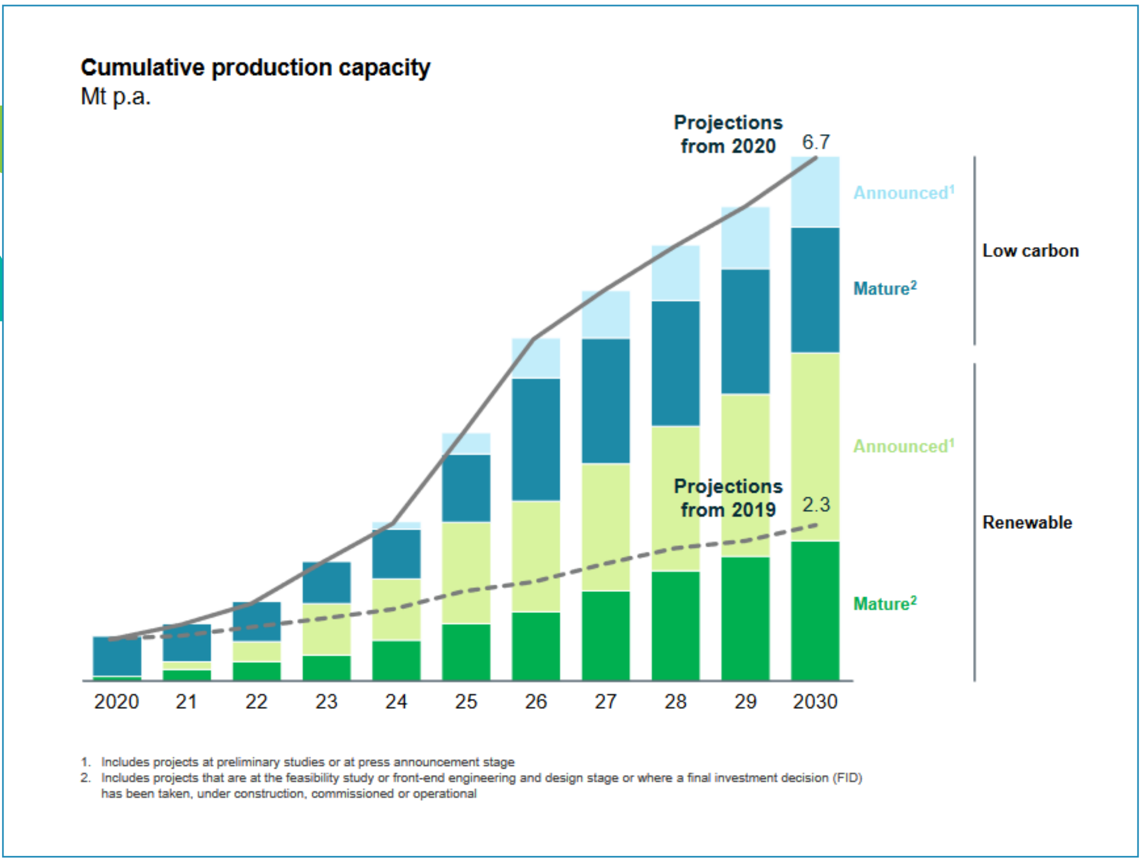
Challenges and Solutions to Offshore Green Hydrogen Generation

BOSLAN
ENGINEERING AND CONSULTING

Advancing together towards climate neutrality

EXECUTIVE SUMMARY

In order for the European Union to achieve its goal of being climate neutral by 2050, **we need to triple the generation of clean energy and increase hydrogen generation fortyfold over the next decade**.[1] In both cases, offshore wind can play a decisive role.



Projected clean hydrogen production capacity by 2030. Source: Hydrogen Council [2]

But offshore generation presents numerous technological challenges. The swell and corrosive effect of sea water and the depth of the ocean in areas with optimal wind profiles skyrocket the installation and maintenance costs of infrastructures, which in turn hampers the development of offshore wind. Its remoteness from the coast and the lack of on-site personnel demand very high reliability of operations. The transportation of hydrogen to land, whether by umbilical or by ship, also involves high operating costs.

To minimize development and implementation costs, the selection of the installation location is critical in the **design phase**, finding the optimal balance between the best available wind profile, the best foundation solution, and the means of hydrogen transportation, as well as bunkering possibilities. During the **operation phase**, complete monitoring of all elements and remote operations allow to reduce operating costs, prevent failures and unexpected stoppages, and increase operational safety.

BOSLAN is a pioneer in Spain in hydrogen project management, and is leading the HYSHORE project, part of the HAZITEK program supporting business R&D by the Basque Government. This project includes the development of a Digital Twin and a feasibility analytics that allow to identify the optimal location for an offshore hydrogen generation plant, as well as the calculation of capital and operating costs throughout its lifecycle and forecasts for payback of the facilities.

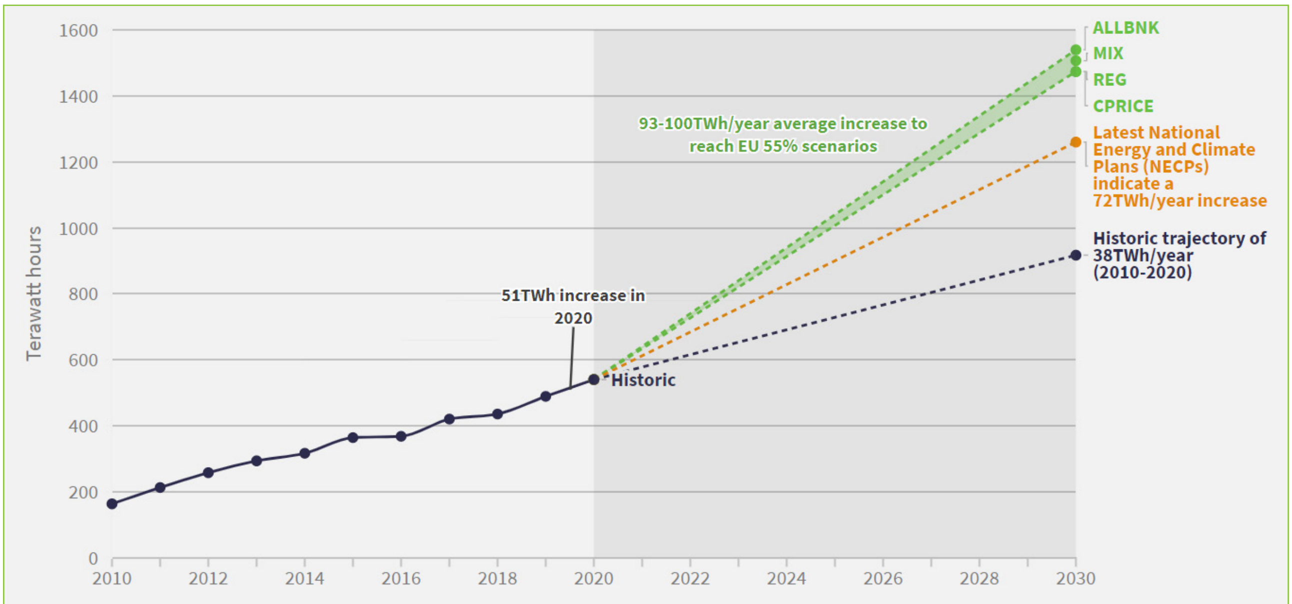
The Digital Twin is a technology that cuts across all engineering specialties, and BOSLAN offers better solutions to its clients' needs with it.

PART 1

The Decisive Role of Offshore Wind in the Decarbonization Process

On the Path to Climate Neutrality

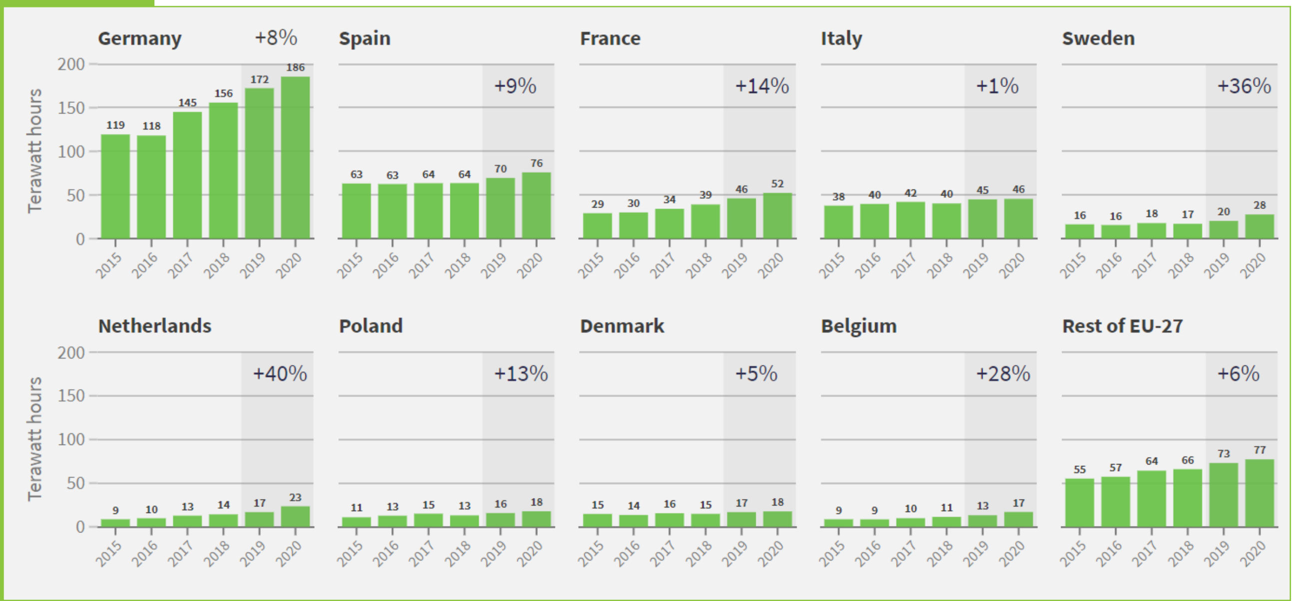
The need to reduce pollutant emissions, coupled with the growing demand for electrical energy, has redirected traditional energy generation towards technologies that allow large-scale capture of renewable resources available in each territory. The European Commission's proposal to reduce greenhouse gas emissions by at least 55% by 2030 puts Europe on the path to achieving the goal of being climate-neutral by 2050.[3] But to achieve this, renewable energy generation in Europe will need to nearly triple the current capacity over the next decade.[4]



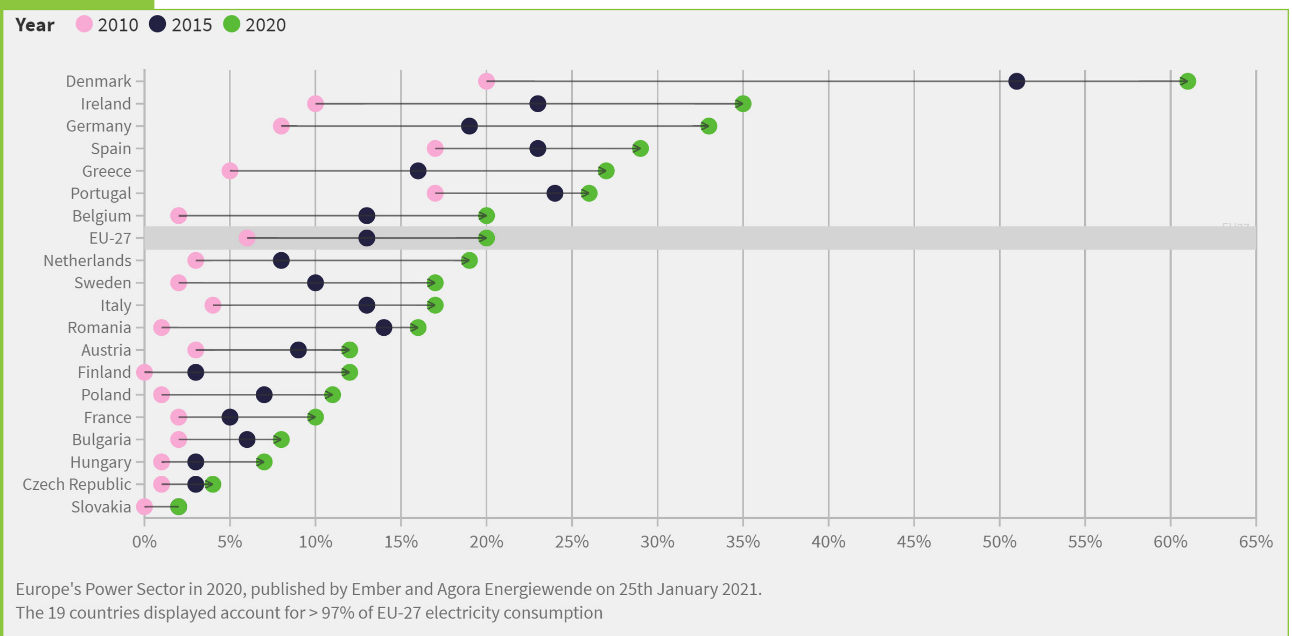
Source: 2030 scenarios from European Commission's Impact Assessment for 55% GHG cuts under Europe's Green Deal (figure 46).

Renewable energies in Europe need to triple current production to meet the EU's climate objectives by 2030. Source: EMBER [5]

Spain is one of the European leaders in renewable energy, both in absolute terms and relative to energy production by other means. This preponderance has intensified over the past two years, during which renewables have increased in our country at a rate of 9% annually.[6] Nowadays, wind energy accounts for 22% of the total energy produced in Spain, thus doubling the energy generated in hydroelectric power stations, which occupies the second place in the ranking.[7]



Renewable energies continue to rise throughout Europe. Source: EMBER [8]



Spain, among the leaders in Europe regarding the relative weight of renewable energies. Source: EMBER [9]

However, although wind energy is the quintessential green energy, the saturation of the landscape with wind farms is producing a growing rejection among some sectors of society, due to their environmental, acoustic, and visual impact. This means that the political cost associated with the new construction or expansion of wind farms could be very high. All this is discouraging the development of new projects by local administrations, which are the ones most affected by protests.[10]

Offshore Wind as a Solution

Countries with long coastlines have an opportunity in the wind resource of their coastal areas. Offshore wind production is expected to quintuple its current production in Europe over the next decade, increasing from 15 to 72 GW,[11] and Spain is betting on this technology as an alternative to the problems of onshore wind farms. The large surface area and average wind speeds higher than those in land areas can turn offshore wind turbines into one of the main sources of green energy in the current context.

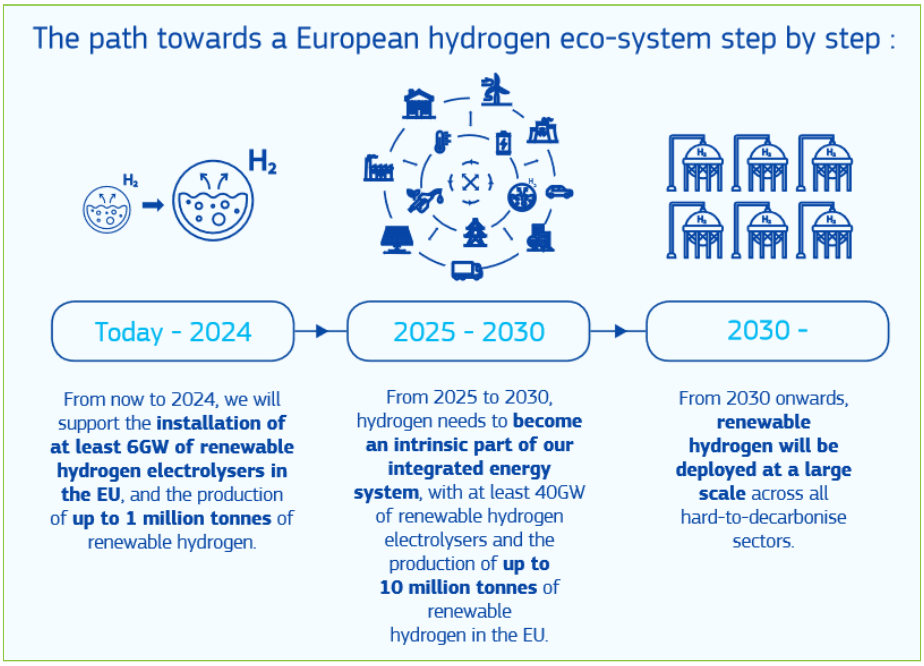
Green Hydrogen, Key to Maximizing Offshore Production

In periods when energy demand is lower, it is convenient to have energy storage technologies that allow us to take full advantage of wind generation. In times of low demand, the installation of electrolyzers at the foot of offshore wind farms allows for the storage of excess energy by generating hydrogen. This results in a storable product that can release energy in a controlled way: *an energy vector*. This hydrogen is called green hydrogen because it comes from a chemical reaction produced in the H2O molecule thanks to the 100% participation of renewable energy, which comes from the wind turbine.

The combination of wind turbines and electrolyzers results in greater efficiency of the available resource, fulfilling the two main objectives of current energy plans: renewable energy and high energy efficiency.

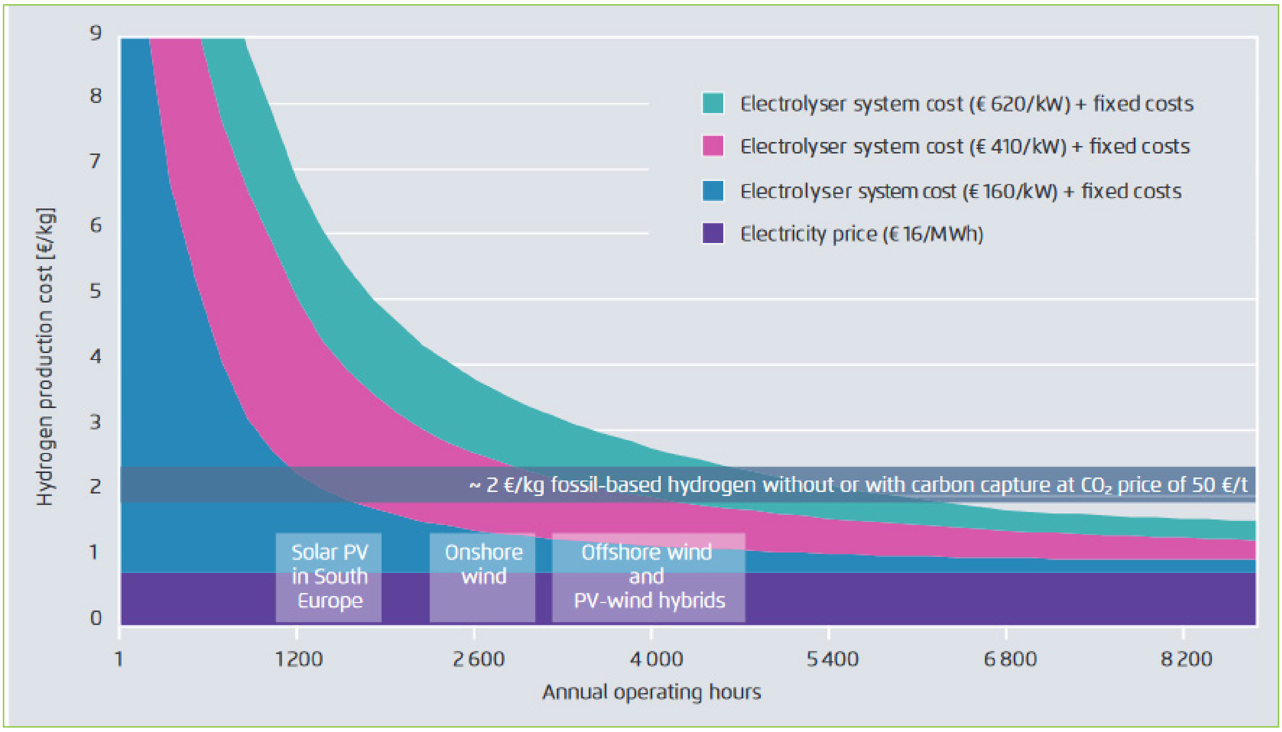
The Added Value of Green Hydrogen

Large-scale green hydrogen generation is a key element in the EU's climate action and the European Green Deal.[12] Hydrogen can be used as a renewable energy accumulator, as fuel and as an energy vector, and has great potential in hard-to-decarbonize sectors such as heavy industry, air and ground transportation, and construction. Its zero environmental impact, its abundance in the atmosphere, and the simplicity of the means to produce it will compensate for the still high electrical costs of renewable energy to make this gas a real alternative in the new Environmental Sustainability Framework.[13] Therefore, the European Commission set in its 2020 strategy for a climate-neutral Europe the goal of increasing hydrogen production fortyfold over the next ten years.[14]



European Hydrogen Strategy. Source: European Commission [15]

Offshore wind power will play a decisive role in the scaling of green hydrogen, as it is the source of renewable energy that can achieve lower production costs for it due to its greater number of annual operating hours. [16]



Hydrogen production costs vs. annual operating hours. Source: Agora Energiewende [17]

PART 2

Challenges of Offshore Production

The marine environment is both an advantage and a disadvantage for the infrastructures located there. The wind speed at sea is much higher, which allows generating much higher power than that produced by a land-based wind turbine, where the wind does find natural barriers (hills, mountain ranges, forests, cities,...). On the other hand, they are megastructures that may be settled 20 or 30 meters deep and more than 30 km off the coast, exposed to waves and a saline environment that accelerates corrosion. In this aggressive context, the installation and maintenance costs, especially for the support solutions for the elements that make up the marine infrastructures, pose a real challenge in order to advance in the development of offshore wind power.

Their location away from the coast and without displaced personnel **requires a very high reliability of operations.** Travel times in case of failure or emergency are increased and downtime periods consequently rise with the economic impact that this implies. The transport of hydrogen to land is carried out by umbilical or by means of ships, with the associated implications that result in higher costs.

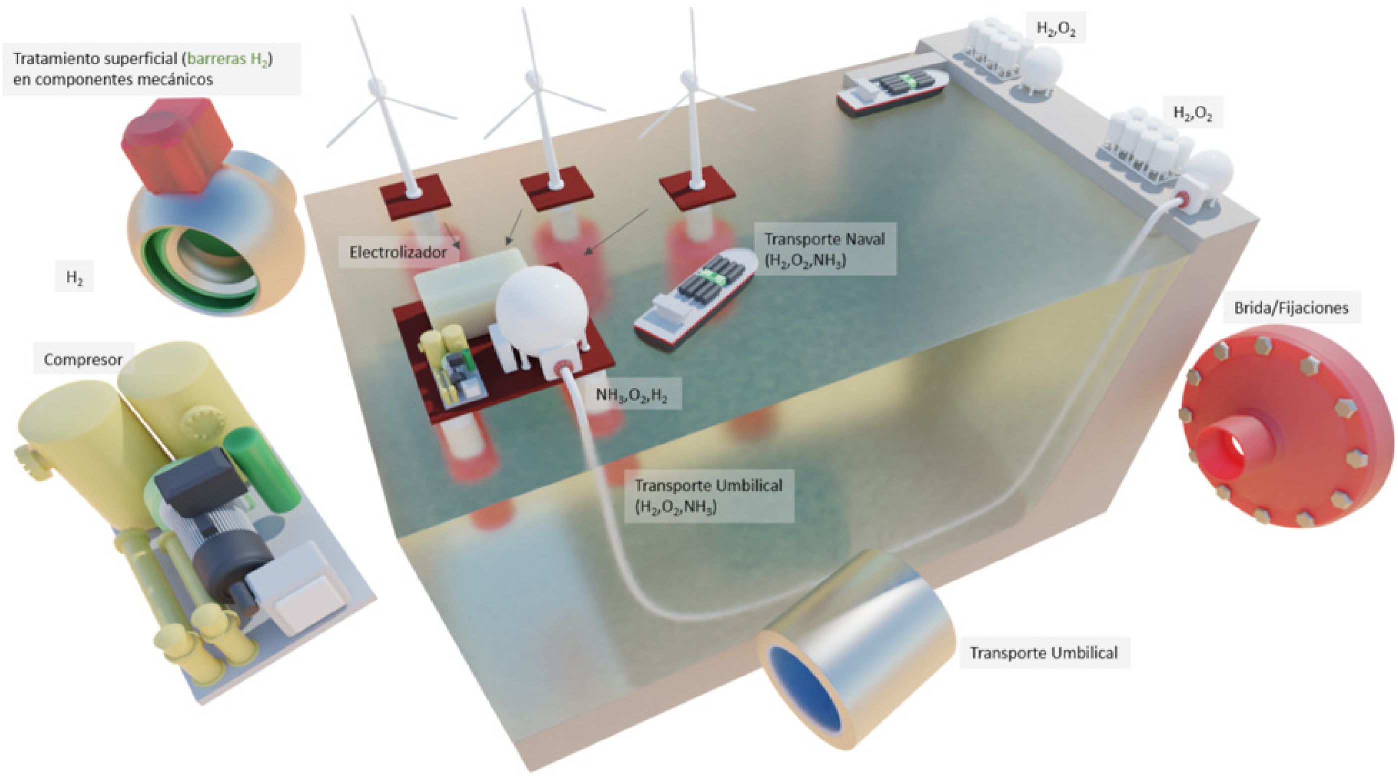
In the design phase, a correct selection of the location of the generation installation must consider for maximum utilization a balance between the best wind profile available in the area and the best support/ foundation solution. The location will also condition the means of transport to be used for hydrogen, so the design will have to take into account the typology of the seabed and the bunkering possibilities due to proximity to maritime lines.

In the operation phase, a complete monitoring and remote operation of all elements contributes to savings in the costs associated with exploitation. This monitoring, along with predictive simulations, allows for the anticipation of failures and unforeseen shutdowns, contributing to safety and a reduction in the plant's OPEX.

Case Study: HYSHORE Project

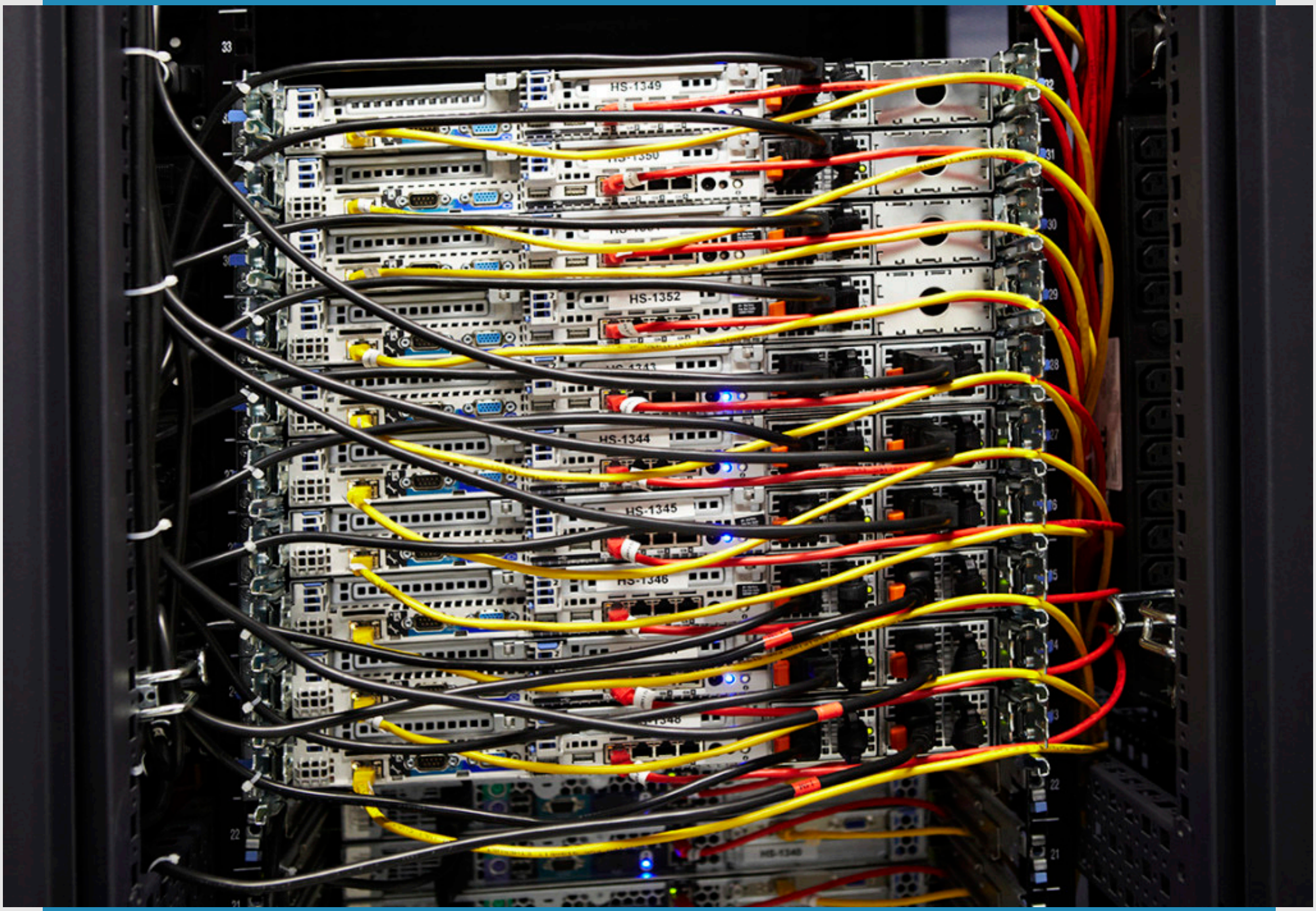
BOSLAN leads the HYSHORE project *"Experimental Development for the Transport and Logistics of Hydrogen generated in Offshore Wind Farms"*, promoted by the Basque Maritime Forum and framed within the HAZITEK program of support for business R&D of the Basque Government. BOSLAN exercises the technical coordination and integration of the project, defining the requirements and design criteria of the developments of the rest of the participating companies. It coordinates seven industrial companies with high specialization in their disciplines to achieve viable solutions that can be realized in real projects of hydrogen generation in very demanding environments for materials.

HYSHORE brings together AI-driven analytics for the best location of a green hydrogen generation installation offshore, and the development of a Digital Twin for monitoring and generating predictive failure models with PHM (Proportional Hazard Model) and Machine Learning techniques. The Digital Twin of the HYSHORE project, designed with the BIM collaborative work methodology, also allows analyzing capital and operating costs throughout its life cycle, forecasting amortizations based on fluctuations in the electricity market, wind profiles, and the marketed green hydrogen.



Hyshore Project. Source: BOSLAN

VIRTUAL POWER PLANTS: DIGITAL TWIN



Managers of industrial plants wish to improve their efficiency, make realistic production forecasts, and reduce operating costs. The promoters of these plants need to reduce execution times and avoid unwanted surprises in order to get returns. The decision centers of companies, possibly located many kilometers away, want to have access to real-time data on what is happening at each production center. Professional training requires greater contact with a reality where what has been learned can be experienced. All this in a situation where presence is not always possible. The 4th Industrial Revolution aims to respond to all these demands and for this, among other solutions, it offers what is called a Digital Twin.

Digital Twins are virtual replicas. They are 3D models that respond exactly like the realities they intend to simulate. They do the same as their Real Twin in response to external stimuli. This allows us to anticipate possible problems by analyzing all possible scenarios without the dangers that this can entail in real installations or Plants. One may think that their development involves many resources if going for an exact replica, but the concept of Digital Twin is very scalable depending on the final needs of the consumer.

Sensors play a fundamental role in this technology since they are the ones that collect real-time information on what is happening in the Plant that wants to be reproduced. The more sensors, the more information and therefore, the closer to reality. The collected information then becomes the key to success in a Digital Twin. Progress in Big Data, Cloud Computing, and the Internet of Things (IoT) has facilitated the implementation of the necessary sensor technology to faithfully simulate reality. The definitive implementation of 5G networks in telecommunications infrastructure will reduce connection wiring, but above all, visualize and manage in reasonable times all the huge amount of data that this technology generates and that are stored in the Cloud. The idea that was born at NASA 50 years ago as a solution to predict failures in aerospace devices is today a realistic solution to design Digital Twins of industrial Plants.

In the energy sector in particular, where the push for Renewable Energies and Hydrogen has been the protagonist in all local and international energy roadmaps, the Digital Twin acquires an even greater importance. Wind turbines, photovoltaic panels, or electrolyzers are modular and integral devices that can leave the factory with the potential for a Digital Twin. Their implementation in the field with low/moderate development investments allows creating a Digital Twin of an entire Energy Installation. Conventional Power Plants that due to their size and complexity require a high process of integration require an effort and investment that possibly still today represents a great obstacle.

Digital Twin technology helps to cut operation and development costs, increase the safety of operations, and shorten development times. The latter is especially relevant in the current context of a climate emergency, which has created an urgent need to accelerate decarbonization.

HYSHORE allows BOSLAN to continue advancing in the design of clean energy solutions to achieve more efficient and safer installations. It enables the teams to equip themselves with advanced knowledge and tools to address each project comprehensively, as well as guaranteeing an agile, personalized, and reliable response with the required quality levels.

The technology of the Digital Twin is transversal to all engineering specialties, and BOSLAN can turn it into their basic working tool with which to offer a better solution to the future needs of its clients.

PART 3

BOSLAN, PIONEER IN HYDROGEN PROJECTS

BOSLAN is a pioneer in Spain in the technical direction of hydrogen projects and has experience in the integral management of renewable gas projects from their initial phase by conducting feasibility studies (technical-economic), the project phase, developing engineering and processing permits and licenses, as well as in the construction phase carrying out contracting engineering tasks and technical assistance in equipment purchasing, in addition to the direction and supervision of work.

The leadership of the HYSHORE project allows BOSLAN to develop its own know-how of the best solutions for the transportation of hydrogen in a marine environment from offshore platforms for the generation of green hydrogen.

In turn, **BOSLAN exercises the Technical Direction of the Puertollano hydrogen project for IBERDROLA,** as well as the contracting engineering tasks and supervision of work in the plant, quality, and environment. This is one of the hydrogen technology projects developed by IBERDROLA, and in which it has trusted BOSLAN for the provision of services from the contracting phase to commissioning. This project, developed at Fertiberia's facilities, involves the construction of a hydrogen and oxygen production plant by electrolysis from renewable sources, integrating both products into Fertiberia's productive process and is framed within the agreement signed by both companies for the development of this technology.

This collaboration has been recently strengthened as BOSLAN has been chosen by IBERDROLA as one of the companies included within the alliance for the development of the **Basque Hydrogen Corridor**, along with other companies in the region.

BOSLAN is also providing services in another hydrogen project that IBERDROLA is developing for TMB, in Barcelona. This project consists of the construction and commissioning of a hydrogen generation plant through water hydrolysis (green hydrogen), with storage capacity and which will supply hydrogen to adjacent facilities (hydrogen stations) to supply the bus fleet of *Transportes Metropolitanos de Barcelona* (TMB).

BOSLAN, A MULTIDISCIPLINARY ENGINEERING AND CONSULTING COMPANY

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BOSLAN is a company with over 20 years of experience offering specialized engineering and consulting services. It has offices in 9 countries and employs 750 people, who participate in projects in 30 countries.

BOSLAN has an organization divided into activity areas from where all the engineering work, technical direction, tests, and commissioning are coordinated and executed in the energy sector, in oil & gas, in various industrial sectors and infrastructures.

Thanks to the multidisciplinary nature of the different departments and the experience acquired in multiple projects, BOSLAN is configured as an integrative engineering and project development company.

With the capacity to accompany its collaborators and clients throughout the entire business cycle: feasibility studies, project submission for funding, conceptual designs, detailed engineering development, project direction and coordination, construction supervision, and commissioning.

As part of its strategy, BOSLAN is committed to R&D investment, to equip itself with knowledge, advanced design tools, and BIM development methodologies, to approach each project comprehensively, as well as guaranteeing a agile, personalized, and reliable response with the required quality levels. Always seeking to exceed our clients' expectations and become their trusted partners.

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