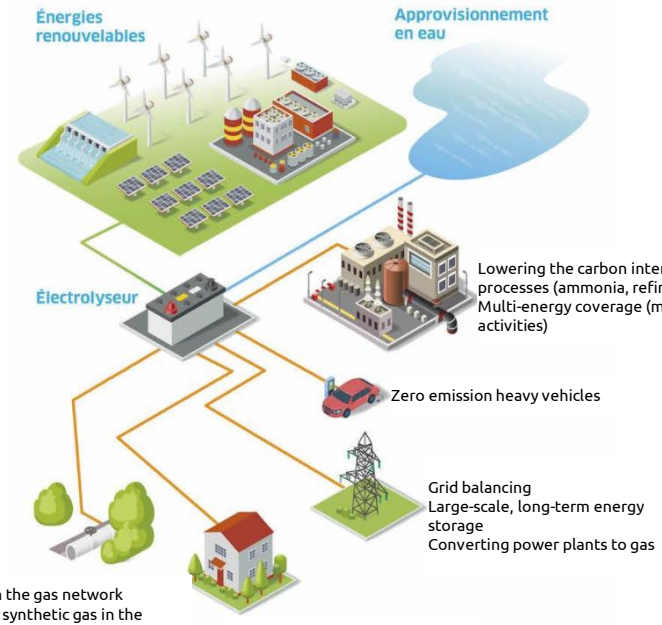
The wind power industry will be one of the key success factors for the development of a hydrogen industry in France

In the medium and long term, **wind farms will allow for the production of green hydrogen thanks to power generation by wind turbines.** This generation of carbon-free energy could foster the establishment of new factories throughout the country in the long run.

Daniel David, Mayor of Benet (Vendée)

"The wind and solar power that we generate could lead in time to fostering the creation of a hydrogen production industry. And ideally attract future plants fuelled with clean energy in France."

Value chain of the production of hydrogen from renewable energies



Sources: ENGIE

Grid integration – Innovation

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

Up to now, building a source substation has taken about 2 years (preceded by a 3 year period for administrative procedures). Enedis is committed to transforming the industrial process and conditions for the construction of source substations with the **Express Source Substation**, **a new industrial standard that halves the time needed for building source substations**.

The two principles of the Express Source Substation:

- **Modularity**: the modular nature of the Express Source Substation allows factory pre-construction of structural elements, parallel processes, accelerated assembly, and great flexibility.
- **Standardisation**: the streamlining of processes and quality control, as well as the standardisation of materials.

The Express Source Substation, a new industrial standard

The Express Source Substation is a **solution adapted to accelerated deployment in rural areas** and whose performance also depends on the conditions of the connection to the transmission grid.

Deployment

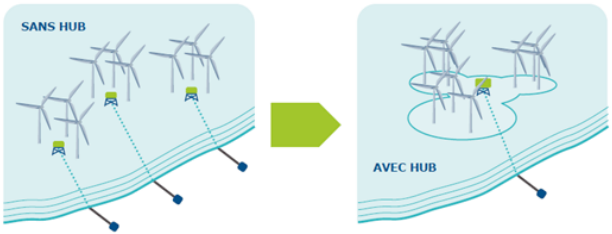
- After nine months of construction work, the first Express Source Substation was commissioned in July 2020 in **Montpison**, in Champagne-Ardenne
- **Monitoring by 2024:**
  - **15 Express Source Substations**
  - Which amounts to **1 out of 4 source substations**
  - And **1 out of 2 S3REnR source substations**

In order to achieve the deployment of **36 Express Source Substations by 2030**

Grid integration – Innovation

Building a new offshore grid to connect more than 10 GW of offshore wind power to the grid over the next 15 years

The objectives of the offshore wind energy sector are defined in the **Multiannual Energy Programming** (*Programmation Pluriannuelle de l'Énergie* – PPE). The corresponding decree was published in April 2020 and follows the **Energy-Climate law** adopted in November 2019. The French Government is showing its desire to accelerate the deployment of offshore wind power with an ambition to launch and award up to 1 GW per year in future projects. The projects awarded starting from 2024 will relate in particular to extensions of previous offshore wind farms with a shared grid-connection.



Means of optimising the connection of offshore wind farms to the grid

RTE is working towards the **ambitious development of renewable marine energies**.

- There are three ways to lower costs and stick to deadlines:
  - develop **pooled**, modular **platforms** (or "hubs") and diversify their use;
  - **adequately sizing of wind farm capacities**, in order to avoid threshold effects;
  - the standardisation of certain types of infrastructure to achieve economies of scale.
- These approaches depend in part on the government and illustrate the **need for long-term planning** (as savings of 15% on grid-connection costs for future calls for tenders are to be expected).

- In order to contribute to the collective reflections on the long-term maritime spatial planning, RTE is drafting **documents on the development perspectives of marine grids** for each of France's seaboards, in connection with ongoing public discussions. One such document was already produced for the Normandy coastline in 2020.

Grid integration – Innovation

A new scheme: alternative technical solutions allowing for feed-in curtailment

Alternative technical solutions (*offres de raccordement alternatives*, or ORA) to the reference technical solution act as leverage offered to producers seeking a connection to the grid. Indeed, the ministerial decree of 12 July 2021, pursuant to Article D. 342-23 of the French Energy Code, allows for requesting an alternative technical solution to the reference technical solution, aiming to reduce costs and/or achieve a faster set-up through lower investments in the grid infrastructure in exchange for occasional feed-in curtailment without financial compensation.

Principles

A producer submits a request for grid connection on the appropriate grid (transmission or distribution), the operator of which then conducts a study in order to establish a reference technical solution that could meet the requested connection capacity. In certain cases, such an alternative may require investments to address grid constraints.

At the request of the producer, the grid operator can offer an "alternative technical solution" (ORA – *offre de raccordement alternative*), which consists in a **connection with a faster set-up and/or a lower cost, in exchange for the possibility of feed-in curtailment, should constraints appear, in other words, when more power is generated** that can be disposed of by the grid, **without financial compensation**.

The implementing order issued by the Energy Minister regulates these new technical solutions in order to:

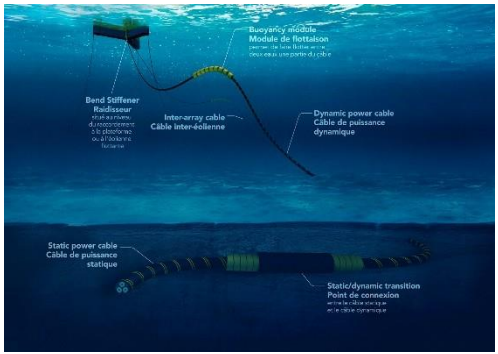
- Enable the grid operator to provide these offers under two cumulative conditions:
- A guaranteed output below the requested connection capacity; the difference between the two being under 30% (i.e. $P_{guaranteed} > 70\% P_{connection}$),
- A maximum amount of shaved-off power not exceeding 5% of the annual output of the facility
- Ensure that the full contractually unsecured feed-in capacity is kept below 1% of the aggregate capacity of renewables connected to the grid and to limit the amount of shaved-off power per year to 0.1% of output of the renewables connected to the grid concerned during the previous year.

Grid integration – Innovation

Supporting the promising development of floating offshore wind

Floating offshore wind, by eliminating the bathymetric constraint and allowing for the installation of wind farms at depths between 30 and 300 metres, emerges as a complementary technology to fixed-base wind, opening up huge amounts of untapped wind power potential at a global scale. **France has one of the largest seaboards in Europe, with the Atlantic and Mediterranean coasts being particularly windy and well-suited to floating offshore wind.**

In this respect, and in order to support the wind industry in developing this highly promising technology, **RTE is now engaged in R&D work focusing on addressing the last extant technological barrier**s and thereby developing increasingly optimal connection solutions.



To this end, RTE works primarily along **two main lines of R&D**:

→ **Floating offshore substations**:

- Relevant for deep sea conditions (>50–60 m);
- An opportunity to:
  - reduce the environmental impact of the connection;
  - Improve buy-in by other users of the sea and people living close by.
- Challenges remain, especially in terms of industrial development: anchoring systems, equipment, dynamic cables;

→ **Extra-high voltage (225 kV) dynamic cables**, capable of accommodating all movements, both sideways and vertical, of the floating wind turbine.

Grid integration – Innovation

Accelerate the energy transition by relying on local flexibilities and optimising the sizing of grids

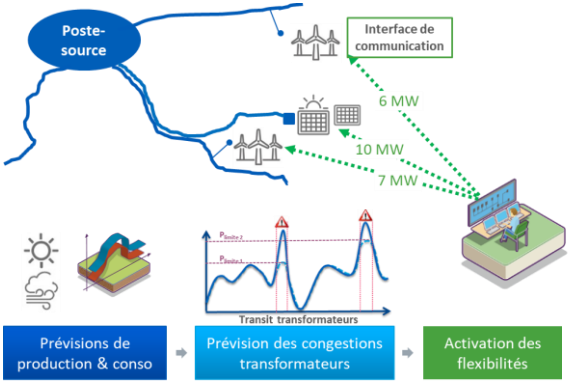
Optimising the sizing of S3REnR source substations accounts for the greatest potential source of value for flexibilities on the public distribution grid for the community. This is the purpose of the **ReFlex** project conducted by Enedis in association with RTE.

New sizing assumptions for source substations

When developing the S3REnRs, the transformers of the high voltage HTB/HTA source substations are currently sized to guarantee that a full 100% of the maximum feed-in power of the identified renewable energy resource can be evacuated. The **occasional activation of flexibilities** during periods of transit constraints linked to feed-in at the level of high voltage HTB/HTA transformer represents a significant **collective force to increase the accommodation capacity of** S3REnR **source substations** .

Flexibilities: calling upon the market

When the need for flexibilities will prove necessary, activations will be subject to **financial compensation** of the shaved-off power. **Calling upon the market** is the preferred approach, in order to compete with technically accessible and controllable load-shaving at a **well-defined and contained cost**.



2021 – launch of the experiment in two areas: the Somme and the Landes

- **Making available additional S3REnR capacities** on the source substations of the two experimental areas,
- **Continued close consultation** with external players on a **thematic basis**: Optimisation of S3REnR investments, market design, collation rules for flexibilities, or post-activation treatment of flexibilities,
- Preparing the calling upon the market for flexibility needs starting in 2023;

Towards an ambition to industrialisation starting in 2024

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 and have close links with stakeholders in the regions as well as 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:** €90m of Turpe 6's €160m from 2021 to 2024 **Enedis:** €144m of its €225m R&D budget from 2017 to 2020

Partnerships – what's new:

RTE:

- Access 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:

- Reinforced partnership with **Grenoble INP** on the integration of renewable energies, grid operation and training in SmartGrids professions.
- New partnerships with **the Interdisciplinary Institute of Artificial Intelligence (3IA)**, whose work could be structured around the integration of renewable energies and grid management.

CAP R&D – RTE's R&D roadmap

In 2020, RTE initiated a process to draw up an R&D roadmap for the next ten years. Indeed, over the past ten years, RTE has been actively discussing and upholding a number of prospective analyses, including **concerning the integration of renewable energies into the power grid.** Some of these considerations are reaching maturity, prompting RTE to update the objectives to be addressed in the future. Furthemore, the long-term challenges are changing: in addition to technical and economic performance, solidarity, climate, biodiversity, sobriety and resilience are now being considered.

RTE thus wishes to adopt a new roadmap that will guide its research activities and make it possible to respond to long-term challenges.

Method: work on RTE's R&D roadmap is shared and collaboratively undertaken within the framework of the Commission on system and network perspectives (CPSR – *Commission perspectives système et réseau*).

Deadline: summer 2021

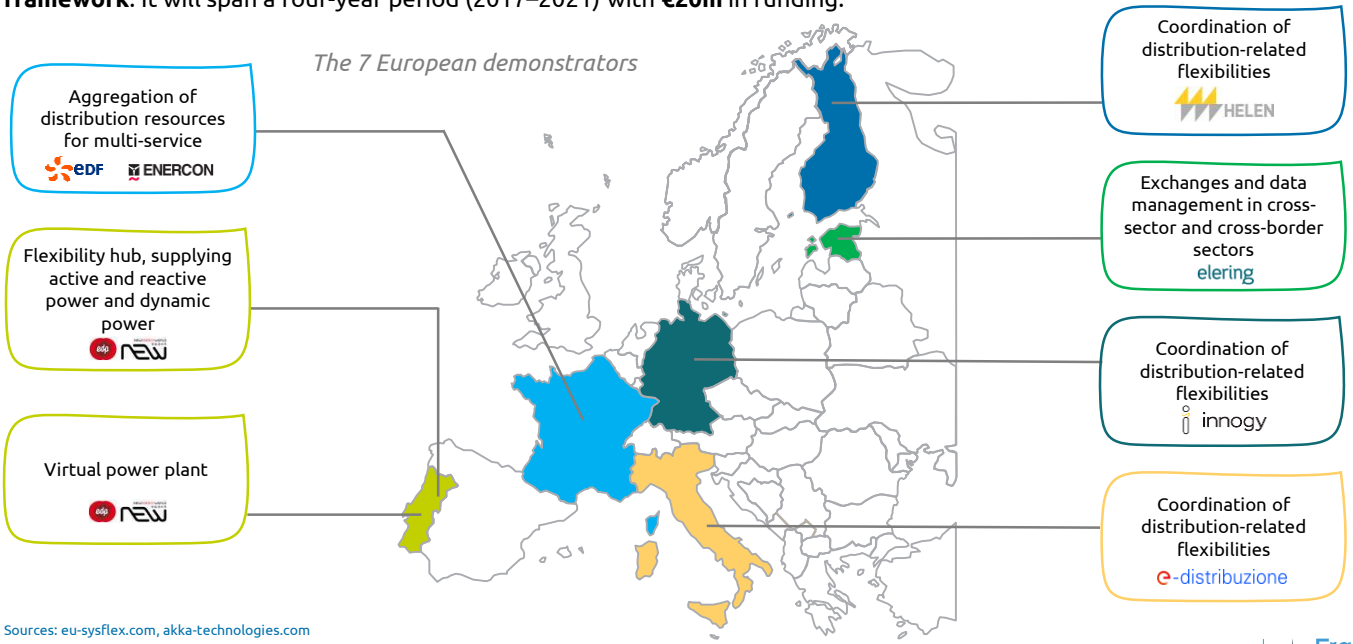
Grid integration – Innovation

Focus on: the BEST PATHS project

EU-SysFlex is a consortium of **34 members** including transmission and distribution operators, aggregators, and technology suppliers. They are present in **15 European countries**.

This project aims to issue **recommendations** on **developments in terms of market design** (mechanisms) and the **regulatory framework**. It will span a four-year period (2017–2021) with **€20m** in funding.

The 7 European demonstrators

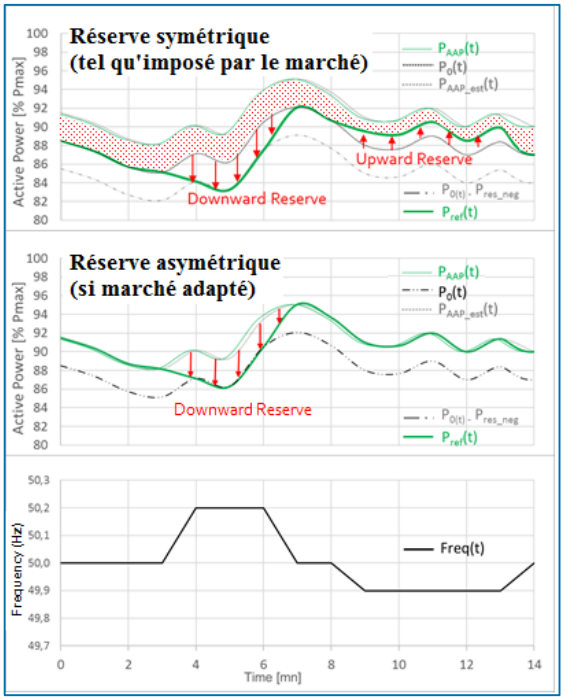


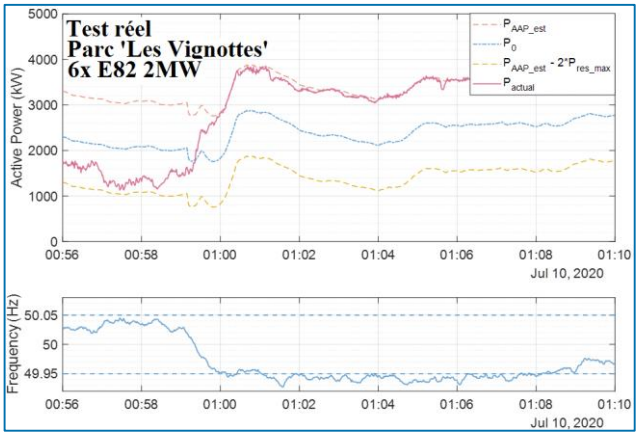
Sources: eu-sysflex.com, akka-technologies.com

Grid integration – Innovation

Focus on: the BEST PATHS project

Frequency Control Reserve (FCR) successfully tested on a wind farm





- The technical capacity of wind power to contribute to the Frequency Control Reserve (FCR) has been demonstrated (EU-SysFlex/Démo France project)
- The market must adapt in order to account for the specific requirements of renewable energies (symmetry of the FCR product, among others)

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. Over the 2020–2022 period, the key aims are 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, etc.), **new fields of intervention** (underwater links, high-voltage direct current links, etc.) **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 (close to Lyon) will receive several thousand trainees each year. Currently, more than 7,000 employees are already being trained yearly.

Since early 2021, the Jonage transformer campus will host replicas of HVDC conversation stations. With its strong external focus, it opens up new perspectives for the implementation of partnerships/collaborations with industrial firms, as well as the establishment of collaborative training courses on these technologies.

The transformation of the electrical system is leading RTE to avail itself of new competencies. The transformer campus addresses two key elements: staff training (in contact with high-level technical expertise), as well as opening to external partners (European transmission system operators, manufacturers, service providers, digital specialists, academics) to provide new collaborations in order to develop tools to help run the future grid and prepare the right skill sets to do so. The third direction followed by RTE concerns recruitment, with around 250 new staff hired every year. Data scientists and developers are now joining the ranks of engineers and technicians with a background in electrical engineering or engineering sciences. They are allowing RTE to prepare the jobs of tomorrow. These are related to topics such as manufacturing digitisation (control, signalling), cybersecurity, the increasing importance of HVDC technologies and power electronics, as well as the arrival of offshore wind farms.

Grid integration – Training

Enedis is bolstering the training of its staff in order to support the ecological transition.

Almost 90% of all renewable power generating units in France are currently connected to the grid managed by Enedis. In order to support the ecological transition and meet new customer and grid requirements associated with the transition, **Enedis is strengthening and adapting its staff training programmes**.

After early work carried out in 2020, Enedis is **now updating its training programmes related to planning and connection to the grid**, with almost **67,000 hours of training provided in its campuses**, including **2,150 hours entirely devoted to the energy transition.**

A section devoted to ***Design*** focuses on training related to the energy transition with a view to **revamping the training sequences** by incorporating the **new tools relating to grid development and alternative technical solutions with feed-in curtailment**, which was an ambition of Enedis' *Human and Industrial Plan*. In particular, Enedis proposes a **new intake route related to the activities of the 7 agencies in charge of connecting large production units to the grid**, beyond 250 kW (the *Agences Raccordement Grands Producteurs).*

Enedis reaffirms its commitment to learning and skills transfer within the company, the guiding thread of its 2020–2025 Human and Industrial Project – for example with the modernisation of the La Pérollière campus initiated in 2021.

High voltage grid and source substation management now has a training programme that is tailored to these new challenges, with special focus on **the forecast management of decentralized, intermittent power generation** (planning, programming and real-time): a skill set that now forms a **new profession**, that of "**Référent conduite**" (Grid Lead).

Challenges relating to flexibility

The use of production flexibilities is set to become widespread due to the increasing integration of renewable energies into the grid

Grid operators, in collaboration with producers, have examined the opportunity of resorting to real-time controllability of renewable energies in order to **optimise requirements for structural changes in the networks** by leveraging the proliferation of solar and wind power generation units in particular. Initial results suggest that, in certain cases, the **occasional activation of supply flexibilities** may alleviate the bulk of power grid upgrades required to accommodate renewable energies on three levels:

- **At the power transmission grid level**, by alleviating one-off congestion issues on lines and in transformers, thereby limiting the need for structural changes in the S3REnR schemes;
- **At the power distribution grid level**, by optimising transit in the transformers;
- **At the dedicated infrastructure level**, by optimising the sizing of the connections of renewable power generation units to the grid through alternative technical solutions using feed-in curtailment.

The benefit of occasionally making use of these production flexibilities would be twofold:

1. **material and economic gain**, by installing fewer transformers and shorter cable lengths and by using existing infrastructures as close as possible to their technical limits;
2. **saving time**, by reducing grid connection times for producers located near existing infrastructures which have residual reception capacities thanks to these flexibilities.

Source: Valuing production flexibilities to integrate renewable energies into electricity grids, UFE, FEE, SER, RTE, Enedis (2019)

Challenges relating to flexibility

Optimize performance

Using peak shaving controllers for renewable energy production – an economically-sensible choice that is conducive to the development of renewable energy

The NAZA (new adaptive zone programmable controllers) project is an ambitious project led by RTE in order to further optimize the existing infrastructure of the electrical grid.

These controllers will make it possible to optimize the contribution of renewable energies to the electrical system by decreasing power generation when necessary. All other things being equal, this increases the accommodation capacities of the distribution grid without delaying the implementation of key infrastructure.

"Zone controllers represent an essential building block of RTE's digitisation strategy, serving the energy transition They materialize our desire to shadow our physical infrastructure network with a digital network in order to optimize the use of the transmission network." Project manager at RTE

Over the next fifteen years, RTE plans to deploy **180 zone controllers**. This perspective is based on **experiments** that are currently being conducted in certain regions that are marked by significant development in wind power, such as Nouvelle-Aquitaine or Hauts-de-France. This strategy can reduce the required investment in distribution grids thanks to the strengthening of the digital backbone (information systems, digitisation of control and command in substations, strengthening of telecommunication links in strategic posts), which acts as a catalyst.

Key data

- **Dates:** Since 2017
- **Budget:** €120 million deployment cost (over the next 15 years)
- **Location:** experiments are underway in
  - Melle Longchamp (in the Niort/Poitiers/Limoges/Angoulême area)
  - Jalancourt (Côte d'Or)
  - €55m out of Turpe 5's €140m from 2017 to 2020
- **Update on the project:** the experiments make it possible to consider industrialising the solution in order to be able to deploy it throughout the country in areas with transit constraints.

Zone controllers will **support the energy and environmental transitions** and allow the transmission grid to be operated as close as possible to its limits without degrading the current level of risk.

Discussions concerning the contractual aspects of the use of such arrangements are being carried out alongside those concerning technical considerations.

"The arrival of the NAZA controllers will allow us to improve the management of the distribution network in areas where renewable energy development is strong as transit constraints are increasingly numerous there."
Account manager in the Operations department.

Challenges relating to flexibility

Optimize performance

RINGO – experimenting the services offered by a storage solution

The **RINGO** project aims to experiment with new flexibilities for the electricity system that will be necessary to accelerate the energy transition.

It proposes to experiment identifying "overflows" of renewable electricity and store them in stationary batteries in order to automatically manage the flows of electricity on the transmission grid.

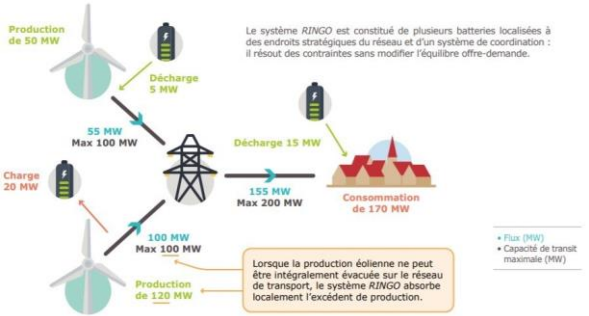
The RINGO project is structured around three pilot sites, the development of which is entrusted to three different groups of manufacturers experimenting with different technologies:

- Vingeanne in Côte d'Or (12 MW and 37 MWh) is being developed by NIDEC ASI. It was inaugurated in July 2021.
- Ventavon in the Hautes-Alpes (10 MW and 30.2 MWh) is being developed by Blue Solutions (Bolloré group), SCLE SFE and Engie Solutions
- Bellac in Haute-Vienne (10 MW and 30.8 MWh) is being developed by Saft and Schneider Electric

The aim of the project is to demonstrate the feasibility of using large batteries to automatically manage congestion due to peaks in renewable energy production and to build up expertise in operating with these batteries. During the large-scale deployment by independent investors, RTE will have capacity to accommodate, control, and thus take full advantage of these flexibility devices.

Key data

- **Dates:** Design phase: 2017-2019
  Construction phase: 2020-2022
  Experimentation phase: 2022-2024
- **Budget:** €80m
- **Location:** 3 sites in France
- **Project partners:**



Research and development (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.

Wind power in general

- Wind farm recyclability
- Acoustic improvements (serrations)

Onshore

- Forecasting of generation potential: LiDARs, short and medium-term simulation tools
- Managing variable and predictable energies
- Aerodynamic losses
- Interaction with radars
- Increase in rotor and mast size
- Lowering raw material costs

Offshore

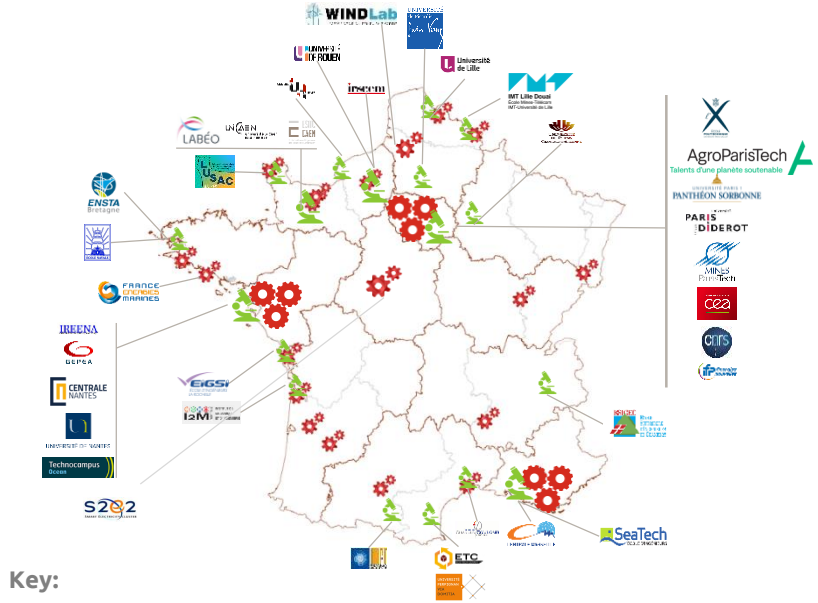
Growth strategy aimed at gaining market share by designing the wind power systems of the future (including floating offshore turbines)

- Combination of Naval / Oil & Gas expertise
- Marine structures and conditions
  Impact of foundations
- Ageing of materials
- Simulation tools
- Analysis of coupled phenomena, requiring testing resources

R&D activities **bring together both public and private operators for collaboration on research projects**. In particular, thanks to a €100 billion budget earmarked in the recovery plan (including €20 billion for the "Investing for the Future Program" No. 4), which was launched in January 2021 and planner will run between 2021–2025), part of which is earmarked for the energy transition, **ADEME acts as a significant catalyst by reducing the risk** of projects at the demonstrator stage through funding.

Research and development (R&D)

Mapping of R&D players



Coupling with storage

Renewable energy storage solutions are a key issue for tomorrow's electricity mix

On April 23, 2020, France adopted a new energy climate strategy. **The PPE for the 2019–2023 and 2024–2028 periods** was thus published in the French official gazette. **Storage is mentioned** without nevertheless drawing up a precise roadmap despite how key it is in supporting the development of renewable energies.

In 2023, electricity from renewable sources should represent 27% of electricity production and 33 to 36% by 2028. However, as repeated in the PPE: "Within the time frame of the PPE, which ends in 2028, the penetration of renewable energies and changes in the power mix set by this PPE will **not require any additional storage needs to ensure the balance between supply and demand**."

And though the PPE identifies **hydrogen as "the most promising means of mass inter-seasonal storage of intermittent renewable electrical energies"**, the text postpones its development to 2035 or even 2040. We would have to wait "beyond 2030–2035" for hydrogen to contribute to the integration of renewable energies into the electricity system. **Nevertheless, the first projects are emerging and the sector of coupling renewable energy production with storage is currently being organised**.

The various types of storage

- Mechanical storage (compressed air)
- Electrochemical storage (batteries)
- Chemical storage (hydrogen, ammonia)
- Electrical storage (condensers)
- Thermal storage

Source: ease-storage.eu

Making the industry biodiversity-friendly

Biodiversity conservation is a priority area for the wind industry during the course of the development and operation of wind farms, but also for research & development

Recognising the fact the wind power development is both a **cornerstone of the energy transition and a vector for potential impacts on biodiversity**, wind farm developers and operators are working with conservation charities and environmental organisations to ensure a **more harmonious development of wind power in France**.

When a new wind farm is installed, many measures are taken in order to **protect biodiversity and lessen the impact of wind turbines, especially on bats and birds**.

The wind industry pays due attention to **accompanying measures** (installing nesting boxes, human-assisted spread, funding warning beacons) **in addition to the regulatory measures** following the ARO sequence (Avoid / Reduce / Offset).

Either individually or through industry organisations, the wind power industry has already funded hundreds of research and development projects and theses on the knowledge and technologies that are being developed.

In 2020, the multi-stakeholder, collaborative research project on “Reducing Bird Mortality in Operating Wind Farms”, also known as Project MAPE, was launched. This project, funded over 3 years (2020–2023) by public and private actors, brings together for the first time all stakeholders concerned by the issue, thanks to an innovative approach instigated by MSH SUD (*Maison des Sciences de l’Homme*).

Making the industry biodiversity-friendly

Focus on the Saint-Arnac wind farm in Fenouillèdes, a power generation unit supporting local biodiversity

As part of the development of this 11-turbine wind farm, Valeco desired to make this project an outstanding example in terms of environmental integration. To do so, it undertook to implement support measures both at the site of the wind farm and at the scale of the intermunicipality. The Massif de la Tourèze, where the wind farm is located, is a ZPS-Natura 2000 designated area (a "special protection zone") and an appealing habitat for the Bonelli's eagle.

A **€575,000 investment** in the Fenouillèdes wind farm to tackle the threats on the loss of critical natural habitats for local biodiversity

In 2020, a set of actions were implemented, working in partnership with the Natural Spaces Conservatories (CEN), the Regional Natural Parks (PNR), the Chamber of Agriculture, the National Hunting Federation, the Association de défense du Massif de la Tourèze, the approved communal hunting associations, the municipality of Latour-de-France, and ENEDIS:

- **Restoring over 230 hectares** of mosaics of *garrigue* scrubland and dry grasslands (favoured habitats of the Bonelli's eagle). This action is an addition to maintaining open heathland recreated by a flock of sheep, which contributes to the regulation of plant growth.
- **Identify and secure almost 15 km of medium-voltage power lines (which are completely unrelated to the buried grid of the wind farm) that are hazardous** to birds of prey. This approach eliminated the risk of electric shock associated with power transmission towers.

In the medium and long term, these measures will result in:

- **an increase in flora and fauna diversity**
- **a significant decrease in the risk of incidental bird mortality**
- **an enhancement of the biological cycle** of a multitude of threatened species, which are emblematic of open environments.

Circular economy

The entire process for managing the end of life of the facilities (disassembly, recycling) is vested in the operator

Wind farm end-of-life management operations are strictly **regulated by law* (AMPG ministerial decrees – *arrêté ministériel de prescriptions générales*)** and include **the entire process of disassembly and recycling** of component waste:

- The **disassembly** of the power generation installations, substations, as well as the cables within a radius of ten metres around the wind turbines and the substations must be carried out.
- **The foundations must be "fully excavated** down to the base of their footing, with the exception of any piles" and replaced by soil with **comparable characteristics** to the soil in place near the installation.
- **The regrading of crane areas and access roads must be filled** with soil of comparable characteristics to that of the soil near the installation
- **Recycling obligations have been laid down**: from 1 July 2022, at least **90% of the total mass of the wind turbines have to be recycled or reused**, including foundations (or 85% when the total excavation of foundations is the subject to derogation granted by the Prefect), as well as **at least 35% of the mass of the rotors**.

Likewise, recyclability obligations are also provided for by the AMPG Ministerial Decree of 22 June 2020: for permission applications filed from 2023 and gradually until 2025, **the reuse and recyclability rates will be increased up to 95% of the total mass of the wind turbines (including foundations) and up to 55% of the mass of the rotors.**

Wind turbines are facilities classified for environmental protection (ICPE), which requires that the issue of dismantling be fully anticipated. **In the event that an operator defaults on its obligations, which has never happened in France to date, site restoration operations will be covered by operational financial guarantees, prior to the commissioning** of the site and set at €50,000 per 2 MW wind turbine and €10,000 per additional MW when the unit capacity is greater than 2 MW.** The arrangements for constituting the operational financial guarantees are laid down by the French Environmental Code.

"Waste resulting from demolition and dismantling is reused, recycled, recovered, or, failing that, eliminated through the channels duly authorised for this purpose".

*Article R. 553-6 of the French Environmental Code (Decree of 26 August 2011, modified on 6 November 2014) – Decree of 22 June 2020, published in the French official gazette on 30 June 2020 entered into force on 1 July 2020

** The first disassemblies carried out in France confirms this estimate

Source: French Environmental Code

Circular economy

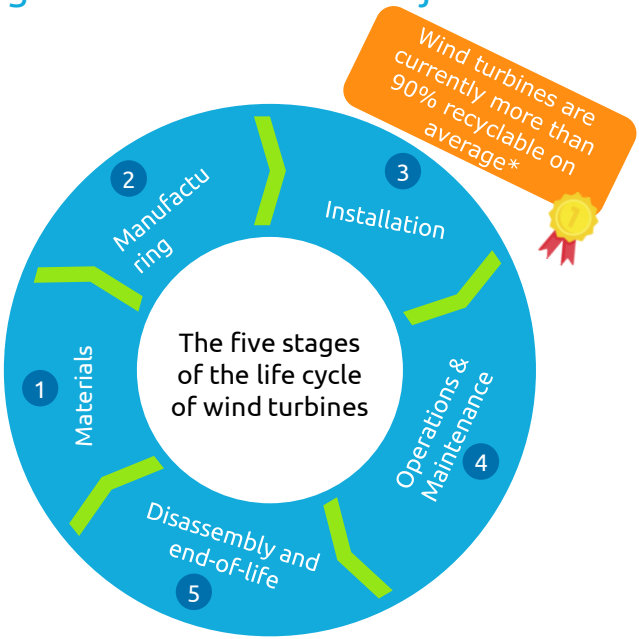
Several wind turbine manufacturers are aiming for a "zero waste" objective and carbon neutrality across their value chain

Manufacturers are also committed to becoming carbon neutral. This requires establishing a strategy based on:

1. Increasing energy efficiency in factories
2. Supplying offices and factories with renewable electricity
3. Renewing the service fleets from thermal to electric vehicles and use of low CO2 emissions transport (sea freight, rail)
4. Increase the recyclability of wind turbines

Several manufacturers have made strong commitments to reduce the environmental impact of wind projects. In order to quantify the environmental cost of the wind farms, these companies carry out **life cycle analyses (LCAs)** in order **to identify, for each link in the value chain, the associated CO_2 emissions and to reduce them as much as possible** (see the figure opposite). This requires innovative processes, new working methods and a **roadmap that defines precise reduction targets to be achieved by 2030 and then 2050**.

For example, manufacturers are committing to designing **zero-waste wind turbines by 2040** and to improve their production processes in order to use parts that can be recycled or are less energy-intensive.



Manufacturers committed to design a **zero-waste** wind turbine by 2040

Source: FEE
* The Suez Group has achieved a rate of 98% on the dismantling at Port-La-Nouvelle.

Circular economy

Repowering, revamping, retrofit: an overview

There are 3 categories of wind farm renewal:

Heavy maintenance (**retrofit**), which consists in the **replacement of certain components** of the wind turbine (blades, generator, and so on) in order to modernize it. This makes it possible to extend the life of wind farms by using newer equipment, as long as the **overall configuration and dimensions remain the same**.

Revamping: consists in **replacing certain components** of the wind turbine. This replacement goes hand in hand with **modifications to the main features of the installation** (wind turbine dimensions, generation capacity, etc.).

Repowering: consists in **completely or partially replacing the installation**, with a view to improving its performance. It therefore leads to **changes in the main features of the installation** (wind turbine dimensions, generation capacity, wind farm size, locations, etc.).

Repowering has many objectives:

Increasing power generation capacity on site both in absolute terms and thanks to more modern components that are capable of harnessing the force of the wind more efficiently.

Extending the life of a wind farm by replacing certain components that deteriorate faster than others or **establishing a new, more efficient wind farm** using the latest technologies available.

Reduce operating costs linked to maintenance thanks to the use of more reliable and modern equipment.

According to ADEME, **the installed wind power capacity that could be gained by 2030** by replacing existing wind turbines with more powerful ones **is estimated at more than 5 GW**.

Source: Enerfip, Capgemini Invent

Circular economy

Focus on the Rivesaltes wind farm – the oldest in Pyrénées-Orientales

The **Rivesaltes wind farm** was the very first to be commissioned in the Pyrénées-Orientales department, almost **20 years ago**. The **repowering** operations have now started and aim to **replace existing turbines with ones that are more powerful, more efficient, and more environmentally friendly**. In 2021, the focus is only on dismantling the upper parts of the turbines. The parts below ground will be dismantled starting in 2022.

	Current wind farm	Upcoming wind farm
Wind turbines	8	**6 (-2 turbines)**
Installed wind farm capacity	7.6 MW	**9.9 MW (+ 2.3 MW)**
Electricity use of	6,500 people	**11,600 people (+5,100 people)**

95% of all materials will be recycled.

The concrete will be crushed and used for grading, the steel from the masts will be melted down to form new parts, and the nacelle will be used in a retrofit. Concerning the rotor blades, they can be reused to manufacture street furniture.

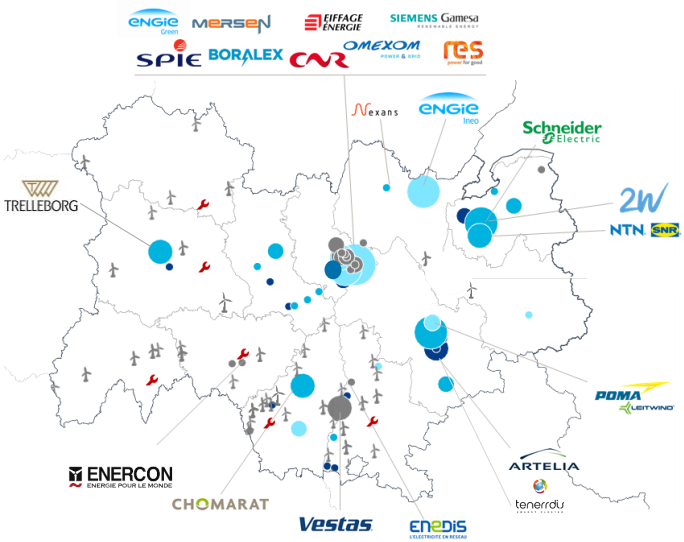
Source: france3-régions & energies-renouvelables.geg.fr

Appendixes

Appendixes

A. The wind industry: regional maps

Auvergne-Rhône-Alpes



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

- Wind farm
- Maintenance facility
- Regional wind capital (FTEs)

NB: Non-exhaustive list of logos
Multisite companies

Key figures on the wind industry in the region

2,095 jobs
+11% compared to 2019

650 MW installed	≃	**1%** of the region's power output	**€7.5m** in tax revenue for regional and local authorities*

**Based on the following calculation: 1 MW corresp. to approx. €12,500 € in tax revenue*

Distribution of jobs on the value chain:*

Planning & Design	Component manufacturing	Engineering & Construction	Operations & Maintenance
415	700	580	400

Top manufacturers (MW)

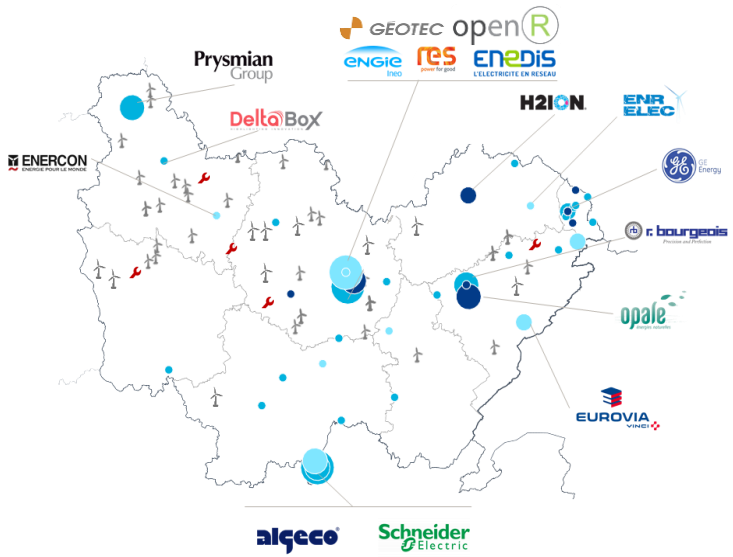
Vestas
ENERCON ENERGIE POUR LE MONDE
POMA LEITWIND

Top developers/ operators (MW)

BORALEX
eole RES L'énergie à l'infini
INNERGEX

** As estimated based on data provided by the industry*

Bourgogne–Franche-Comté



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

Wind farm

Maintenance facility

NB: Non-exhaustive list of logos
Multisite companies

Key figures on the wind industry in the region

865 jobs
+8% compared to 2019

862 MW installed ≃ **2%** of the region's power output | **€10.7m** in tax revenue for regional and local authorities*

**Based on the following calculation: 1 MW corresp. to approx. €12,500 € in tax revenue*

Distribution of jobs on the value chain:*

Planning & Design	Component manufacturing	Engineering & Construction	Operations & Maintenance
190	480	180	15

Top manufacturers (MW)

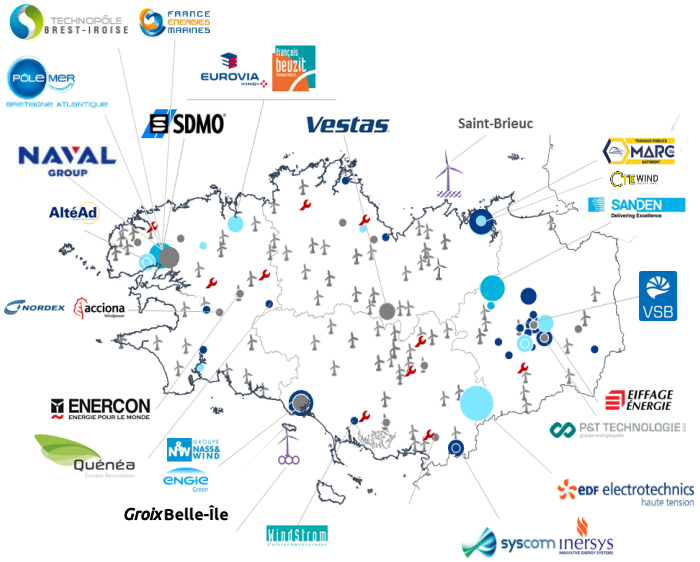
ENERCON ENERGIE POUR LE MONDE
NORDEX
acciona
SIEMENS Gamesa RENEWABLE ENERGY

Top developers/ operators (MW)

wpd think energy
eole res L'énergie à l'infini
VSB

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

Brittany



- 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

NB: Non-exhaustive list of logos
Multisite companies

Key figures on the wind industry in the region

1,050 jobs
+11% compared to 2019

1,071 MW installed	≃	**2%** of the region's power output	**€13.4m** in tax revenue for regional and local authorities*

**Based on the following calculation: 1 MW corresp. to approx. €12,500 € in tax revenue*

Distribution of jobs on the value chain:*

Planning & Design	Component manufacturing	Engineering & Construction	Operations & Maintenance
380	155	340	175

Top manufacturers (MW)

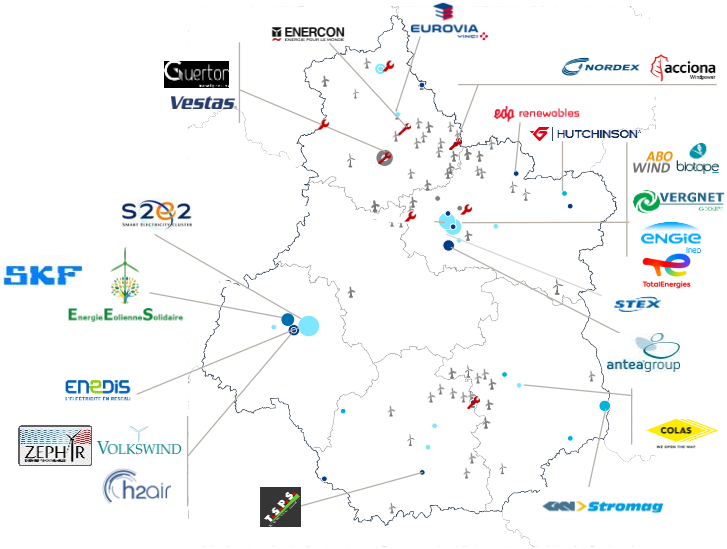
NAVAL GROUP
Vestas
ENERCON ENERGIE POUR LE MONDE

Top developers/ operators (MW)

ENGIE Green
VSB
P&T TECHNOLOGIE

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

Centre-Val de Loire



- 1. Planning & Design
- 2. Component manufacturing
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- 4. Operations & Maintenance

Wind farm

Maintenance facility

NB: Non-exhaustive list of logos
Multisite companies

Key figures on the wind industry in the region

580 jobs
+18% compared to 2019

1,305 MW installed ≃ **3%** of the region's power output | **€16.3m** in tax revenue for regional and local authorities*

**Based on the following calculation: 1 MW corresp. to approx. €12,500 € in tax revenue*

Distribution of jobs on the value chain:*

Planning & Design	Component manufacturing	Engineering & Construction	Operations & Maintenance
175	80	210	115

Top manufacturers (MW)

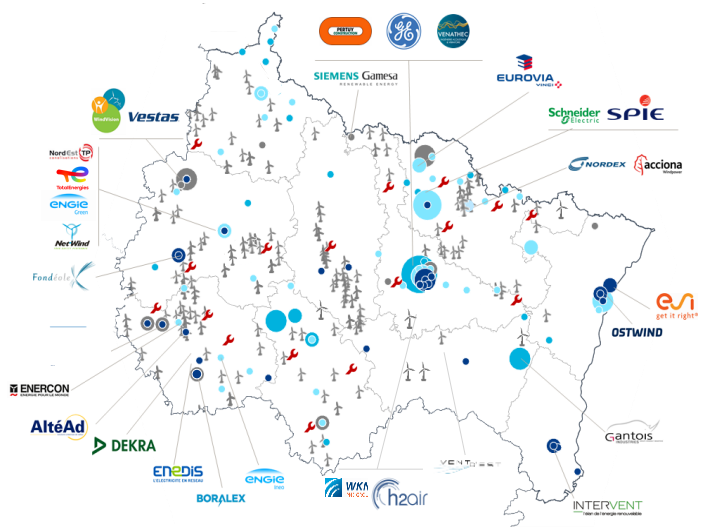
VERGNET GROUPE
Vestas
NORDEX
acciona

Top developers/ operators (MW)

VOLKSWIND
ABO WIND
TotalEnergies

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

Grand Est



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

Wind farm

Maintenance facility

NB: Non-exhaustive list of logos
Multisite companies

Key figures on the wind industry in the region

1,640 jobs
+3% compared to 2019

3,861 MW installed ≃ **8%** of the region's power output | **€48.3m** in tax revenue for regional and local authorities*

**Based on the following calculation: 1 MW corresp. to approx. €12,500 € in tax revenue*

Distribution of jobs on the value chain:*

Planning & Design	Component manufacturing	Engineering & Construction	Operations & Maintenance
410	350	600	280

Top manufacturers (MW)

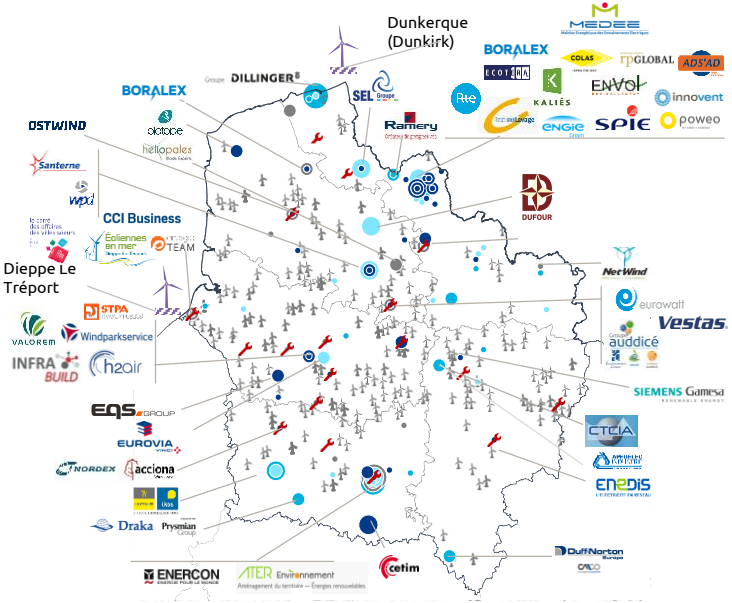
Vestas
ENERCON ENERGIE POUR LE MONDE
NORDEX
acciona Windpower

Top developers/ operators (MW)

ENGIE Green
OSTWIND
INTERVENT l'élan de l'énergie renouvelable

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

Hauts-de-France



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

Wind farm

Maintenance facility

NB: Non-exhaustive list of logos
Multisite companies

Key figures on the wind industry in the region

2,140 jobs
+2% compared to 2019

4,867 MW installed ≃ **10%** of the region's power output | **€61m** in tax revenue for regional and local authorities*

**Based on the following calculation: 1 MW corresp. to approx. €12,500 € in tax revenue*

Distribution of jobs on the value chain:*

Planning & Design	Component manufacturing	Engineering & Construction	Operations & Maintenance
490	390	700	560

Top manufacturers (MW)

ENERCON ENERGIE POUR LE MONDE
Vestas
NORDEX acciona

Top developers/ operators (MW)

BORALEX
ENGIE Green
h2air

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

Île-de-France

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

Wind farm

Maintenance facility

NB: Non-exhaustive list of logos
Multisite companies

Key figures on the wind industry in the region

6,080 jobs
+13% compared to 2019

88 MW installed	≃	**0%** of the region's power output	**€1.1m** in tax revenue for regional and local authorities*

**Based on the following calculation: 1 MW corresp. to approx. €12,500 € in tax revenue*

Distribution of jobs on the value chain:*

Planning & Design	Component manufacturing	Engineering & Construction	Operations & Maintenance
3,080	700	1,420	880

Top manufacturers (MW)

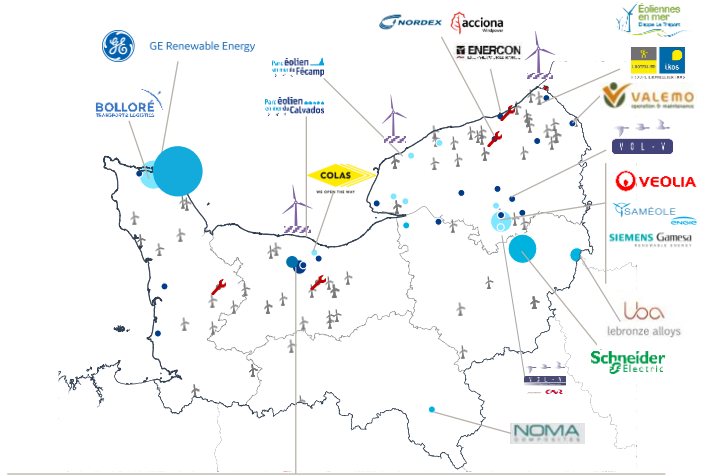
NORDEX
acciona
GE Renewable Energy
Vestas

Top developers/ operators (MW)

edf renouvelables
ENGIE Green
ENERTRAG

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

Normandy



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

Wind farm

Maintenance facility

NB: Non-exhaustive list of logos
Multisite companies

Key figures on the wind industry in the region

1,065 jobs
+17.2% compared to 2019

859 MW installed	≃	**2%** of the region's power output	**€10.7m** in tax revenue for regional and local authorities*

**Based on the following calculation: 1 MW corresp. to approx. €12,500 € in tax revenue*

Distribution of jobs on the value chain:*

Planning & Design	Component manufacturing	Engineering & Construction	Operations & Maintenance
160	630	210	65

Top manufacturers (MW)

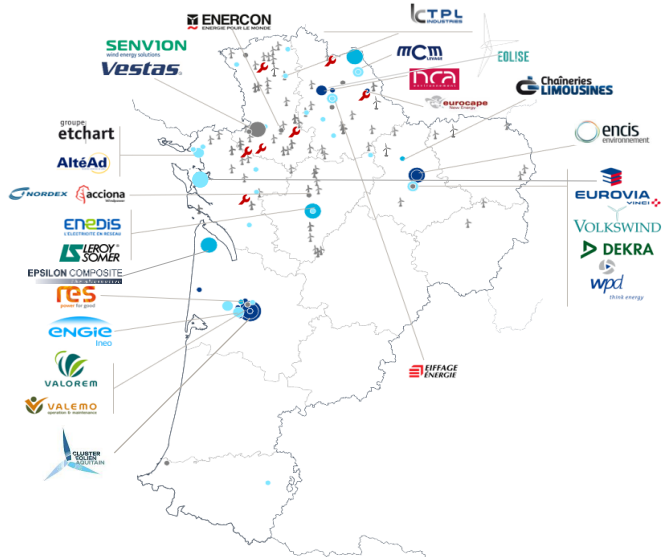
ENERCON ENERGIE POUR LE MONDE
NORDEX
acciona
SIEMENS Gamesa RENEWABLE ENERGY

Top developers/ operators (MW)

SAMEOLE
ENGIE Green
énergie environnement

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

Nouvelle-Aquitaine



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

Wind farm

Maintenance facility

NB: Non-exhaustive list of logos
Multisite companies

Key figures on the wind industry in the region

1,140 jobs
+3% compared to 2019

1,168 MW installed ≃ **2%** of the region's power output | **€14.6m** in tax revenue for regional and local authorities*

**Based on the following calculation: 1 MW corresp. to approx. €12,500 € in tax revenue*

Distribution of jobs on the value chain:*

Planning & Design	Component manufacturing	Engineering & Construction	Operations & Maintenance
295	155	460	230

Top manufacturers (MW)

Vestas
ENERCON ENERGIE POUR LE MONDE
noveol L'ÉOLIEN VISIBLEMENT INNOVANT

Top developers/ operators (MW)

VOLKSWIND
wpd think energy
3D ENERGIES

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

Occitanie

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

Wind farm

Maintenance facility

NB: Non-exhaustive list of logos
Multisite companies

Key figures on the wind industry in the region

2,090 jobs
+7.1% compared to 2019

1,659 MW installed ≃ **3%** of the region's power output | **€20m** in tax revenue for regional and local authorities*

**Based on the following calculation: 1 MW corresp. to approx. €12,500 € in tax revenue*

Distribution of jobs on the value chain:*

Planning & Design	Component manufacturing	Engineering & Construction	Operations & Maintenance
925	180	500	485

Top manufacturers (MW)

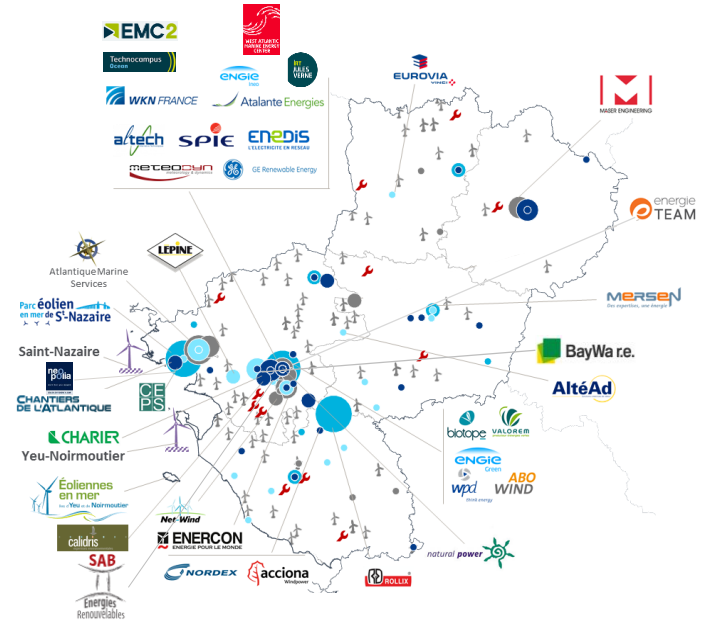
Vestas
ENERCON ENERGIE POUR LE MONDE
VERGNET GROUPE

Top developers/ operators (MW)

edf renouvelables
ENGIE Green
valeco

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

Pays de la Loire



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

Wind farm

Maintenance facility

NB: Non-exhaustive list of logos
Multisite companies

Key figures on the wind industry in the region

2,245 jobs
+21% compared to 2019

1,059 MW installed	≃	**2%** of the region's power output	**€13.2m** in tax revenue for regional and local authorities*

**Based on the following calculation: 1 MW corresp. to approx. €12,500 € in tax revenue*

Distribution of jobs on the value chain:*

Planning & Design	Component manufacturing	Engineering & Construction	Operations & Maintenance
510	590	415	730

Top manufacturers (MW)

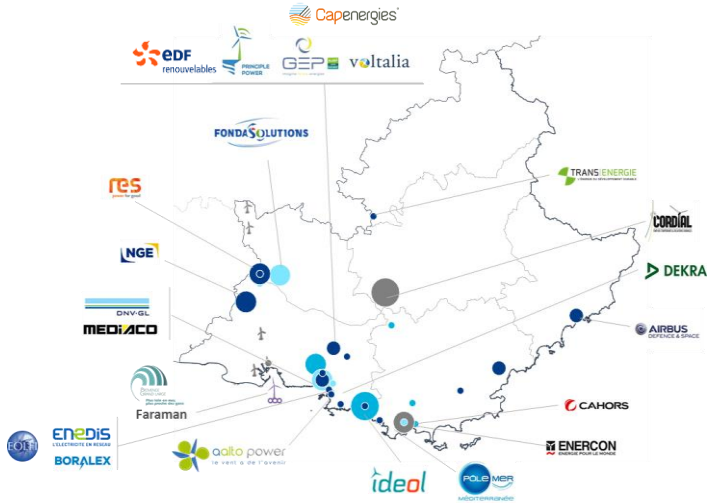
GE Renewable Energy
ENERCON ENERGIE POUR LE MONDE
NAVAL GROUP

Top developers/ operators (MW)

energie TEAM
BayWa r.e.
WKN FRANCE

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

Provence-Alpes-Côte d'Azur



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

Wind farm

Maintenance facility

NB: Non-exhaustive list of logos
Multisite companies

Key figures on the wind industry in the region

780 jobs
+12% compared to 2019

121 MW installed ≃ Less than **1%** of the region's power output | **€1.5m** in tax revenue for regional and local authorities*

**Based on the following calculation: 1 MW corresp. to approx. €12,500 € in tax revenue*

Distribution of jobs on the value chain:*

Planning & Design	Component manufacturing	Engineering & Construction	Operations & Maintenance
310	140	270	60

Top manufacturers (MW)

IDSUD ENERGIES
Eole System

Top developers/ operators (MW)

eole res
voltalia
juwi

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

Appendixes

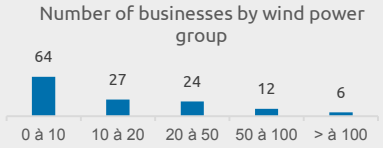
B. Participants in the wind industry by category

Value chain participants, by category

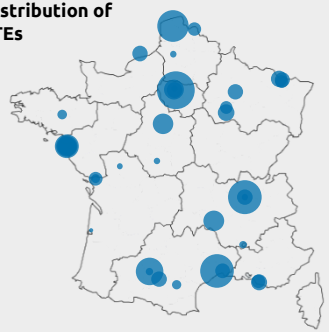
Developer and/or operator

Wind power jobs

- Total wind power jobs: 4,548
- Number of businesses: 133

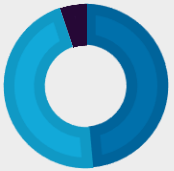


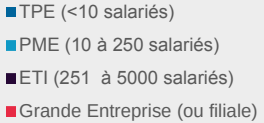
Distribution of FTEs



Typical profile

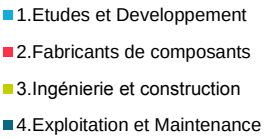
- Majority business type: VSE
- Average creation date: 2004





Wind power jobs

Distribution of wind jobs:



Top 10 wind employers

1. EDF renouvelables	2. ENGIE Green	3. BORALEX	4. wpd think energy	5. valeco
6. res power for good	7. voltalia	8. edp renewables	9. BayWa r.e.	10. VSB énergies nouvelles

Value chain participants, by category

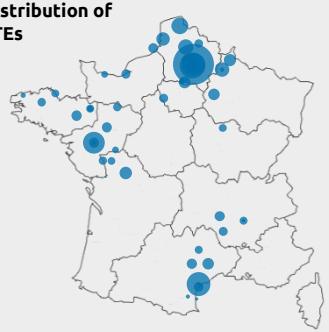
Turbine manufacturer and maintenance

Wind power jobs

- Total wind power jobs: 3,050
- Number of businesses: 25

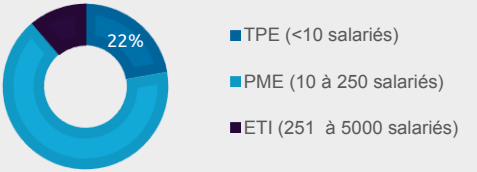
Number of businesses by wind power group

Distribution of FTEs



Typical profile

- Majority business type: SME
- Average creation date: 2007



Wind power jobs

Distribution of wind jobs:

Top 10 wind employers

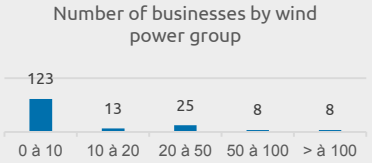
1. ENERCON	2. GE Renewable Energy	3. Vestas	4. SIEMENS Gamesa RENEWABLE ENERGY	5. NORDEX / acciona Windpower
6. NAVAL GROUP	7. VERGNET GROUPE	ENO ENERGY	9. IDSUD ENERGIES	10. POMA / LEITWIND

Value chain participants, by category

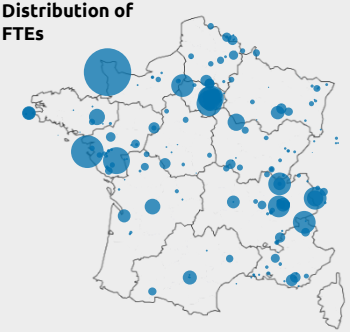
Component manufacturer

Wind power jobs

- Total wind power jobs: 3,990
- Number of businesses: 190

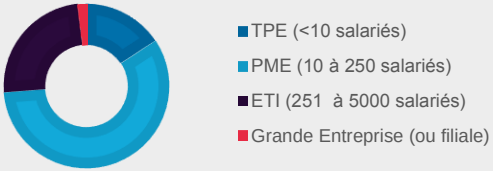


Distribution of FTEs



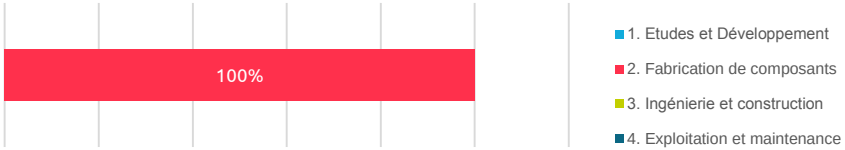
Typical profile

- Majority business type: SME
- Average creation date: 1985



Wind power jobs

Distribution of wind jobs:



Top 10 wind employers

1. Schneider Electric	2. LM WIND POWER a GE Renewable Energy business	3. GE Renewable Energy	4. Chantiers de l'Atlantique	5. ROLLIX
6. GE Grid Solutions	7. HUTCHINSON	8. DILLINGER FRANCE	9. SDMO	10. MERSEN

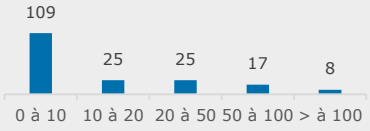
Value chain participants, by category

Civil or electrical engineering / Logistics

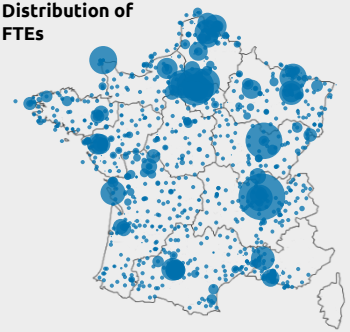
Wind power jobs

- Total wind power jobs: 5,300
- Number of businesses: 184

Number of businesses by wind power group

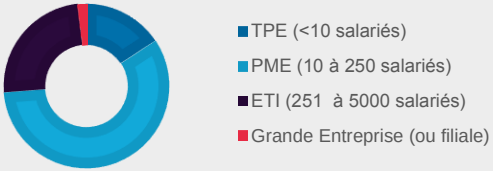


Distribution of FTEs



Typical profile

- Majority business type: SME
- Average creation date: 1999



Wind power jobs

Distribution of wind jobs:

Top 10 wind employers

1. Enedis	2. Engie Ineo	3. RTE	4. Omexom	5. SPIE
6. Eurovia	7. Colas	8. Holcim	9. EDF electrotechnics	10. AltéAd

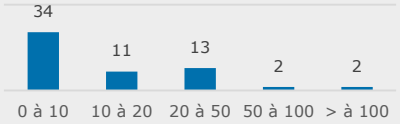
Value chain participants, by category

Maintenance (excl. manufacturers)

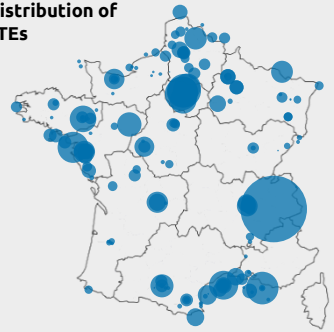
Wind power jobs

- Total wind power jobs: 1,275
- Number of businesses: 62

Number of businesses by wind power group

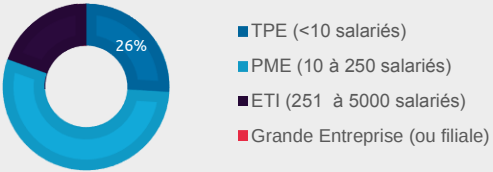


Distribution of FTEs



Typical profile

- Majority business type: SME
- Average creation date: 1992



Wind power jobs

Distribution of wind jobs:

Top 10 wind employers

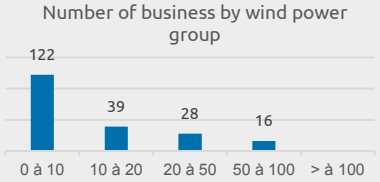
1. VALOREM	2. Groupe Qualiconsult	3. Eneria CAT	4. Baurès	5. Net-Wind
6. Manutan	7. COVED ENVIRONNEMENT	8. cmi	9. MASER ENGINEERING	10. ENGIE Cofely

Value chain participants, by category

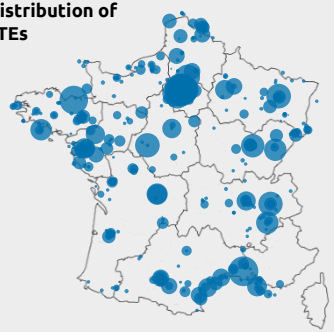
Engineering consultancies, expertise & other service providers

Wind power jobs

- Total wind power jobs: 5,300
- Number of businesses: 184

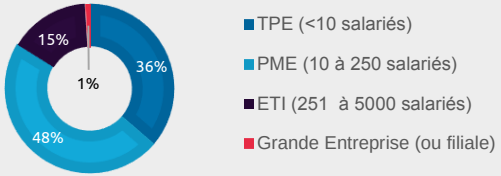


Distribution of FTEs



Typical profile

- Majority business type: SME
- Average creation date: 1995



Wind power jobs

Distribution of wind jobs:

Top 10 wind employers

1. MATIS Technologies	2. DEKRA	3. biotope	4. E.H.T.P.	5. AKKA
6. MARC	7. TRACTEBEL ENGIE	8. ALHYANGE Acoustique	9. WIND	10. SOFRESID ENGINEERING

Appendixes

C. Contributions of the industry – testimonials by local officials

Economic and fiscal benefits for local authorities

Focus on the locality of La-Chapelle-au-Mans (250 inhab.)

"We have a low annual budget of €240,000, so the revenue generated by the wind turbines will help us make the roadway that runs through the town centre safer."

Armelle Devillard,
Mayor of La-Chapelle-au-Mans
(Saône et Loire)

Wind farm factsheet

- Installed capacity (1 wind farm): 12 MW
- Estimated average annual electricity generation: 32,000 MWh
- Share of energy consumption covered: 5,000 households
- CO_2 avoided: 10,523 metric tons of CO_2

La Chapelle-au-Mans wind farm
(Photo: JSL /Alain LARDRY)

Economic effects on local municipalities and companies

Tax revenues for the federation of municipalities **€32,000 per year**	Full tax exemption for new companies for the first 2 years
Use of the trails and flying over the turbine blades **€30,000 per year**	Revenue for the federation of municipalities **€83,000 per year**

Economic and fiscal benefits for local authorities

Focus on the locality of Ally (145 inhab.)

Jean-Louis Portal,
Mayor of Ally (Haute-Loire)

"We self-manage our water. Now, **thanks to the presence of wind turbines in our municipality, the price per cubic metre of water hasn't budged** (at €0.75€ per m^3) and is much lower than the national average. "

Wind farm factsheet*

- Installed capacity: 39 MW
- Estimated average annual electricity generation: 90,000 MWh*
- Share of energy consumption covered: 19,100 households*
- CO_2 avoided: 30,000 metric tons of CO_2

Wind farm in the town of Ally
(Credit: messortiesculture.com)

Economic effects on local municipalities

Tax revenues for the locality **€50,000 per year**	Revenues for the département **€90,000 per year**
Revenues from the overflight of the plots (for the landowners) **€1,000 per plot per year**	Revenue for the federation of municipalities **€150,000+ per year**

Local job creation with Boralex's arrival for the installation and maintenance of the wind farm

* The data is derived from theoretical calculations based on installed capacity and a study on other municipalities

Economic and fiscal benefits for local authorities

Focus on the locality of Benet (4,000 inhab.)

Daniel David,
Mayor of Benet (Vendée)

"The wind turbines result in **economic development in isolated municipalities like ours.** This energy could be recovered to encourage the establishment of companies in the vicinity"

Wind farm factsheet

- Installed capacity (2 wind farms): 27 MW (10 + 17)
- Estimated average annual electricity generation: 64,500 MWh
- Share of energy consumption covered: 27,000 households
- CO_2 avoided: 19,100 metric tons of CO_2

Wind turbine in the town of Benet
(Photo: The Wind Power)

Economic effects on local municipalities

Tax revenues for the locality **€20,000 per year**	Revenues for the département **€30,000 per year**
The arrival of wind turbines locally has **generated local jobs in maintenance**	Revenue for the federation of municipalities **€200,000 per year**

Expanding public services

Building and maintaining roads is a major expense for municipalities. The tax revenue derived from the installation of wind farms can help address this need

Armelle Devillard, Mayor of La-Chapelle-au-Mans (Saône et Loire)

"Renovating **a 1 km length of road calls for a €30,000 investment.** This investment, which was out of our reach up to now, was made possible thanks to the tax revenue derived from the wind farm. "

Jean-Louis Portal, Mayor of Ally (Haute-Loire)

"Within our municipality, we have 42 km of roadways. Currently, **the mail carrier refuses to go to the village because the road is too damaged**. The tax revenues from the wind farm will help us remedy this situation."

Other examples of road rehabilitation in French regions

- Rehabilitation of the roadways – *Savières (Aube)*
- Upgrading of the roadway to improve safety in the town centre – *La Faye (Charente)*
- Renovating the sidewalks – *Dampierre-sur-Moivre (Marne)*

Sources: "Quotes from elected officials", France Énergie Éolienne

Appendixes

D. Breakdown of wind jobs by region and link in the value chain

Details by link in the value chain

The wind power value chain is multi-business and integrated

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.

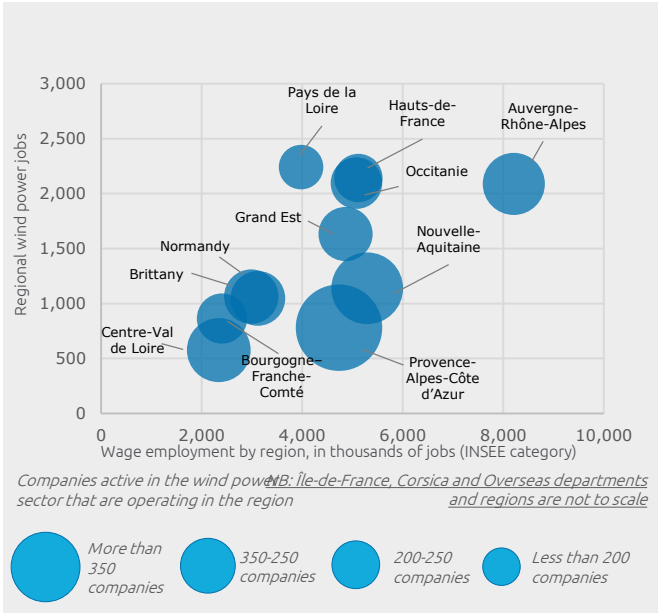
	Planning & Design	Component manufacturing	Engineering & Construction	Operations & Maintenance
Engineering consultancy & Expertise	✓			
Turbine manufacturer	✓	✓	✓	✓
Developer	✓			
Developer and/or Operator	✓		✓	✓
Operator				✓
Component manufacturer		✓		
Civil and electric engineering			✓	
Logistics			✓	
Maintenance				✓
Other service provider	✓			

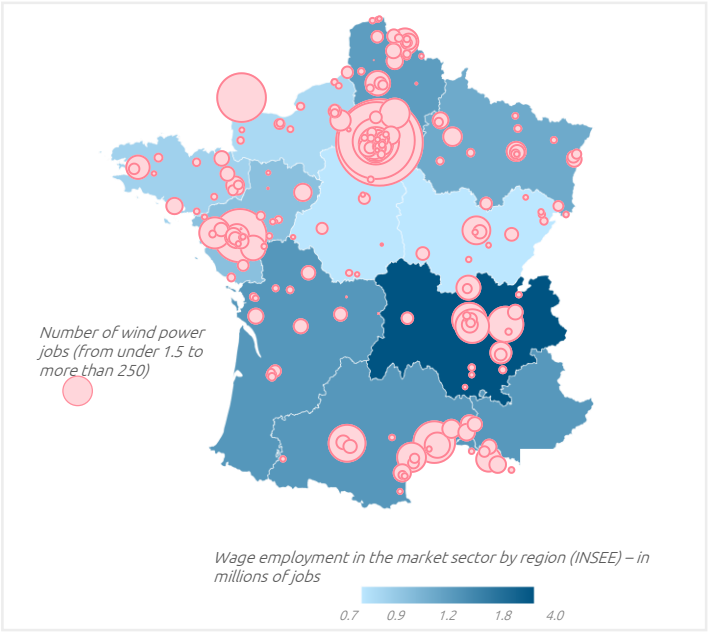
Many services have developed with the new possibilities offered by technology and regulations. From divers to shared platform managers and IT developers, they are spread over the entire value chain.

Breakdown of wind jobs by region

The more dynamic the region is in terms of jobs, the more the wind sector benefits

Contribution of the wind sector to regional employment



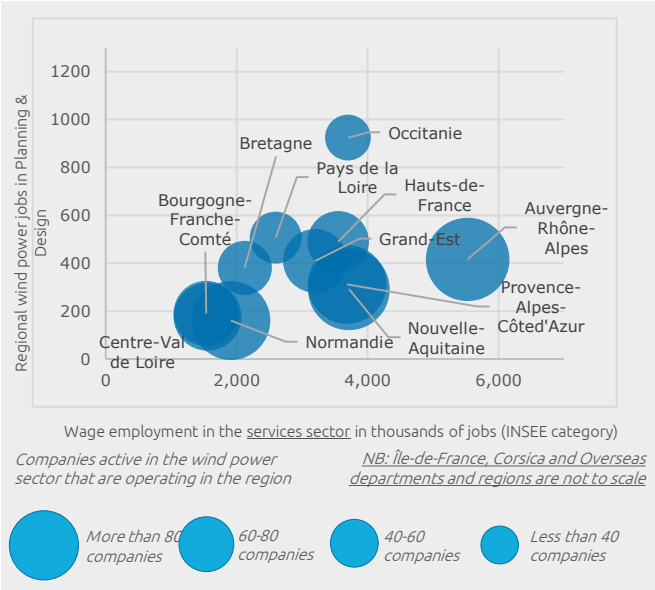


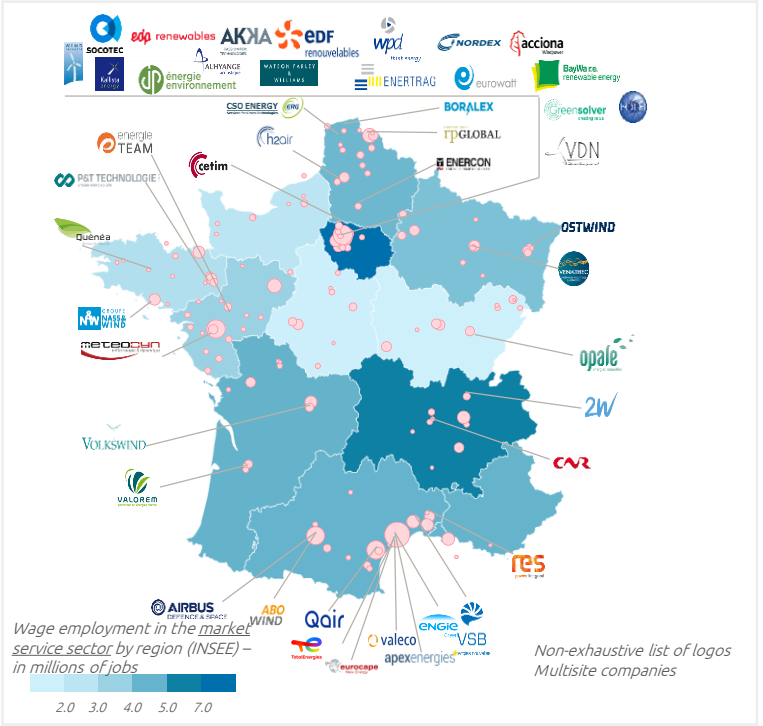
Source: FEE study, data processing by Capgemini Invent, INSEE 2021

Breakdown of wind jobs by region

Jobs in **Planning & Design** are mostly located in the vicinity of France's major urban centers

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

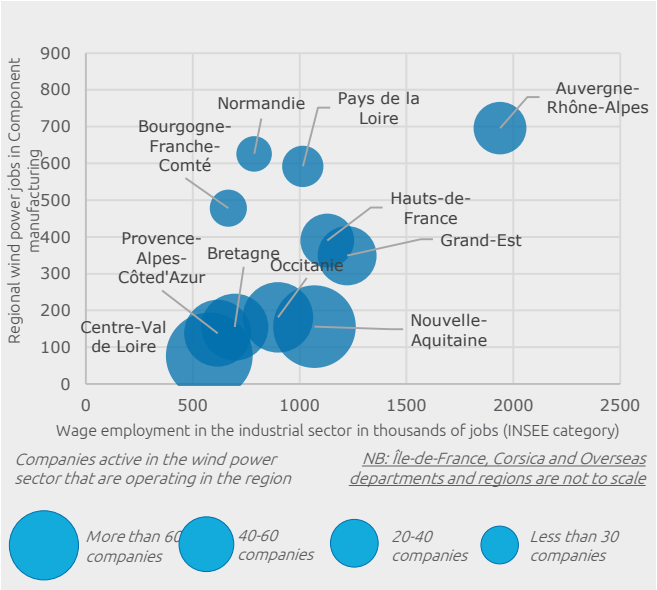




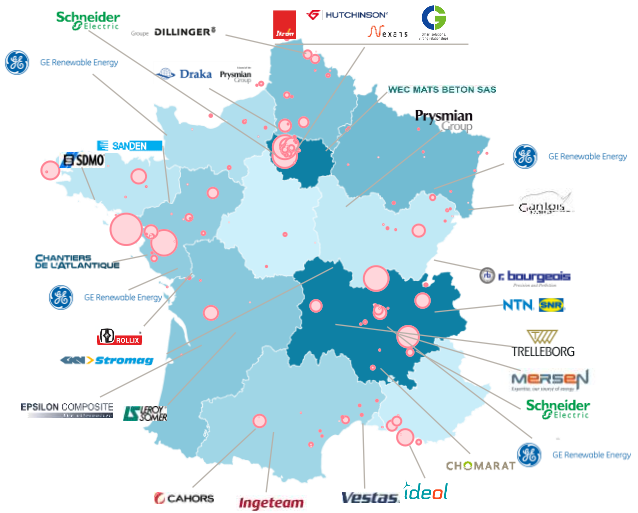
Breakdown of wind jobs by region

Component manufacturing generates 4,500 jobs across the country

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



Source: FEE study, data processing by Capgemini Invent, INSEE 2021



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

0.5 0.7 1.0 1.2 1.5

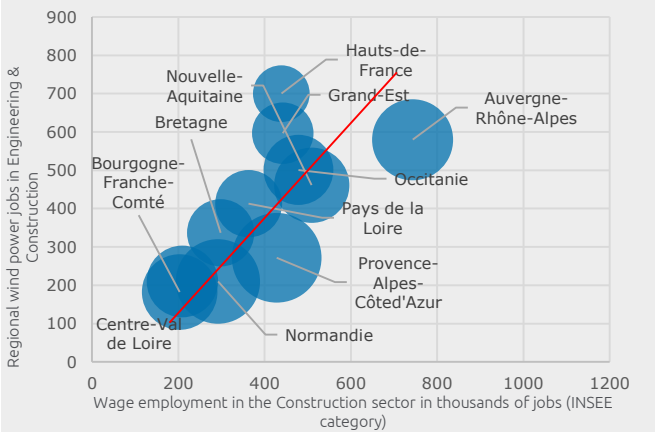
Non-exhaustive list of logos
Multisite companies

Capgemini invent | France Energie Eolienne

Breakdown of wind jobs by region

In **construction**, at least one job in one thousand is generated by wind power in the vast majority of regions

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

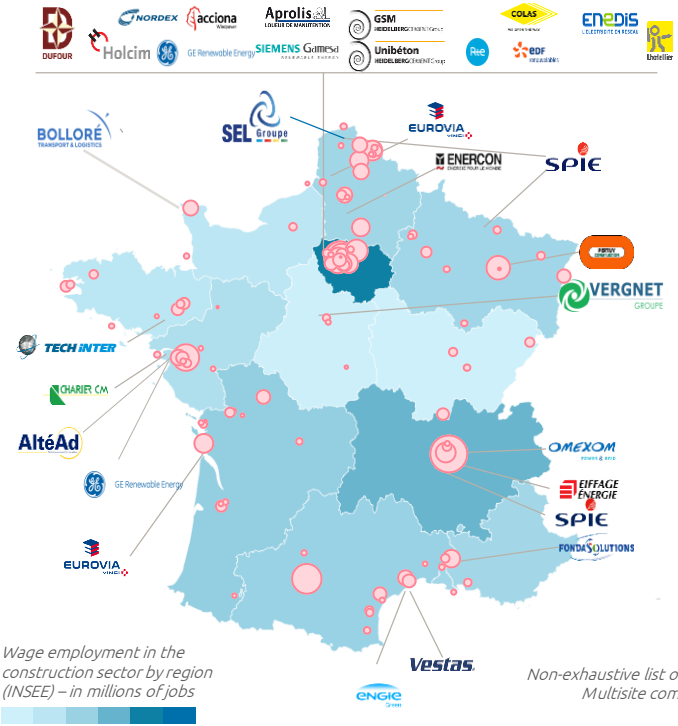


Companies active in the wind power sector that are operating in the region

NB: Île-de-France, Corsica and Overseas departments and regions are not to scale

More than 190 companies | *150-190 companies* | *150-100 companies* | *Less than 100 companies*

Source: FEE study, data processing by Capgemini Invent, INSEE 2020



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

Non-exhaustive list of logos Multisite companies

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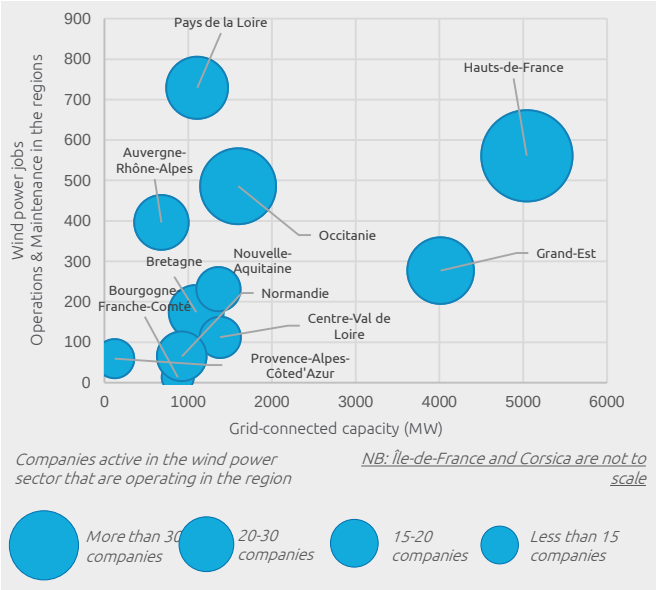
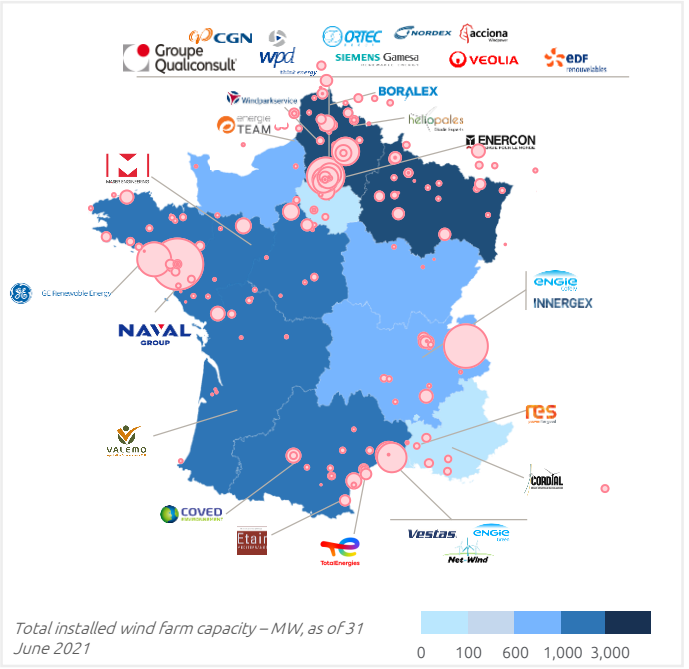
Breakdown of wind jobs by region

Jobs in **maintenance and operations** are mostly located in regions with the highest installed capacities

Wind power jobs in Operations & Maintenance relative to installed capacity





Source: FEE study, data processing by Capgemini Invent 2021, INSEE 2020

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Appendixes

E. Training

Typical profile – an example of a wind job

Amelia C.

31 years

Paris (75)

Wind farm project manager

- An engineering school graduate, I have 3 years of experience in developing renewable energy projects
- I have strong analytical and synthetic skills, and also improved my managerial skills in project development
- I am highly self-driven in my day-to-day work

Missions

- Managing the scope of the projects with considerable self-initiative
- Arranging and running work meetings and presentations
- Reporting on the activity (monthly report, monitoring tools)
- Ensuring cooperation with local stakeholders and making sure they are kept informed
- Taking part in technology watch, regulatory watch, and marketing intelligence

Typical profile – an example of a wind job

Patrick D.

28 years

Aude (Occitanie – 11)

Service technician

- I hold an undergraduate degree in electrical engineering and have 2 years of experience in maintaining electronic systems, ideally wind power systems
- I am team player and am concerned about environmental issues

Missions

- Controlling, monitoring, and maintaining equipment on a regular basis
- Troubleshooting malfunctions (on-site or remotely), making a diagnosis
- Fixing the situation in the event of a malfunction
- Proposing solutions to optimize equipment safety and performance

Appendixes

F. Driving the industry forward

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 (including 244 associate 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, hybridisation)

Key data for 2020:

- 244 members, 15 new members, 59% of SMEs, start-ups, VSEs
- 58 members involved in the wind power sector
- 948 funded or accredited projects
- 379 projects & demonstrators funded
- 3,071 followers on Twitter, 2,720 on LinkedIn

Designers (BE, influencers) | **Technologies** | **Products** | **System integration integration** | **End customer** | **Operation**

Sources: Tenerrdis

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

The French Maritime Cluster (CMF) brings together all the protagonists in the maritime ecosystem, from industrial companies to services and maritime activities of all kinds with the objective of ensuring the sustainable development of maritime activities. Today, it is made up of more than 430 entities: companies of all sizes, competitiveness clusters, federations and associations, laboratories and research centres, schools and training organisations, communities and local economic players, as well as the French Navy. FEE is a member of CMF.

CMF is at the service of its members, acting as a facilitator for the development of their businesses and the emergence of new innovative projects. It supports its members in the sustainable and responsible development of their activities and projects, in France and internationally.

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 5th 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 in regard to the development of MREs), CMF has developed clusters in: Guadeloupe, Réunion, French Guyana, Martinique, French Polynesia, New Caledonia and Saint-Pierre et Miquelon.

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 cohosted 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 cohosted 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 2021 will be held from 16 to 18 November 2021** in Marseille.

FOWT 2020 was held from 7 to 8 September 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 industrialisation 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 2020 edition: Giles Dickson (WindEurope), Laurent Michel (French Ministry of Ecological 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.

More information on www.fowt-conferences.com.

Key data on the event (2020 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 (online) • 800+ participants • 28 nationalities represented • 500 B2B meetings / Meet the Buyers

Driving the industry forward

Focus on the Neopolia Offshore & MRE Cluster

The Neopolia Neopolia Éolien Offshore & EMR Cluster (Neopolia Offshore & MRE Cluster) brings together more than **105 industrial companies** that combine their know-how in order to find innovative answers to the needs of the **marine renewable energies** (MREs) market. The Cluster is part of the **Neopolia network composed of 5 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**
- **EPCI* bottom-fixed or floating wind**

Neopolia Éolien Offshore & EMR will be a partner of the FEE's National Wind Power Conference, which will take place on October 13–14 of this year.

* EPCI = Engineering, Procurement, Construction, Installation

Driving the industry forward

Focus on Pôle Mer Méditerrannée

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 defense, 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
  - **59 funded projects and 82 accredited in MREs**
  - **With a total budget of €188.62M**

Sources: Pôle Mer Méditerranée

And 3 cross-cutting themes:

- the ecological transition;
- digital transformation;
- robotics.

Now boasting more than 438 members (laboratories, large corporate groups, ETIs and SMEs), Pôle Mer Méditerranée has been actively identifying all potential participants in the floating wind sector since 2013. It has thus identified 582 potential participants including 60 confirmed participants in the regions of Sud-Provence-Alpes-Côte d'Azur, Corsica and Occitanie. 266 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.

Driving the industry forward

Focus on: Pépinière Entreprises Énergies Renouvelables (80)

The Pépinière d'Entreprises Energies 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

- 2060 members in fixed-bottom wind, floating wind, tidal barrage and tidal stream
- Active on all of continental France's seaboard
- Co-organising events

Accompanying the diversification in wind power and MREs

Personalised 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.

Cohosting and co-organising events on wind power on a national or interregional scale

- FEE/Éole Industrie event at the regional Chamber of Commerce and Industry in Lille and a Technical one-day Operations & Maintenance event at the renewables incubator, Pépinière EnR
- Windustry France meetings
- International SEANERGY conventions in Le Havre, Cherbourg, and Dunkirk
- Business event on offshore wind with 15 international contracting authorities and 50 regional companies at the Chamber of Commerce and Industry in Dunkirk
- 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** specialising 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 trial base combining several technologies** related to offshore wind and wave power; furthermore, it is connected to the national grid.

The SEM-REV sea test site and the laboratory's test basins are one of the components of the THOEREM research infrastructure, which brings together the testing resources of Ifremer, Centrale Nantes and Gustave Eiffel University on the EMR theme.

THeoREM listed on the 2018 national research infrastructure roadmap

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. FLOATGEN is connected to the medium-voltage grid operated by Enedis. An onshore research base also hosts researchers and engineers.

The **activities carried out on the site around technology testing** include:

- hosting and conducting **national and European research projects**, in particular aiming to improve performance and reliability
- collecting **environmental data** (marine weather, physical and biological, and so on)
- **operation and maintenance** of the infrastructure
- **the study of the environmental impact** of the MREs employed (on fauna, sediment transport and so on)
- the **security and surveillance** of maritime space.

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