




BUILDING A SUSTAINABLE
FOUNDATION FOR
RENEWABLE ENERGY

OFFSHORE WIND ENERGY



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EDITORIAL



Bertrand Burtschell,
CEO of Bouygues
Travaux Publics

Offshore wind power is based on a natural, renewable energy source. It is one of the most promising solutions to meet the challenges of the energy transition.

This potential is reflected in the emergence of more and more ambitious projects, requiring ever more efficient solutions in terms of technology, cost and time.

In the face of ever-growing market demand, Bouygues Travaux Publics has naturally positioned itself as a preferred partner for developers and investors. Our societal commitment to sustainable and responsible growth, our recognised expertise in civil engineering and maritime structures, our innovative spirit and our ability to industrialise the execution of large-scale projects, such as the Fécamp offshore wind farm, all combine to make us a key player in the field of decarbonised and offshore wind energy infrastructure. I invite you to join us over the next few pages on our journey through innovation and the ongoing development of high value-added solutions tailored to support the offshore wind market.



Industrialised construction of the gravity-based structures : view of the production lines. Fécamp offshore wind farm - 2022.

HARNESSING OFFSHORE WIND POWER TO MEET THE ENERGY TRANSITION CHALLENGE

In a context of climate change, increasing scarcity of fossil fuels and the need to secure energy supplies, the transition to decarbonised energy sources is more necessary than ever. Offshore wind energy is one of the answers to this challenge.

A NATURAL RESOURCE TO BE HARNESSSED

Capturing the driving force of the wind using the blades of a rotor, transforming it into mechanical energy, and converting it into electrical energy using a generator: this is how wind turbines were first conceptualized in works from the 19th century. However, although onshore wind power, which appeared in the 1970s, has long been favoured because it is cheaper to install, it has its limits in terms of efficiency, visual and noise pollution, and the availability of sites. Hence the more recent development of offshore wind turbines, which overcome some of these constraints. Benefiting from stronger and more constant winds, they offer more continuous energy production, while their location off the coast limits

their impact on the landscape and makes it possible to set up larger farms. However, the development of this new sector is conditional on the evolution of technologies as well as the reduction of construction and operating costs.



Offshore installation, Fécamp offshore wind farm - 2022.



57.6 GW
Global installed
offshore wind
capacity as of 2022⁽¹⁾,
of which about 50%
is in Europe⁽²⁾.



300 GW
Objective set by
the European
Commission for
2050⁽³⁾.

(1) Source : Global Offshore Wind Report.
(2) Source : Wind Energy in Europe.
(3) Source : European Commission.

BOUYGUES TRAVAUX PUBLICS, AT THE HEART OF OFFSHORE WIND POWER

For decades, Bouygues Travaux Publics has been making its mark on major infrastructure projects across the globe. The company is recognised for its technical excellence and has proven its ability to manage complex projects, particularly in the maritime works and port sectors.

Bouygues Travaux Publics, with its 400-strong technical management team and longstanding presence on several continents, has been quick to apply its skills and capacity for innovation to major projects, with an industrial approach to manufacture massive reinforced concrete structures among which the required infrastructure for offshore wind power generation. The Monaco offshore extension project and the foundations for the Fécamp offshore wind farm are among the company's most recent reference projects in this field.

2011

At a time when offshore wind energy was taking off in France following the launch of the government's *Grenelle de la Mer* initiative, Bouygues Travaux Publics assisted the developers of the offshore wind farm project near Fécamp in their response to the government's call for tenders, which they won two years later. Bouygues Travaux Publics was then selected to design, build and install the foundations for what would become France's second offshore wind farm.

2020

Award of the design & build contract for the foundations of the Fécamp offshore wind farm.

2022

Bouygues Travaux Publics underscored its ambitions in floating offshore wind by acquiring an innovative concrete floating substructure technology called OO-STAR. This concept offers increased wind turbine efficiency, high durability and optimised operating and maintenance costs. All this, while enabling mass production to be carried out competitively in terms of time and costs.

2013

Bouygues Travaux Publics took part in the Floatgen experimental project to prove the feasibility and competitive performance of the floating wind turbine design.

AN ARCHITECT AND LEAD CONTRACTOR'S KNOW-HOW

While Bouygues Travaux Publics' expertise in civil engineering and marine works proved essential to the success of the Fécamp offshore wind farm (see the following page), the company's unique ability to offer an integrated design/manufacturing/installation solution while successfully interfacing with other project work packages (supply of turbines, laying of cables, etc.) made the difference in terms of cost, schedule management and risk mitigation. Bouygues Travaux Publics has thus positioned itself as a designer-builder and integrator of global EPCI (Engineering Production Construction Installation) solutions.

Analysis

CONVICTION, EXPERTISE, COMMITMENT



Jérôme Furgé,
head of Nuclear and
Offshore Wind business
at Bouygues Travaux
Publics, explains the
company's commitment
to offshore wind power
and its strengths in this
market.

Why did Bouygues Travaux Publics invest in the offshore wind sector?

J.F. This strategic choice was led by different drivers. Firstly, our strong belief that we have a role to play in decarbonising energy production. Secondly, our know-how in civil engineering and maritime structures which provides us with the exact blend of experience needed to support the offshore wind sector. In particular, I am thinking of projects such as Beirut waterfront, the Tangier Med port complex and the offshore extension of Monaco, and of course, the experience acquired by our teams on the Fécamp offshore wind farm for gravity-based foundations, as well as the lessons learnt from the Floatgen project for floating foundations.

What are the expectations of the market?

J.F. Developers and investors want high-performance technical solutions that meet their needs, buildable at competitive costs and within ambitious schedules. They are looking for partners that are capable of controlling risks on such complex projects.

How does Bouygues Travaux Publics respond to these challenges?

J.F. By positioning itself as a true solutions integrator, attentive to its clients' needs, capable of developing tailor-made solutions based on proven technologies and, above all, of proposing global EPCI solutions.

→ See over leaf.

GRAVITY BASED STRUCTURES

A TRIED AND TESTED SOLUTION

The installation of 71 Gravity Based Structures (GBSs) to support 7MW wind turbines on the Fécamp offshore wind farm is a benchmark project by its scale. The on-time delivery of the foundations demonstrates the efficiency of an execution process based on meticulous preparation and industrialised construction. It also paves the way for other projects using the bottom-fixed technology, the technical maturity of which is no longer in doubt.

AN EXCEPTIONAL WORK SITE

A hollow substructure made of prestressed reinforced concrete, resting on the seabed on a layer of gravel and filled with ballast: such are the ingredients that formed the 71 gravity-based foundations built by Bouygues Travaux Publics ⁽⁴⁾. Weighing around 5,000 tonnes each, the structures were built in Le Havre at a yard created specifically for the project, transported by barge to the open sea off Fécamp in water depths of 25 to 30 metres, then lifted and grounded into position using a heavy-lift vessel. The combined optimisation of design, methods and transport at sea, made it possible to minimise the quantities of materials required, resulting in a lean, tailor designed GBS solution.

(4) leader of the consortium including Saipem and Boskalis

NUMEROUS ADVANTAGES

Placed on the seabed, the GBS eliminates the need to drive or drill large offshore piles which is traditionally a key source of risk and additional cost for the industry, particularly in the face of complex geotechnical conditions. In addition, during offshore installation operations, the GBS further helps to minimize underwater noise pollution. The use of concrete also supports an extended lifecycle, reaching beyond 100 years with minimal maintenance of the main structure. Implemented on Fécamp for 7MW wind turbines, the solution has been scaled up for wind turbines up to 20MW, and developments are underway to go even further.

AN INDUSTRIAL APPROACH

Integrating mass production methods to the construction cycle: this is the *tour de force* achieved by Bouygues Travaux Publics on the Fécamp offshore wind farm project. At the heart of this success: the implementation of Lean Management principles, a project breakdown that optimises the programme and resource allocation, specialised teams divided into four parallel production lines, and the use of digital tools to efficiently handle production and quality management. This combination enabled very high production rates with the foundations being delivered only 21 months after construction kick-off.

A CONSTRUCTION SITE THAT CONTRIBUTES TO LOCAL DEVELOPMENT

The gravity-based structure solutions proposed by Bouygues Travaux Publics further bring sustainable job creation to the construction process, supporting the use of local construction sites and helping to create skills and employment opportunities for the local area around each new development. This is best illustrated through the Fécamp offshore wind farm project which employed nearly 1,000 people at its peak, including 250 on back-to-work schemes, and enabled many local companies to contribute to the project's value chain, a further factor in the acceptability of offshore wind farms.

Key figures



71
concrete
foundation bases



21 MONTHS
of construction:
a record time!



5
weeks of
installation at sea



4
parallel production
lines



1,000
staff on site
at peak activity



Nicolas Jestin,
Production Director,
Fécamp offshore wind
farm foundations,
Bouygues Travaux
Publics

CLIENT RELATIONS AT THE HEART OF FÉCAMP'S SUCCESS

"Manufacturing the 71 gravity-based foundations for the Fécamp wind farm in just over a year and a half is, of course, a tremendous operational achievement, demonstrating our ability to set up high-performance industrial solutions to meet our clients' expectations in terms of schedule and costs. But this success also called for meticulous upstream preparation, to design and deliver an industrial plan best suited to the project, and to secure the key means and resources, on land and at sea, required for its completion. In this context, **building a relationship of trust and taking our client's needs into account from the outset, and keeping those needs at the heart of our decision making throughout the entire project was essential to shape the future joint success of the Project.** Deploying our «flying start» initiative to support early mobilisation of key members of the construction team during the initial commercial phase helped us move seamlessly from one stage to the next, guaranteeing continuity in our client relationship and establishing the right project culture from the very beginning."

FLOATING FOUNDATIONS

A TECHNOLOGY OF THE FUTURE

2028 is the most likely starting date for the construction of the first floating offshore wind projects. In the meantime, the required technology to make these innovations a success must continue to mature and become more competitive. Leveraging the learnings from the Floatgen experimental project and the acquisition of an exclusive patent for a floating foundation concept (OO-STAR), Bouygues Travaux Publics continues its development activities to prepare for the transition to the new generation of offshore wind turbines.

FLOATGEN, A PIONEERING PROJECT

In 2013, Bouygues Travaux Publics joined the offshore wind adventure by participating in the Floatgen project. The objective was to install France's very first floating wind turbine off the coast of Le Croisic, at the École Centrale de Nantes' marine renewable energy test site (SEM-REV). Although technologies have evolved since then, this pilot project demonstrated the relevance of the floating foundations concept in the production of decarbonised energy at sea.

CAPTURING MORE SUSTAINED WINDS

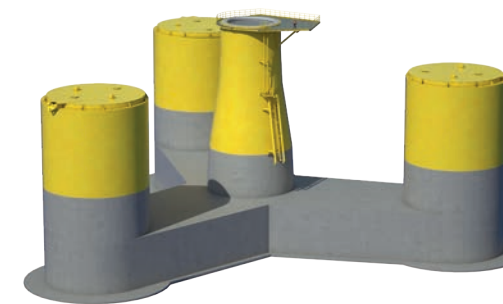
Floating foundations are at the heart of Bouygues Travaux Publics' innovation efforts to meet future market expectations. They are complementary to gravity-based structures that reach their limits towards a depth of around 60 to 70m. The installation of floating offshore wind turbines also enables the capture of more powerful and more regular wind flows and accommodates the use of more powerful turbines, all of which will contribute towards optimising investment costs. In addition, certain floating concepts, including the OO-STAR offered by Bouygues Travaux Publics, allow for a more circular economy with the reuse of the foundations being made possible on later projects at the end of the concession, or where feasible extending the concessions lifecycle.

THE OO-STAR CONCEPT, THE RESULT OF 15 YEARS OF R&D

Acquired exclusively by Bouygues Travaux Publics in 2022, the OO-STAR technology was developed by the Norwegian company Dr.techn. Olav Olsen, an expert in the design of infrastructure for the oil and gas industry. It consists of a semi-submersible platform made up of three satellite floaters arranged in a star (hence the name of the concept) around a central floater that accommodates the wind turbine. Adapted to modular construction, this floater can be assembled on the quay or at sea with a shallow draft before being towed to the installation site. Its hydrodynamic and structural behaviour, tested for a decade, guarantees optimal turbine performance and high durability of the structure, thus allowing greater efficiency, including in the toughest metocean conditions.

OFFERING INTEGRATED AND COMPETITIVE SOLUTIONS

In order to meet market expectations in terms of turbine performance (efficiency, operability, resistance to marine conditions, etc.), but also economic competitiveness and lead times, Bouygues Travaux Publics has been working to optimise the design and implementation of its OO-STAR floating technology. The objective is to offer a comprehensive package covering design, production and installation, and possibly even operation and dismantling. Bouygues Travaux Publics is exploring ways to optimise the floaters access arrangements for personnel from transport and maintenance vessels, as well as designing specific production facilities and decommissioning solutions for the end of a concession.



INNOVATIONS FOR A SUSTAINABLE SOCIETY

Because sustainable development challenges are at the heart of its clients' concerns, Bouygues Travaux Publics wants to make the most of the decarbonisation potential of its OO-STAR floating solution. This includes the use of low-carbon concrete and steel, and even more innovative solutions such as the production and storage of hydrogen in the floaters.



Catherine Boucard,
Offshore Wind Power
Technical Director

THE TECHNICAL STRENGTH OF BOUYGUES TRAVAUX PUBLICS a differentiator at the heart of the project

"Bouygues Travaux Publics draws on the expertise of its over 400 staff strong technical department to bring together all the skills required for innovation and success in the Offshore Wind industry. This includes experts in hydrodynamics, structural calculations, and the design of construction, load-out, and offshore installation methods, applied in particular to large-scale concrete infrastructures and offshore wind farms. To further improve performance and competitiveness, we collaborate with key partners such as Dr.techn Olav Olsen and others from highly specialised sectors (offshore operations, turbine, maintenance, cable). This enables us to deploy innovative technical solutions with high added value for our clients. Through this approach, several patents are currently being developed for the OO-STAR floater."

Key info

MEETING THE NEEDS OF TODAY... AND OF TOMORROW



Interview with
Audrey Goulven,
Offshore Wind
Business Development
Manager.

Will floating foundations replace gravity-based structures?

A. G. No, the two will coexist because they fulfil different needs. With bottom-fixed wind farms, turbines are fixed thanks to foundations either in concrete (as is the case for Bouygues Travaux Publics GBS solutions) or in steel. But beyond a certain depth, this solution is more complex and more expensive to deploy. This is why, after equipping the shallowest areas, we can expect project developers to turn to floating wind turbines, which allow for installation at greater depths and at more competitive costs, where the wind resource is more qualitative.

What is the status of the floating foundation solution offered by Bouygues Travaux Publics?

A. G. At present, many different floating concepts are put forward by players wishing to position themselves on the market. The OO-STAR floating foundation technology, for which Bouygues Travaux Publics acquired exclusive rights in 2022, stands out because of its greater maturity, with over 15 years of R&D. Currently at the development stage TRL5*, it will soon be upgraded to TRL7-8 thanks to upcoming prototype projects.

*TRLs (Technology Readiness Levels) are a scale used to assess the degree of maturity reached by a technology.

THE STRENGTH OF BOUYGUES TRAVAUX PUBLICS

Bouygues Travaux Publics supports the development of decarbonised offshore energy production projects by offering high-performance solutions that meet market expectations.

PROVEN SKILLS

➔ The concrete foundation solutions offered by Bouygues Travaux Publics for the offshore wind market are the result of the combined expertise of over 400 technical subject matter experts, and over 35 years of experience in delivering successful civil engineering and major marine infrastructure projects.

INDUSTRIALISATION CAPACITY

➔ Bouygues Travaux Publics' ability to industrialise the manufacturing of its foundations, whether gravity-based or floating, as successfully demonstrated on the Fécamp offshore wind farm project, meets market expectations in terms of competitiveness and completion times for offshore wind turbine projects.

CREATING VALUE THROUGH LOCAL SKILLS DEVELOPMENT AND EMPLOYMENT OPPORTUNITIES

➔ Unlike steel equivalents which rely on an industrial model based on imported materials, the concrete foundations offered by Bouygues Travaux Publics allow for the use of local manufacturing sites, generating value for local economies through sustainable skills and employment creation.

DESIGN-BUILD EXPERTISE

➔ By offering integrated engineering and production solutions, Bouygues Travaux Publics provides its clients with optimised design solutions built around a full understanding of the construction methods, all leading to better control over costs and more certainty over each project deadline.

DURABLE STRUCTURES

➔ Because they offer a lifespan that can exceed 100 years with minimal maintenance, concrete foundations are a relevant solution to reduce the operating costs of offshore wind farms.

Height
FROM 48 TO 54M
Weight
5,000 TON



GRAVITY-BASED STRUCTURES

A proven benchmarked solution



OO-STAR FLOATING FOUNDATIONS

An innovative technology offered by Bouygues Travaux Publics

Height
~ 40M
Diameter
~ 80M
(for a 15 MW turbine)

Learn more QUESTIONS/ANSWERS



WHAT IS THE DIFFERENCE BETWEEN FIXED AND FLOATING OFFSHORE WIND TURBINES?

Fixed offshore wind turbines are installed on concrete foundations rested on the seabed, known as Gravity Based Structures (GBSs). Floating offshore wind turbines, on the other hand, are founded on platforms that float on the surface of the water.



WHAT ARE THE RESPECTIVE ADVANTAGES OF THE TWO TECHNOLOGIES?

A fixed foundation wind turbine is the most appropriate solution up to a depth of 60 to 70 metres. Beyond, floating foundations allow to exploit stronger and more stable winds, with higher capacity turbines. The robustness of the OO-STAR provides it with an ideal hydrodynamic behaviour which optimises the turbine efficiency, including in the toughest environments.



WHAT ARE BOUYGUES TRAVAUX PUBLICS' REFERENCES IN OFFSHORE WIND ENERGY?

Bouygues Travaux Publics was one of the pioneers in the French offshore wind sector building the foundations for the Fécamp offshore wind farm and that of France's first floating wind turbine with the Floatgen experimental project.



OFFSHORE WIND POWER IS A RELATIVELY RECENT MARKET FOR BOUYGUES TRAVAUX PUBLICS. IS THE COMPANY READY TO MEET THE CHALLENGES?

Bouygues Travaux Publics' legitimacy in offshore wind is based primarily on its historical expertise and track-record in civil engineering and the construction of maritime structures. In addition to the Fécamp and Floatgen offshore wind projects, Bouygues Travaux Publics is a key player in the sector, with references such as the Monaco offshore extension, the port of Tangier and the Beirut waterfront.



HOW ARE BOUYGUES TRAVAUX PUBLICS' SOLUTIONS FOR OFFSHORE WIND POWER SUSTAINABLE?

While the production of renewable energy from wind is naturally virtuous, Bouygues Travaux Publics goes further in the decarbonisation process by integrating the use of sustainable materials such as low-carbon concrete and steel into its solutions. Consideration is also being given to the possible synergies between floating foundations and the production and storage of hydrogen.



HOW DOES BOUYGUES TRAVAUX PUBLICS PROVIDE SUPPORT FOR ITS CLIENTS' OFFSHORE WIND FARM PROJECTS?

Aware of the scale, complexity and levels of investment involved to develop offshore wind farms, Bouygues Travaux Publics offers its clients support throughout the life cycle of their projects. This ranges from taking their needs and constraints into consideration at tender stage, to working in partnership to optimise tailor-made solutions, manufacturing and installing foundations, all the way through to maintenance and decommissioning services.

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