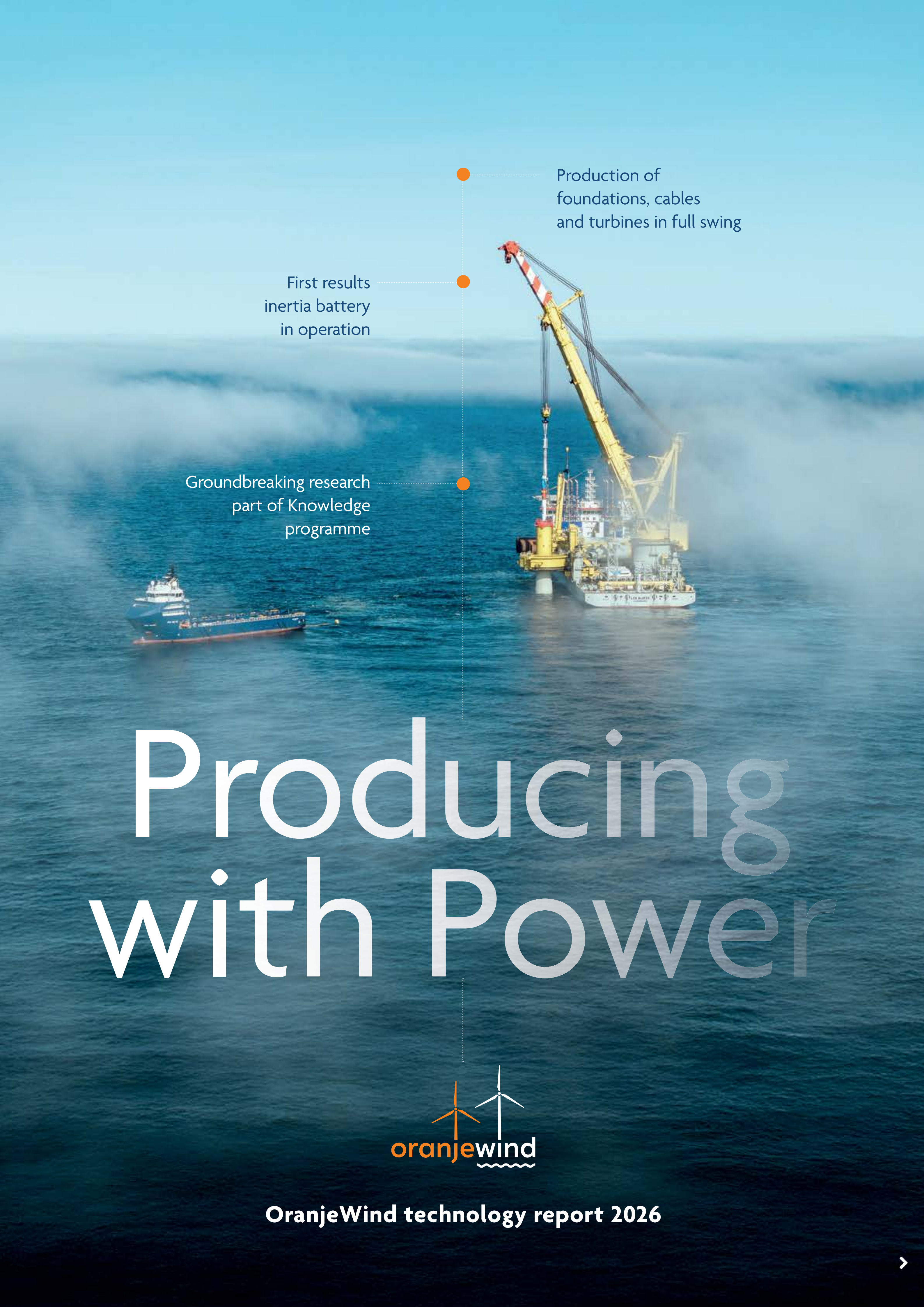


Production of foundations, cables and turbines in full swing

First results inertia battery in operation

Groundbreaking research part of Knowledge programme

Producing with Power

oranjewind

OranjeWind technology report 2026

FOREWORD

It gives me great pleasure to introduce this second OranjeWind technology report, *Producing with Power*. That phrase sums up exactly where we stand today. Whereas last year's efforts centred on setting up this complex and exciting project, we are now in full fabrication phase and have started the first offshore installations.

Our focus now is on ensuring timely delivery of the constituent elements of the wind farm. Our decision-making has become faster, our co-ordination tighter, and our teamwork closer than ever. This is a highly energised and absolutely critical phase.

Manufacturing in progress and offshore construction started

We already have a number of key milestones behind us. During the summer of 2025, the grid operator TenneT completed the offshore substation, which in due course will take the inter-array cables (see p. 18 for the full report). The Royal Netherlands Navy did outstanding work in securing the OranjeWind site, successfully removing three items of unexploded ordnance from the seabed without incident. And manufacturing is now under way, with almost all key components – foundations, turbines and cables – to be built in several brand-new factories.

While such a project always faces some challenges, these have been successfully managed, and our installation schedule is on track. We plan to deliver the first wind power to the grid in April 2027, and the commercial operation date (COD) is the end of that year. Producing with power on many fronts during the construction phase, we are more committed than ever to our goal of delivering the project without any major HSE incident and building up a new operations team in the Netherlands.

Innovations demanding more energy from the teams

Besides the wind farm project, we also have to realise many sub-projects for the innovations and system integration assets with our teams and partners. There have been certain technical and company-related challenges which have led to changes. This is almost inevitable in an undertaking that explores the potential of highly innovative technologies in an extremely demanding operating environment. Such was the case with our sub-surface energy storage project. Investigations by our partner Ocean Grazer showed this concept to be unfeasible in the context of OranjeWind, and the company regrettably went into administration. Meanwhile, the realisation of the sub-sea battery, floating PV and other system integration assets needed additional energy from the teams.

Committed and energised

We have learned a great deal in the past year. Our OranjeWind Knowledge programme is developing well. We now have six PhD candidates working on various aspects of system integration of offshore wind on the North Sea. The Knowledge programme is unique in its direct outreach to universities, policy-makers, schools and industry – who we stimulate to produce with power – and provides a blueprint for educating society to the value of large-scale, integrated sustainable energy solutions.

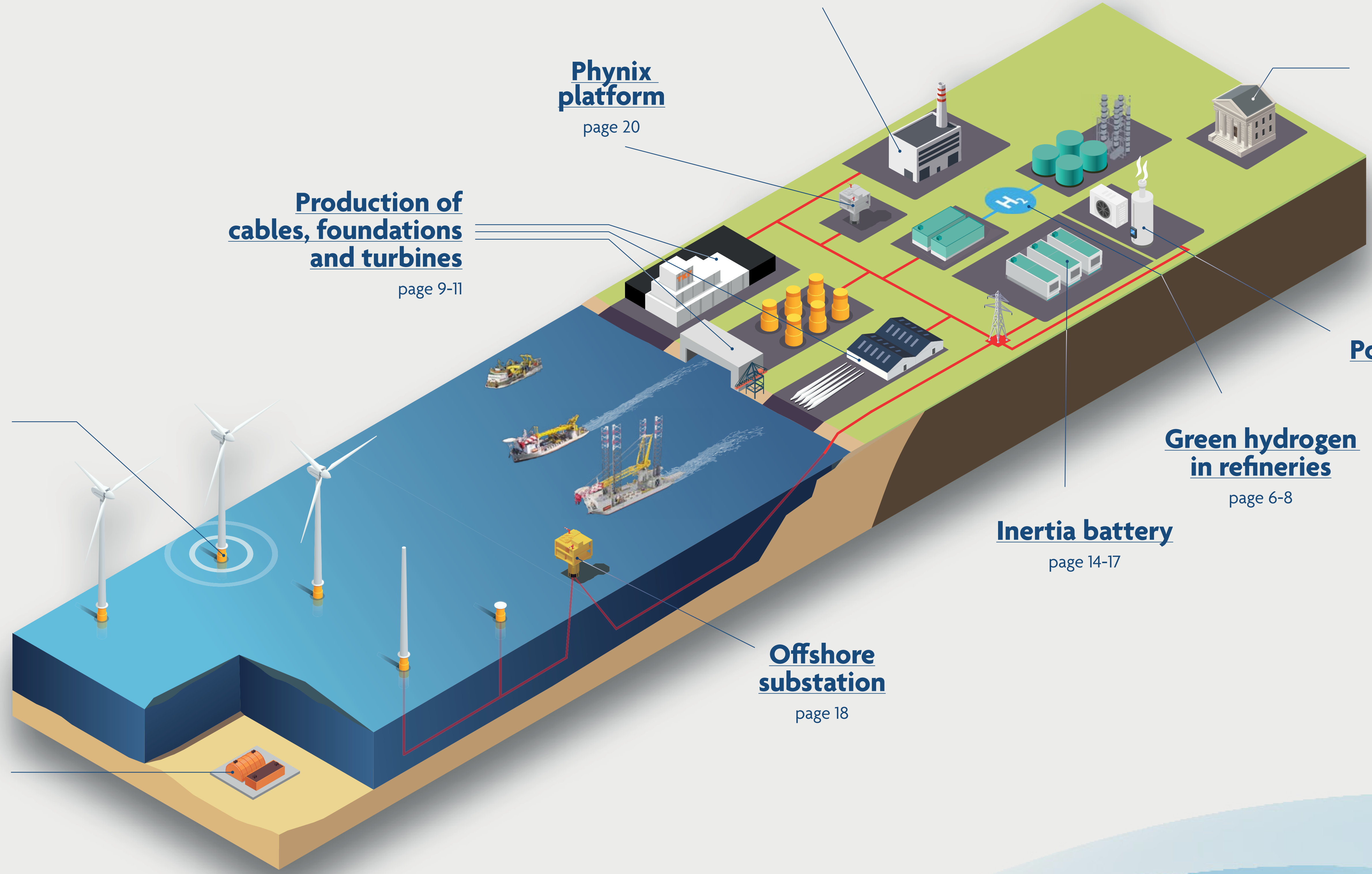
We remain as committed and energised as ever, while our partnership with TotalEnergies is as effective as it is enjoyable. I would like to take this opportunity to thank everyone involved in OranjeWind for everything that they are contributing to this transformative undertaking.

I hope you will enjoy this second technology report and I am already looking forward to introducing the third … with the first turbines producing green power!

Kind regards,

Matthias Esken | Project Director OranjeWind

Table of Contents



The key role of green hydrogen in reducing emissions in industrial processes

Green hydrogen – hydrogen produced via electrolysis powered by renewable energy – has a key role to play in the energy transition. In our 2025 technology report, we described the production of green hydrogen as the most ambitious and wide-ranging of all the system integration applications in the OranjeWind Project.

TotalEnergies has set itself the target of using up to 500 kt/year of low-carbon or green hydrogen in its European refineries as of 2030, subject to the implementation of regulatory frameworks that effectively support the reduction of the carbon footprint. A core goal is direct coupling of offshore wind power and hydrogen production, using electricity from the OranjeWind offshore wind farm. This is essential in order to build a credible, low carbon hydrogen value chain rather than isolated demonstration projects for green hydrogen.

It was in this context that in last year's technology report Laurent Ferry, Director for the Zeeland Hydrogen Project at TotalEnergies, introduced TotalEnergies' plan to build what will be one of the largest electrolysers in Europe. This electrolyser will enable the production of up to 30,000 tons of green hydrogen a year. It will be supplied by renewable energy produced by OranjeWind.

The Zeeland electrolyser

On 18 February 2025, TotalEnergies and Air Liquide signed an agreement to set up a 50:50 joint venture to build this 250MW electrolyser to reduce emissions associated with the hydrogen used in Zeeland Refinery. This Zeeland electrolyser project entered the engineering and design phase in 2025 and is targeting a final investment decision in 2026.

In addition, TotalEnergies signed a 130MW tolling agreement under Air Liquide's ELYgator electrolyser project, located in the Maasvlakte (a man-made extension of the Port of Rotterdam), to supply the TotalEnergies Antwerp platform. This project reached FID in July 2025.

> "This electrolyser will enable the production of up to **30,000 tons of green hydrogen** a year."

In combination, the two projects will contribute an emissions reduction of up to 450kt CO_2 per year for TotalEnergies' refineries. They will help establish Rotterdam and Zeeland as early European hydrogen hubs.

The role of green hydrogen production in decarbonizing refineries

1. How does the production process work?

The main process for producing green hydrogen is to apply electricity to demineralized water, thereby separating it into hydrogen and oxygen, a reaction that would not naturally occur otherwise. The electrolyser (the industrial device realizing this process) therefore contains multiple cells with electrodes and an electrolyte. When current flows, water splits at the anode (the positive terminal) to produce oxygen and protons. Approximately 9 kg of demineralised water is required to produce 1 kg of hydrogen and 8 kg of oxygen.

The hydrogen is collected and compressed for use in applications such as mobility fuel cells or industrial processes, while oxygen is released as a valuable co-product that can be used in a range of applications in refining, petrochemical processes, and a variety of industries ranging from steel manufacturing to medical gases. The demineralised water itself is produced on site from treated industrial water by means of technologies such as reverse osmosis and deionisation.

2. What are the main areas of application for green hydrogen?

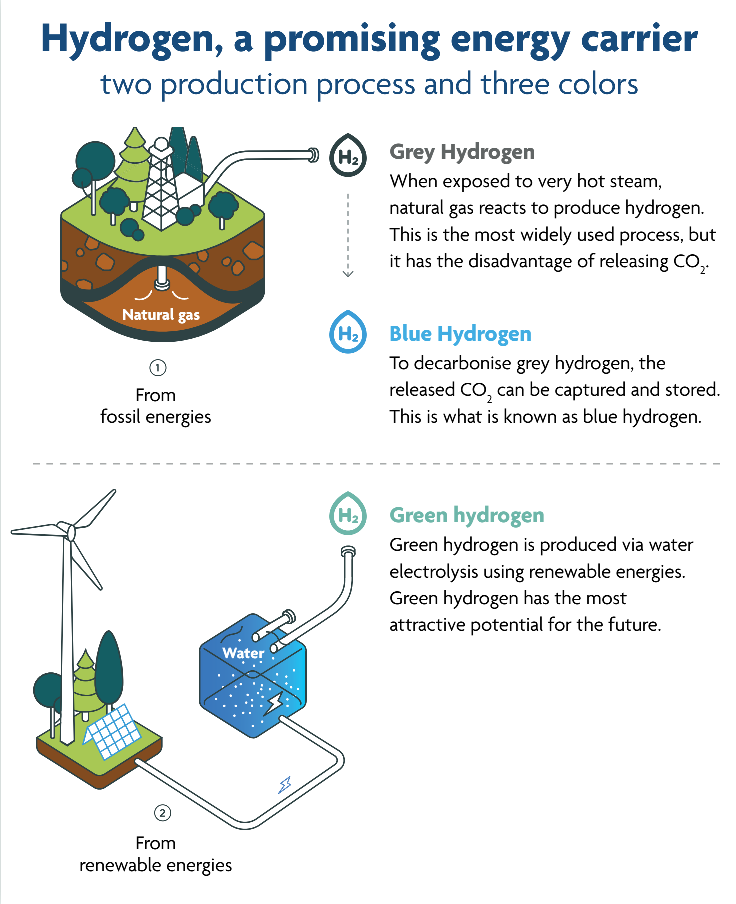
Green hydrogen is primarily used to decarbonise industrial processes by replacing hydrogen produced from fossil fuels in sectors such as refining, chemicals, and steel, significantly reducing CO_2 emissions.

When used in fuel cells, it generates electricity with only water as a by-product, making it particularly suitable for zero-emission mobility in heavy transport where battery solutions are less practical.

It can also be blended into existing natural gas networks, gradually lowering the carbon intensity of gas used for heating and industry without requiring entirely new infrastructure.

Finally, green hydrogen acts as an energy storage solution by absorbing surplus renewable electricity during periods of high wind or sun and releasing that energy later, helping to balance the intermittent nature of renewable power generation.

3. Why is it called green hydrogen and what is the difference with grey and blue hydrogen?



4. How does green hydrogen help decarbonise industrial processes?

Refineries are major consumers of hydrogen, which is today predominantly supplied as grey hydrogen produced from natural gas via steam methane reforming (SMR), a process that entails significant direct CO_2 emissions.

Replacing grey hydrogen with green hydrogen, produced through electrolysis using renewable electricity, enables refineries to substantially reduce these emissions at source. In addition to its CO_2 mitigation potential, the use of green hydrogen also enhances energy security by reducing refineries' dependence on imported natural gas and fossil-based feedstocks.

How is green hydrogen used in refineries?

Desulphurisation
Hydrogen plays a crucial role in several refinery processes. One of its most important uses is in **desulphurisation**, a method that reduces the sulphur content in fuels such as diesel and petrol. High sulphur levels in fuel contribute to air pollution, including sulphur dioxide (SO_2) emissions, which can cause acid rain and respiratory problems. By using hydrogen to remove sulphur, refineries help meet environmental regulations and produce cleaner-burning fuels.

During this desulphurisation process, hydrogen reacts with sulphur compounds present in fuels. The mixture of fuel and hydrogen is passed over a catalyst at high temperature and pressure, causing the sulphur atoms to break away from the hydrocarbon molecules. These sulphur atoms then combine with hydrogen to form hydrogen sulphide (H_2S), a gas that can be safely separated and processed further.

This method enables refineries to produce fuels with much lower sulphur content, helping them comply with environmental standards and reduce harmful emissions. This not only lowers SO_2 emissions but also helps reduce secondary pollutants like fine particles and indirectly cuts other harmful emissions, such as nitrogen oxides (NO_x).

Hydrocracking
Another vital application for hydrogen in refineries is **hydrocracking**. Hydrocracking is an advanced refining process that transforms heavy fractions of crude oil into lighter, more valuable products. In this method, heavy oil molecules are exposed to hydrogen and a catalyst under high pressure and elevated temperatures. The combination of hydrogen and catalyst causes the large, complex hydrocarbon chains to break apart, or 'crack', into smaller molecules. This chemical reaction produces lighter fuels such as diesel, jet fuel, and naphtha.

"Hydrocracking is an **advanced refining process** that transforms heavy fractions of crude oil into lighter, more valuable products."

The presence of hydrogen is essential, as it saturates the newly formed hydrocarbon fragments, making the resulting fuels more stable and cleaner-burning. Hydrocracking is a key process for refineries seeking to maximise the yield of high-quality fuels from each barrel of crude oil.

Production in full swing

Producing with Power means efficiently channelling the energy of every aspect of OranjeWind. We are building a wind farm that draws substantially on European manufacturing capabilities. In a strong demonstration of the case for sustainable wind energy, a significant proportion of those components are being produced in state-of-the-art new factories, using renewable energy supplied by wind turbines.

Critical to the success of this ambitious undertaking is the contribution of our suppliers. With the project now fully in the production phase, we shine a light on three vital project partners: Sif, responsible for manufacturing the monopiles on which the wind turbine generators will be mounted; TKF, who are producing the inter-array cables (IAC) that will connect the individual wind turbine generators to one another and the string to the substation; and Vestas, tasked with the manufacturing and installation of the wind turbine generators.

The sustainable electricity produced by OranjeWind will be transferred to the offshore substation that has been built by the grid operator TenneT, another key partner in the OranjeWind project, as described on page 18 of this report. Subsequently, the power is transmitted via an export cable to the landing point in Wijk aan Zee.

Sif OFFSHORE FOUNDATIONS

Serving over a third of the European market, Sif has been a frontrunner in monopile foundations for offshore wind farms for almost a quarter of a century. Today, the company's monopiles support a total of 22.7 GW of installed offshore capacity, equivalent to the annual energy requirements of 23 million households.

Sif typically operates on the basis of 'build to print' contracts. This means that the design of the monopile is usually executed by an engineering company contracted by the windfarm developer. Sif then uses this design to guide its own production process, from preparation of the steel plates that will be rolled and welded to create each monopile through non-destructive testing, flange fitting, and finally the application of internal and external coatings.

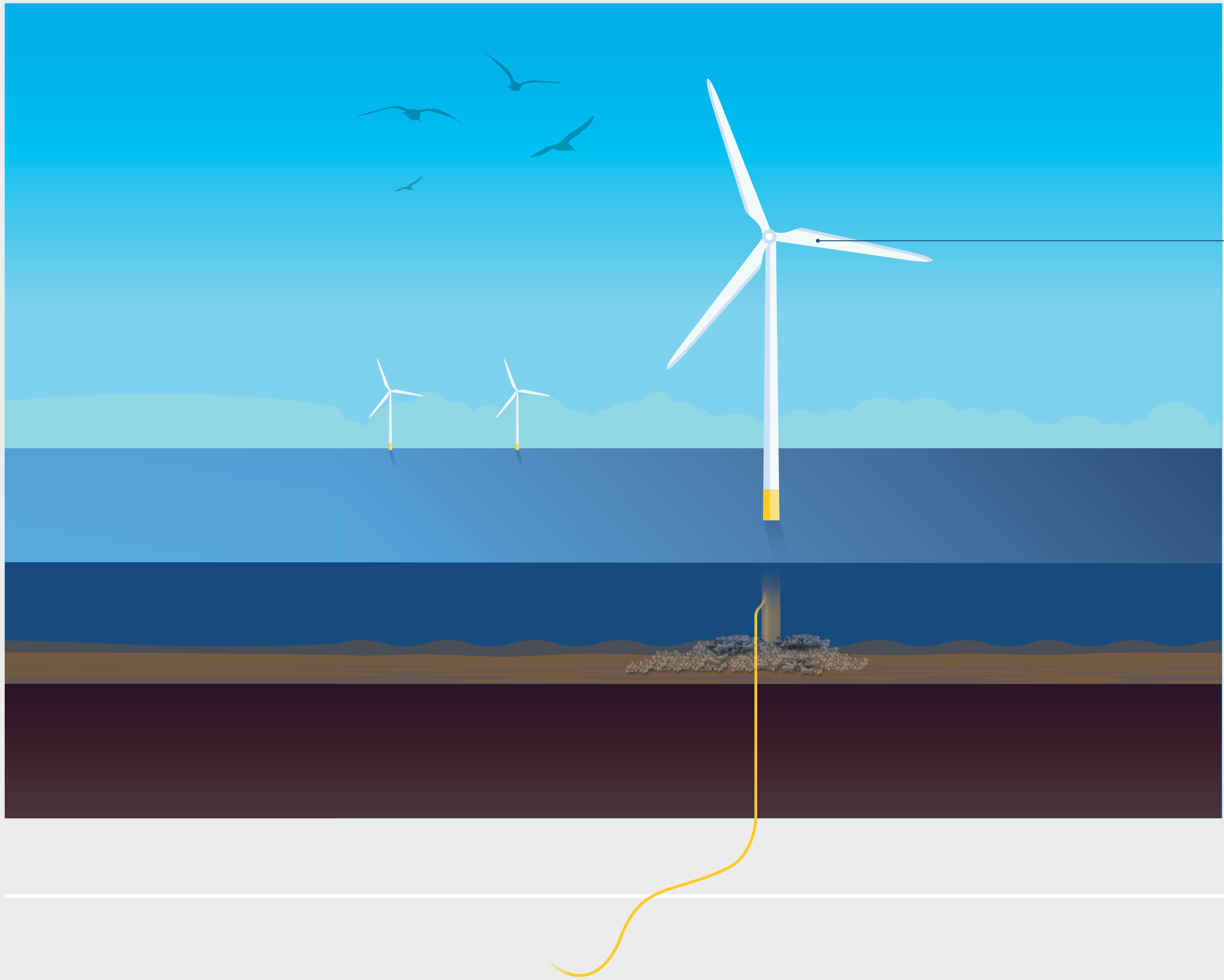
Sif is supplying 53 monopile foundations with a total weight of approximately 80 kilotons – roughly equivalent to eight Eiffel Towers – for OranjeWind's turbines. Fabrication of the secondary steel components – such as platforms and boat landings – by the multidisciplinary construction company Smulders commenced in Poland in October 2025, while Sif itself started manufacturing the top sections of the monopiles in Roermond in December 2025. The first load-out onto a sea-borne vessel for transportation to the offshore installation site is scheduled for August 2026, with the final one planned for the week of December 2026.

Continues on page 10 >

Stefan Erents | Programme Manager Product Development, Sif

Kevin van Hoesel | Project Manager, Sif

Offshore monopiles
An offshore monopile is a thick-walled, cylindrical steel tube that is driven deep into the seabed by means of a hydraulic hammer or a vibratory pile driver to create a stable base for a turbine tower. Offshore monopiles are typically between 6 and 11 meters in diameter. The OranjeWind monopiles range from 80 to almost 95 meters in height, roughly the same height as the Big Ben in London. Their weight, meanwhile, ranges between 1,300 to around 1,600 tonnes, the equivalent of almost 300 fully grown African elephants. They are particularly suited to shallow or medium water-depths, which characterise the North Sea.



Frank Spee | Vice President, Engineering & Technology Offshore, Vestas

With a total installed capacity of 200 GW reached at the beginning of 2026, Vestas became the first company worldwide to surpass this milestone, reflecting 30 years of innovation in the offshore wind industry – including an extraordinary scaleup from early ~0.5 MW turbines to today's 15+ MW offshore machines.

Building on this legacy, Vestas is supplying OranjeWind with 53 of their V236 wind turbines, a cutting-edge technology that is already being installed in a number of other wind farms. With a power rating of 15 MW, each turbine has a hub height of 143 metres and a rotor diameter of 236 metres. Imagine something the height of the 63-story high Messeturm in Frankfurt, Germany, turning out enough sustainable electricity to power some 20,000–25,000 European households worth of electricity per year.

Since 2020, Vestas has sourced 100 percent renewable electricity across its own operations globally. As a company that designs, manufactures, installs, and services both onshore and offshore wind turbines worldwide, Vestas brings deep experience across all project environments. Installation at sea presents significant logistical challenges, as does maintenance. The wind and wave characteristics of the North Sea – one of the roughest seas in the world – are well known, but the prevalence of winter storms means that careful advantage must be taken of 'weather windows' for installing the turbines. With pre-installation planned for December 2026 and loading onto transport vessels scheduled for 2027, production is now ramping up in Vestas' supply chain. This calls not only for a high level of technical and operational expertise but also for strong working relationships and project management.

Laurens Pots | Director R&D Power Cables, TKF

Originally founded in Haaksbergen, in the eastern Netherlands, as a cable manufacturer in 1930, TKF is a technology leader in connectivity solutions, offering a broad portfolio of cables, systems and services for creating secure and reliable energy and data connections.

The company's commitment to the wind energy sector is evidenced not only by its cutting-edge solutions but also by the fact that its operations are 100% wind-powered, and the factory in Eemshaven is CO_2-neutral. TKF currently supplies more than two thirds of wind farm projects in Europe with IAC cables and is providing the IAC cables for OranjeWind.

IAC cables have a dual function, connecting the individual turbines to one another and also connecting the wind farm to the TenneT offshore substation. Subsea cabling is subject to intense environmental pressures and therefore has to be extremely robust and reliable. The IAC cables for OranjeWind are being manufactured in a dedicated factory in Eemshaven whose annual capacity has been expanded to 1,200 km of IAC cable. The TKF IAC cable is lead- and bitumen-free, preventing the leakage of chemicals and metals into the marine environment and enabling clean and easy installation as well as good recyclability.

"TKF is a **technology leader** in connectivity solutions, offering a broad portfolio of cables, systems and services."

The power cables themselves are covered with an aluminium laser-welded sheath, ensuring exceptional durability and 100% protection against water ingress. This sheath also protects the integrated fibre optic cables that facilitate high-speed data transmission. Highly impact-resistant, the TKF IAC cable can also withstand high pulling forces, permitting it to be laid in more challenging weather conditions.

With production of the IACs already under way, load-out to the cable-laying vessel is scheduled for November 2026, with the installation campaign to be finished in the second quarter of 2027.

Power to Heat:

Advancements in sustainable heat delivery

E-boilers and heat pumps turn renewable electricity into useful heat, covering demand that would otherwise have to be met by fossil-fuel-based sources. They also have an important role to play in balancing the grid. Both technologies are fundamental to OranjeWind's system integration concept, whose goal is to flexibly match energy supply from wind power with onshore energy demand. David Yamoah, Asset Development Manager at RWE, discusses the progress made with these two technologies in the past year.

David, for anyone not familiar with e-boilers and heat pumps, could you explain these two technologies?
Of course. Electric boilers, also known as e-boilers, convert electricity into heat by ionizing water in a half-filled pressurized tank. The electric current ionizes the water and turns it into steam. E-boilers switch on when electricity is abundant, thereby making use of surplus renewable power that might otherwise be curtailed, and they're typically used for industrial heat processes and district heating networks.

Heat pumps, which are up to three times as efficient as e-boilers, likewise use surplus renewable electricity, but their approach involves exploiting ambient heat in air or water. Making use of a compressor, a refrigerant and a heat exchanger, they take a heat source, increase its temperature, and transfer it to where it's needed. Heat pumps likewise have both industrial and district heating applications. However, they cannot be switched on and off as fast as an e-boiler. They're more suitable for baseload operations.

Because they can absorb renewable output even during periods of low electricity demand, both of these power-to-heat solutions can help prevent curtailment of wind power generation. They thus contribute to a more optimal balance between supply and demand. And as replacements for fossil-fuel technologies, they of course also play an important role in helping to decarbonise the electricity and heat sectors.

Last year, it was announced that a 34 MW e-boiler was being built at the RWE power plant in Eemshaven. What's the status of this project?
Commissioning occurred according to plan, and the e-boiler was handed over for commercial operation on 19 December 2025. RWE had previous experience of building e-boilers in Germany, but this was the first time we had built one in the Netherlands, where the regulations are rather different. Furthermore, integrating such an installation into a complex existing power plant is always a challenge. The construction process was carried out by the Norwegian manufacturer PARAT Halvorsen on RWE's behalf and went extremely smoothly, I'm delighted to say.

David Yamoah | Asset Development Manager at RWE

ECW Energy partners with OranjeWind in system integration approach

The private utility company ECW Energy is supporting OranjeWind's system integration approach through the installation of three e-boilers at Agriport A7 near Middenmeer, North Holland.

Agriport A7 is a large agro-industrial and logistics hub, purpose-built to unite horticulture, energy and data infrastructure in a single location. With one of the largest concentrations of greenhouses in Europe, Agriport 7 deploys advanced climate control, hydroponics (a method of soilless cultivation) and automation to produce vegetables such as tomatoes and bell peppers all the year round. ECW Energy was established by the major greenhouse operators at Agriport 7 to provide energy for this high-tech production ecosystem.

New partnership agreed

ECW's ownership of its own closed distribution system, its substantial heat demand, and its professional energy production and trading activities make it an ideal partner for OranjeWind's system integration activities. This is an excellent example of how renewable electricity can be put to good use for heat demand that otherwise would be met by fossil natural gas.
Three e-boilers with a total combined installed capacity of 50MW have been developed by ECW Energy for three of their partners: Horticulture Kwekerij De Wieringermeer (10 MW), Horticulture Helderman (10 MW), both producers of sweet peppers, and Horticulture Royal Pride (20 MW), a producer of tomatoes. All e-boilers have been supplied by PARAT Halvorsen. The 10 MW e-boiler at Helderman is currently in its testing phase, while the other two are available for commercial dispatch.

Improved sustainability footprint

The e-boilers will be used to improve the sustainability footprint in a utility setup consisting of existing combined heat and power units that run on natural gas plus biomass installations. The horticultural companies aim to reduce future price risks, and OranjeWind and ECW Energy are jointly exploring how collaboration through trading products can support this objective. OranjeWind will provide ECW Energy with access to its trading platforms.

Ensuring stability for the grid of the future

Inertia Battery now in commercial operation

The 2025 OranjeWind technology report explained the technology of an inertia battery and the potential role of inertia batteries within OranjeWind. In June 2025, OranjeWind's first inertia-ready battery energy storage system (BESS) started commercial operation on the site of RWE's power plant in Moerdijk, the Netherlands. Rajiv Hotchandani, Battery Project Developer, reflects on the progress of the past year.

Rajiv, the Moerdijk synthetic inertia battery has been in operation for more than nine months now. What does this mean for the OranjeWind project as a whole?
The inertia battery is one of the important innovations being explored within the framework of OranjeWind's system integration approach. This is not the first battery in the world that delivers synthetic inertia, but it's the first that's connected to the Central European high voltage grid. The European grid is the world's largest synchronous grid, and one might describe it as the most complex machine in the world. Just think: what happens on one side of the grid is instantaneously felt on the opposite side, despite the vast distances involved.

Rajiv Hotchandani | Battery Project Developer

So, we were extremely happy when we first tested the live connection and found that the battery worked exactly as intended, reacting within milliseconds to provide grid stability as and when required. This is a great achievement in itself, and it promises very well for the OranjeWind project as a whole.

What technical challenges had to be overcome before the inertia battery went into operation?
There were quite a few, because at Moerdijk we were integrating a new technology into an existing combined cycle gas turbine (CCGT) power plant – an electricity generation facility that uses both gas and steam turbines. It's essential not to disrupt the system in any way when the connection goes live. Our initial tests involved the simulation of inertia events to measure the rate of change of frequency (ROCOF) and ensure that the system reacted as expected.

> "We were extremely happy when we found that **the battery worked exactly as intended**"

Based on the results of the test protocol, TenneT granted us authorisation to continuously run the inertia battery in grid-forming mode. Following additional testing and alignment, we've been doing this since mid-February of this year. We're piloting the battery in three-month periods during which we test specific sets of operating parameters to determine which are the most effective.

Is the Moerdijk inertia battery capable of further optimisation?
That's certainly the object of this pilot, which was scheduled to run until the summer of 2026, with a possible extension to allow us to gather further information. Thus far, we've been using parameters that we knew would work, but we'd like to test the battery with parameters that are set closer to its operating boundaries. It's important to understand what the system does to the battery, and how the battery ages.

The tests we're currently conducting will help develop operating standards which will be mandatory for all synthetic inertia batteries in the Netherlands in future. They will also give us valuable insights into developing tests for other types of batteries, and not just batteries capable of delivering inertia.

And do we have any initial results yet?
We have incontrovertible proof of concept. This occurred in the context of the extraordinary blackout of 28 April 2025, which was the most severe blackout incident to occur on the European power system in more than two decades, and the first ever of its kind.

At 12:33 CEST on that day, the power systems of continental Spain and Portugal experienced a total blackout. A small area in Southwest France close to the Spanish border experienced disruptions for a very short period, and several industrial consumers and generators were affected.

This unprecedented event happened by chance during our first week of testing the inertia battery. Although the frequency deviation in the Netherlands remained limited, the battery rapidly responded by delivering synthetic inertia. In doing so, it made a contribution to stabilizing grid frequency, proving the operational functionality of the technology for the first time. The event underscores the added value of batteries for the resilience and stability of the power grid.

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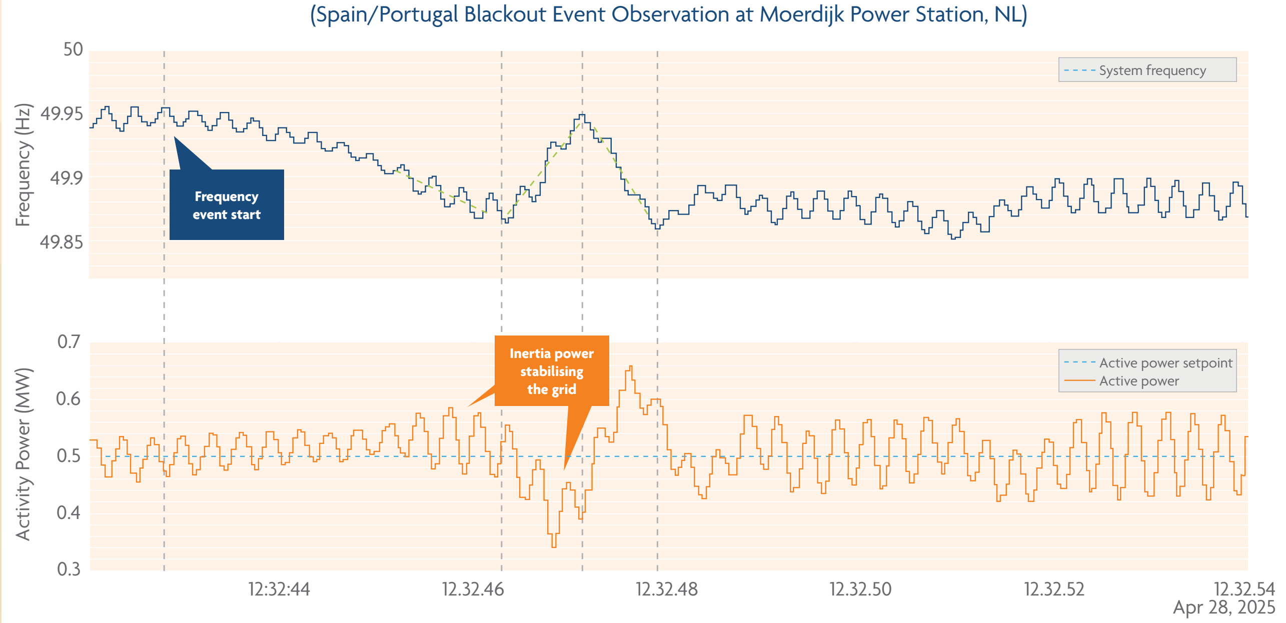


Grid stabilisation by OranjeWind inertia battery during the Spain/Portugal blackout event on April 28th
(Spain/Portugal Blackout Event Observation at Moerdijk Power Station, NL)

"I'm convinced that synthetic inertia batteries will have a **pivotal role** to play in the future"

It's no surprise, then, that the case for using inertia batteries to balance the grid is growing stronger all the time. As a commercial company, RWE has to provide solutions that are not only technically robust but also financially viable. The provision of synthetic inertia creates additional value for the system. We're therefore preparing for a future where, given the right incentives, all batteries installed by RWE will have grid-forming capability.

Are there plans to build further inertia batteries within OranjeWind?
Yes, indeed. We are developing a very large inertia-ready battery for OranjeWind with a power capacity of approximately 400 MW and storage in the region of 800 MWh. Like our test model, which has a power capacity of 7.5 MW and 11 MWh storage, it will also have grid-forming capability. This means that the battery storage system will have the technical capability to set its own voltage waveform and frequency, rather than passively following an existing grid signal. It will thus be able to provide synthetic inertia.

What might be the role of inertia batteries in ten years' time, do you think, Rajiv?
European Grid operators are currently working on a new set of requirements. I can imagine that there will be a requirement for all large-scale batteries which are connected to the high-voltage grid to have grid-forming capability. These updated Network Code Requirements for Generators, NC RfG 2.0, are due in 2028. From today's perspective, I cannot make precise predictions, but I'm convinced that synthetic inertia batteries will have a pivotal role to play in providing stability to the European electricity grid of the future.

The rationale for synthetic inertia

The standard grid frequency in Europe is 50 Hz, and all devices connected to the grid are designed to operate on this frequency. Deviations consequently can result in damage and grid failures. However, the frequency of the grid is not automatically constant, due to many variables such as the market conditions, the weather and the season (the ratio of grid following inverters delivering power to the grid is much higher when it is sunny or windy). The behaviour patterns of those using it also have a major influence, of course. It is therefore necessary to keep the grid stable by actively resisting such sudden changes in frequency. This is achieved through the power of inertia.

In conventional fossil-fuel power stations, the spinning mass of heavy turbines naturally resists sudden changes in rotating speed: the turbines 'want' to continue at the same pace, even if external forces are 'telling' them to slow down or speed up. The inertia within them therefore acts rather like a shock absorber on the grid, keeping the turbines turning at the same rate and thereby helping to maintain a stable frequency within the network.

Replacing conventional power plants with renewable sources of electricity such as wind and solar means phasing out the turbines with their inherent capacity to deliver inertia. Unless addressed by some other means, this would lead to a lack of inertia in the grid, a less stable frequency, and therefore a less reliable electricity supply. The stabilising influence of inertia has to be provided by some means. Hence the need for synthetic inertia.

Inside the inertia battery

RWE's inertia battery energy storage system in Moerdijk is powered by lithium iron phosphate (LFP) batteries housed in three containers, and it has the ability to provide or absorb electricity within milliseconds, to meet the demands of the grid.

The innovation lies in the highly reactive 'grid-forming' inverters with which they are equipped, which can set their own voltage waveform and frequency and thus provide inertia by not 'following' the grid.

The software and hardware on the inverters have been upgraded so that they can make measurements and perform appropriate adjustments in milliseconds, thereby providing virtual inertia. The inverter allows the battery to operate independently of fluctuations in the grid to which it is connected by establishing its own stable voltage and frequency.

Investigations into Solid Oxide Electrolyser Cell (SOEC) technology

In addition to the inertia battery, OranjeWind has been working on the development of Solid Oxide Electrolyser Cell (SOEC) technology.

Electrolysis of water to produce hydrogen (and oxygen, as a byproduct) can be performed by two means: at low temperatures using either alkaline electrolysis (AEL) or proton exchange (PEM) technology, or at high temperatures using steam and a solid oxide electrolyte. The latter technique is called SOEC technology.

Efficiency analysis
The main advantage of SOEC is that less energy is required to dissociate steam than to dissociate liquid water. When heat sources are available at low cost – or even better, when waste heat is available – replacing electricity as the process input with heat leads to higher efficiency.

Electricity costs are by far the most significant variable cost component, meaning that the efficiency advantage of SOEC technology offers the potential for cheaper hydrogen. However, study shows that the availability of suitable steam sources is difficult to find in practice. The steam conditions and availability required to realize the efficiency benefit are often not present, making it necessary to introduce an external steam source. As a result, the efficiency benefit is no longer present.

System integration analysis
In addition, OranjeWind studied the application of the technology as a future system integration. However, current insights show that this technology is not suitable for fluctuating production conditions, such as varying electricity and steam supply. This is due to the system's limited flexibility and material properties. Unlike PEM and alkaline systems, SOEC cannot – or can barely – adapt to fluctuating electricity production from wind and solar sources. As a result, the technology is not suitable for application in today's dynamic energy landscape and is not being considered as a future system integration solution.

OranjeWind will share further lessons learned in upcoming communications.

TenneT's offshore substation now operational

A significant early milestone in the overall realisation of OranjeWind was achieved on 30 October 2025, when the 700 MW offshore grid connection received its grid readiness certificate from the independent Dutch certification body DNV. This means that OranjeWind's electricity connection to the high-voltage grid meets all the necessary standards and is fully ready for use.

The offshore substation was built by the grid operator and OranjeWind partner TenneT. Its topside – the structure above the waterline that houses all the electrical equipment and control systems – had been successfully installed in the North Sea on 21 May 2025. The jacket – the steel lattice framework that forms the foundation and supports the topside – had been installed in 2024.

The onshore station, likewise built by TenneT, is situated at Wijk aan Zee, on the coast of the North Sea in the municipality of Beverwijk, North Holland. This station receives export cables from the offshore substation Hollandse Kust (West Beta), situated some 50 km off the Dutch coast, and will deliver OranjeWinds's wind power into the Dutch grid.

Efficient partnerships

TenneT was designated the operator of the offshore grid by the Dutch government in 2016. It has since delivered seven offshore substations to serve Dutch offshore wind farms, all of them constructed to a standard design, although realised in collaboration with a range of partners. The past three of these seven offshore substations have been constructed in partnership with the contractor consortium Equans/Smulders.

Long-term partnership is the object of TenneT's framework agreements, encouraging learning from experience and the sharing of insights. It was this philosophy, together with the policy of strict standardisation of design, that allowed the Hollandse Kust (West Beta) offshore substation to be constructed so efficiently and economically. It was delivered within budget and a full five months ahead of schedule – a remarkable achievement. The same spirit of close partnership and pooling of knowledge informs TenneT's relationship with the OranjeWind team.

Nature-inclusive programme

As a state-owned company controlled by the Dutch government, TenneT is a major enabler of the transition to sustainable energy in the Netherlands. This responsibility extends also to the marine ecosystems impacted by the construction of wind farms, and is reflected in all tenders and framework agreements drawn up by TenneT, which incorporate strong sustainability requirements.

While the introduction of wind energy infrastructure is intrinsically invasive, it can also present opportunities to restore depleted marine environments, as wind energy brings with it restrictions on shipping, fishing and other industrial activities. TenneT operates a nature-inclusive programme which features, for instance, the creation of oyster banks and 'fish hotels' – underwater structures to attract and shelter fish and other marine life – within a 500-metre radius of its offshore platforms.

The onshore substation station at Wijk aan Zee will start receiving electricity from OranjeWind once the wind farm's first turbines are installed and fully operational at the end of 2027.

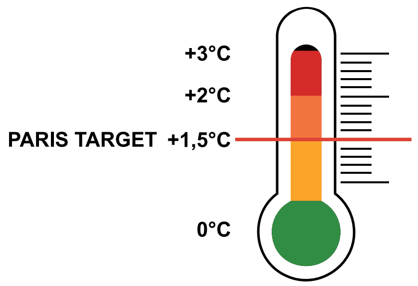
> "As a state-owned company controlled by the Dutch government, **TenneT is a major enabler** of the transition to sustainable energy in the Netherlands."

Knowledge programme update

DEFLAME: The path to electrification of industrial heat demand

The energy transition is a process that involves many pathways. One important avenue of exploration is how an industrial infrastructure created in the age of fossil fuels can be adapted to depend on intermittent renewable energy. OranjeWind is therefore sponsoring a satellite research initiative to investigate this subject: Project DEFLAME, which stands for Direct Electrification of Industrial Heat Demand supported by Flexibility at Multiple Levels and their Exchanges.

The Paris Agreement on climate change underpins the ambitions of DEFLAME. The Agreement has the long-term goal of keeping the rise in global surface temperature to significantly less than 2 °C above pre-industrial levels. It also states that the increase should preferably be limited to no more than 1.5 °C.



Project consortium

DEFLAME was officially initiated on 1 May 2025, with the active kick-off of the project following in September of the same year under the overall coordination of Machteld van den Broek, Full Professor Energy System Integration at TU Delft. It involves research by five PhD candidates, four of them at TU Delft and the fifth at Eindhoven University of Technology.

DEFLAME also draws on the expertise of many partners: the energy structure operators Atlas Copco, Cosun, Nobian and RWE (via OranjeWind); Stedin, TenneT and SmartPort, whose focus is system integration; and The Netherlands Organisation for Applied Scientific Research (TNO) plus The Institute for Sustainable Process Technology (ISPT), alongside TU Delft and Eindhoven University of Technology.

Finding new forms of flexibility

Besides exploring how industrial heat processes traditionally powered by fossil fuels can be decarbonised through the switch to renewable energy, DEFLAME also seeks to help industrial users adapt to the variability intrinsic to weather dependent renewable power. The addition of new renewable sources can only be realised if sufficient power is offtaken at times of high wind or solar energy production. This means that the build-out of renewables must go hand in hand with the electrification and flexibilization of demand – a complex balancing act.

We do not have the time or the carbon budget to wait for the market to achieve this balance by natural evolution. Our energy system was designed to offer flexibility, but on the basis of the perpetual availability of fossil fuels. New forms of flexibility appropriate for the specifics of renewable energy therefore have to be introduced at both the supply and the demand side of the system. As Professor van den Broek explains, "DEFLAME aims to find the right mix of flexibility at many different levels – technology, individual plants, industrial clusters, and national and international energy systems – so that industry can better respond to fluctuations in the energy network."

The electrification of low-temperature heat

DEFLAME focuses on removing obstacles to the electrification of low-temperature heat (up to 400°C), with particular attention to the chemical and food sectors in the Netherlands. Low-temperature heat is used in many industrial processes for driving chemical reactions, as well as for the processes of drying, distillation and evaporation. Approaches such as scaling installations up or down, storing heat in underground systems, or storing electricity in batteries may all have a role to play in providing the desired flexibility.

"We have a great consortium," observes Professor van den Broek, "and we already have some very interesting ideas on the table, ready for execution. Our PhD candidates are currently learning in depth about the tools they'll be using for their research, and we're developing common terms of reference to inform our approach. DEFLAME is a highly promising project with excellent partners from both industry and academia, and we're all looking forward to delivering our first results in due course."

Machteld van den Broek | Full Professor Energy System Integration at TU Delft

Phynix: Fire from Water

Green hydrogen has significant potential in enabling a full-scale energy transition. The European Union's Hydrogen Strategy considers hydrogen "essential to support the EU's commitment to reach carbon neutrality by 2050 and for the global effort to implement the Paris Agreement while working towards zero pollution."

In economic terms, the technology has yet to reach full maturity, however. For this reason, the Phynix project is an important stepping-stone on the way to full inclusion of green hydrogen within a comprehensive renewable energy mix. Phynix also promises to deliver valuable insights into what offshore system integration role hydrogen might play in future.

New name, new destiny
'Phynix' is the new name for an offshore platform originally commissioned by CrossWind. Known initially as the 'Base Load Power Hub', it was one of the five innovations of CrossWind's Hollande Kust Noord project. Its role was to turn intermittent wind energy into dependable, on-demand power by using hydrogen and battery energy storage as a buffer. Following development and construction, it was acquired in October 2025 by Delft Offshore Turbine (DOT) for research purposes.

As its name suggests, Phynix has risen from the ashes to take on a new role, this time as an open R&D platform to advance offshore hydrogen technology. Located onshore near the BUSS Terminal, Eemshaven, in the province of Groningen, this open asset hydrogen testing facility is today referred to as "the pilot flame (Dutch: waakvlam) for offshore hydrogen."

A catalyst for collaboration
Phynix is the first ever platform for hydrogen production and storage designed and built for offshore. Now a not-for-profit asset operated for the benefit of people and planet, it offers an open learning and innovation environment in which students, researchers, and companies alike can work under realistic conditions on the technologies that are essential for the energy transition.

It is absolutely unique that students can experience and learn, at first hand and in complete safety, about an offshore installation on the same day that they have breakfast and dinner at home. The platform has the potential to act as a catalyst for collaboration across the entire value chain, bringing together public and private partners to work on technological validation, knowledge development, the shaping of future regulations, and the preparation of offshore applications. Its role is to maintain the momentum behind the development of green hydrogen until conditions are appropriate for scale-up, in the words of David Molenaar, co-owner of Phynix and Hydrogen Lead at DOT.

"The Phynix project is an important stepping-stone on the way to **full inclusion of green hydrogen**."

A kick-starter for a whole-system approach
Green hydrogen is a technology that requires a whole-system approach for successful ramp-up. Phynix is the kick-starter to make that happen. "Phynix is not the project of one organisation," states David: "it belongs to all of us. In the Northern Netherlands, and especially in the Eemshaven, much pioneering work has already been done, with hydrogen as a key focus. Here, Phynix has been welcomed with open arms – the ideal place to continue to innovate and learn together."

Supporting the energy transition with original research: Six groundbreaking PhDs

System integration – the concept that lies at the heart of OranjeWind – involves much more than simply investigating technologies and developing infrastructure. It calls for new ways of thinking about a wide range of complex systems and how these interrelate. As part of this drive, six young scientists are currently conducting original research within the framework of OranjeWind.

The findings of their PhDs, which are to be concluded in 2029, will significantly deepen our understanding of the context in which offshore wind projects like OranjeWind are being developed. They will also enrich the thinking of our entire energy sector. We spoke with these six PhD candidates about what motivates them most in their research work, and what new insights they hope to be able to share with the world.

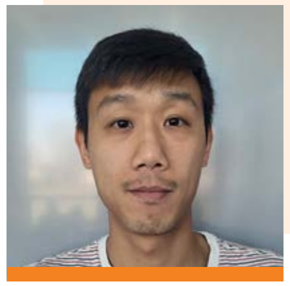
Continues on page 22 >

Supporting successful integration of the chemical industry into the energy supply sector:

System Integration with Demand-side and Industrial Transformation

The chemical industry accounts for about 20% of the Netherlands' total energy use. My research focuses on analysing the energy flexibility and demand patterns of the current and future chemical industry in the Netherlands.

My research aims to guide policymakers in creating policies that incentivise the transition to green energy. This involves solving complex problems, which naturally appeals to me: I love maths, which plays an important role in my work. One of the challenges, of course, is how to scope one's research: the more you research, the more you know, but you can't investigate everything! Connecting the different levels of technical detail in my work and connecting them to the bigger picture is often challenging. But if the challenges are real, so is the potential impact of this kind of research, and I'd encourage other early-career scientists to explore this fascinating field.



PhD candidate: Adreano Boris |
Faculty of Applied Sciences,
Department of Chemical Engineering,
TU Delft

PhD candidate: Viola Angesti |
Faculty of Spatial Sciences,
Department of Spatial Planning and Environment, University of Groningen

A path towards the effective use of space and time in an integrated North Sea:

Spatial Temporal Layout of Energy Infrastructure

Many scenarios for North Sea integration present are perfectly optimised future, but they often overlook how to realistically get there. My PhD investigates how the offshore energy system in the busy North Sea can be planned and optimised across space and time. Planning an integrated offshore grid to support the energy transition involves accommodating the needs of all other sea users as well as the marine environment itself.

As a planner, I naturally believe that this calls for the integration of multiple disciplines to ground the challenges in the actual, interlinked context. This is why I very much enjoy the regular meetings in which I participate during the course of my PhD, which are always fun and can be very challenging, too. It's a very dynamic and collaborative environment in which to conduct research. I'm encouraged to think differently, to think creatively, and I greatly appreciate this. We're all working in a very fast-moving field, and there's so much of value that lies beyond the realm of my own discipline: taking these many factors into account in an integrative way is a great challenge to myself.

PhD candidate: Charalambos Xydas | Department of Industrial Engineering and Innovation Sciences, Eindhoven University of Technology

Enabling faster, more reliable and cost-effective deployment of integrated energy systems:

Technological Learning Potentials and Pathways of Advanced Offshore Energy and Balancing Technologies

For offshore renewable energy to achieve critical mass, innovative technologies must be developed to help balance supply and demand. My research involves developing frameworks and tools to evaluate and accelerate how offshore renewable energy can be integrated with such balancing technologies. The work identifies diffusion barriers, policy requirements, and pathways for cost reduction, scalability, and standardisation.

"My research involves developing frameworks and tools to evaluate and accelerate how offshore renewable energy can be integrated with such balancing technologies."

I'm seeking to provide actionable recommendations for the development and application of balancing technologies – covering aspects such as technology maturity, operational and economic performance, and system barriers. This harbours the potential of seeing the results of my work translated into practice, which is highly motivating. Of course, the various technologies under review all draw on different disciplines, so one challenge for me is to make my own work interpretable outside my own mind. Discipline and self-motivation are essential for this kind of undertaking: you set the boundaries yourself, but you have to follow through with discipline all the way!

Understanding how to help the offshore wind sector mature faster:

Acceleration of Implementation and Future Scale-up

Having the right technology, including storage and other generation technologies, is fundamental to ensuring that we reach our climate targets in time. An adequate supply chain, experienced personnel and standardisation also play a role, as do governments and regulators. My work investigates these interdependencies.

The growth of the offshore wind sector has been very uneven in recent years, and I'm investigating how it might be made smoother and more continuous. One of the things that fascinates me about my work is that it allows me to think about the North Sea energy system in terms of the 'big picture' as well as all the detail – and no-one ever tells me that the detail is too detailed, which I love! To find your niche as a researcher, you have to identify the thing you love and then go beyond your own boundaries. If you want to be original, you have to find the necessary originality within yourself.

PhD candidate: Roos de Jonge | Faculty of Geosciences, Copernicus Institute of Sustainable Development, University of Utrecht

PhD candidate: Christos Pavlopoulos | Faculty of Electrical Engineering, Department of Electrical Energy Systems, Eindhoven niversity of Technology

Enabling the large-scale integration of offshore wind energy into regional electricity networks:

System Integration on Local/ Regional Level of Offshore Wind farms

The large-scale integration of offshore wind energy into regional electricity networks is a crucial component in the decarbonisation of Europe's energy sector. My work will enable the identification of cost-effective and grid-reliable strategies for grid integration.

"My work will enable the identification of cost-effective and grid-reliable strategies for grid integration."

My research involves creating a structured framework to support the development of policies that will encourage the necessary stability and flexibility in the grid to enable the energy transition. This is essential for effective scale-up. I very much appreciate the opportunity to connect my research with applications in the real world. The question of how to integrate different energy resources is fascinating. One challenge I have encountered is how to find a balance between simplicity and accuracy in the current models: too much detail can make a model unreliable, but the same holds true of too much simplicity!

A modelling framework for the North Sea energy system to guide policy planning:

System Integration on North Sea Region Scale

My research develops an integrated and policy-relevant modelling framework for North Sea energy planning. It combines technical, spatial, and governance perspectives to support the design of offshore grids under real-world constraints, evaluate robust system pathways under uncertainty, and identify high-impact cross-border projects. The results provide an evidence base to inform policy processes such as the ENTSO-e Offshore Network Development Plan (ONDP), particularly regarding coordination, cost-sharing, and investment timing.

"I don't just want to write another unread paper."

In considering a PhD subject, I was keen to study something that was applied rather than theoretical, and I was attracted by the open-source philosophy of OranjeWind. I don't just want to write another unread paper! My supervision team, like that of the other PhD candidates, covers various areas of specific expertise, and that 'external' perspective is very helpful. I'm an offshore wind enthusiast, and I hope that my research can contribute to the development of more offshore wind power. I'm also hoping to be able to incorporate some of the results of my fellow PhD candidates' work in my own, to provide a system-level view.

PhD candidate: Lisa Behm | Faculty of Geosciences, Copernicus Institute of Sustainable Development, University of Utrecht

A thank-you to all PhD promotors and supervisors!

Our warm thanks go to the promotors and supervisors at the University of Utrecht, TU Delft, Eindhoven University of Technology, the University of Groningen, and TNO who are guiding our six PhD candidates in their important research.

Project OESTER: Offshore Electricity Storage and Research

Delivering a reliable supply of green electricity to the grid involves much more than simply producing energy from sustainable sources: efficient storage and distribution of the electricity generated are just as vital. For this reason, Project OESTER plays a big role in the theoretical research projects of OranjeWind.

Standing for Offshore Electricity Storage and Research, Project OESTER is a three-year initiative involving many partners and covering the entire wind farm supply chain. Its strategic significance is clear from the spectrum of participating organisations: wind energy developers and operators; storage technology developers; companies supporting offshore energy storage; research and knowledge institutes; financial and insurance companies; law firms; and Energy Storage NL, the Dutch association dedicated to this topic.

Initiated by OranjeWind Knowledge and led by TNO, the Netherlands Organisation for Applied Scientific Research, Project OESTER aims to accelerate the development and deployment of offshore electricity storage technologies. Its findings will be relevant not only for OranjeWind but for the offshore wind industry as a whole.

Theoretical benefits of offshore electricity storage

TNO's mission is to create impactful innovations for the sustainable well-being and prosperity of society. Project OESTER aligns perfectly with this mission, for it explores offshore energy storage as a potential source of flexible power, a prerequisite a more sustainable and resilient energy system.

Offshore electricity storage might hold some systemic benefits. By allowing power delivery on demand, it has the potential to support the flexibility and stability of the grid. Energy could be stored offshore until required, instead of being 'cocktailed' at shoreline locations where the onshore grid is congested.

De-risking, development and validation

Project OESTER is investigating how best to de-risk, develop and validate a range of storage technologies and how to roll these out at scale. Technologies under review are amongst others lithium-ion batteries within turbine monopiles, hydro-pneumatic energy storage and a 100% flexible electrolyser on a platform, which can quickly scale its operation from 0% to 100% and back, to match the intermittent power output intrinsic to renewable energy sources.

The aspect of storage duration is also under investigation. Across these four offshore electricity storage technologies, this ranges from minutes to several days, with each technology providing different forms of flexibility.

The technologies identified as most suitable will be assessed on their business case, bankability, technical-, ecological- and regulatory integration. The candidate technologies are not yet sufficiently mature to be trialled offshore but are currently being validated by means of an onshore 'digital twin in the loop' of the projected systems.

Innovations offshore

An innovative approach to smoothing output

Subsea Energy Storage

OranjeWind's unique system integration concept combines many angles of approach: using the very best of existing technologies, using those technologies in new as well as established ways, and at the same time exploring the potential of a range of innovative new technologies.

OranjeWind's innovations aim to tackle the fundamental system challenge of how to store energy produced by the wind turbine generators so that it can be released to the grid as and when it is needed, pre-empting the disruptive and costly phenomenon of curtailment when more electricity is produced than can be offtaken. This means turning a wind-following generation asset into a flexible source of renewable power.

Increasing the autonomy of wind farms

One of the technologies currently being explored to this end involves the use of a subsea lithium-ion battery to optimise the connection between wind farm and grid. In collaboration with our partner Verlume, the global leader in subsea batteries and power management systems, a pilot project is running involving a small-scale battery with a capacity of 500 kWh and an output of 250 kW.

This is one of the first developer-led demonstrations of subsea energy storage: it represents a pioneering step forward in the development towards large-scale offshore storage. Storage via the lithium-ion battery enables local buffering of excess generation during constrained periods. This might reduce the need to turn down turbines when wind conditions permit the generation of high quantities of electricity. The output is captured and can be released at a suitable time, when export capacity becomes available or when prices recover.

A controllable offshore node

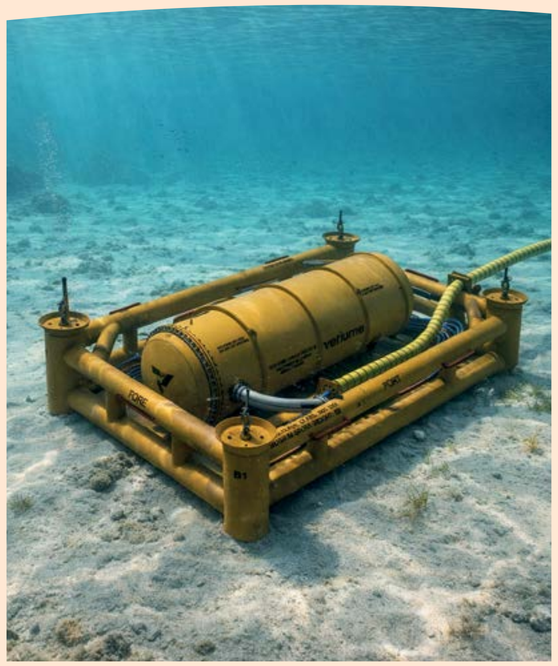
In a subsea configuration, storage is co located with the turbine or offshore network: it can respond to constraints without relying on topside space, additional platforms or retrofits. This creates a controllable offshore node capable of smoothing output, reducing volatility and improving utilisation of installed capacity.

For all the promise of this technology, subsea energy storage presents additional engineering challenges, including enclosure integrity, subsea connectors, installation procedures and offshore safety cases, all of which must be demonstrated to high reliability standards. Moreover, OranjeWind's location in the North Sea, with its powerful currents and sandy seabed, throws up special demands.

Progress

The project is currently advancing through the construction stage of the subsea battery. The construction also includes the completion of the subsea cable, topside cabinets and installation auxiliaries. So far, the schedule is on track to commence testing by the end of June 2026. The system will undergo extensive factory acceptance testing to ensure compliance for offshore installation and operation.

The insights into subsea storage currently being gained will be of use not just to OranjeWind itself but also to wind farm developers around the world in years to come.



Enhanced wind forecasting systems piloted in North Sea conditions

LiDAR

Accurate forecasting of wind speeds is crucial to the effective management of wind farms. With too little wind, the turbines naturally stop turning. With too much, the turbines shut down for safety reasons. And even between these extremes, the general unsteadiness of wind flow leads to fluctuations in wind power production.

Whenever power production deviates from plan, grid operators have to restore balance by ramping other controllable power sources up or down. A key innovation challenge for OranjeWind is therefore to reduce this intrinsic volatility so as to be able to provide the grid with maximum consistency of supply.

The forecasting of wind speeds has so far mainly depended on the use of large weather models – digital simulations that predict weather patterns across extensive geographical areas. Large weather models, however, are unable to provide the very short-term local information about sudden increases in speed, known as wind ramps, which are important to wind farm operators – and indeed to everyone dependent on the power output of wind farms. Moreover, the accuracy of large weather models is compromised during extreme weather events such as storms, when the complexity of the data they have to interpret greatly increases.

More accurate short-term wind forecasting

LiDAR – 'light detection and ranging' – offers the prospect of far more accurate short-term forecasting. Determining distances and velocities by means of laser light, it is an important component of the OranjeWind system integration concept.

As the OranjeWind wind farm is still to be constructed, LiDARs cannot yet be deployed in their eventual operating positions. Prior to installation in OranjeWind, therefore, a test system was installed at RWE's Amrumbank West offshore wind farm in the German Bight in the spring of 2025. Completion of this power forecasting demonstrator is expected in the spring of 2026. It will deliver the capability of real-time forecasting and will also permit initial comparisons with current short-term forecasts. Potential limitations due to external factors such as dense fog and rain will also be evaluated.

In addition, this demonstration provides first-hand experience of operating scanning LiDARs in offshore conditions. For example, one of the LiDARs at Amrumbank West experienced a technical issue in the fourth quarter of 2025 and required unscheduled onshore maintenance.

Once all the relevant turbines at OranjeWind are in place, the scanning LiDARs will be relocated there and the forecasting system adapted to the requirements of the new location.

XXL-LiDAR for longer-range forecasting

The LiDARs being used at Amrumbank West offer a measurement range of up to 15 kilometres in good atmospheric conditions, which should allow a forecast horizon of approximately 15 minutes, depending on the wind speed. From an operator's perspective, a greater forecast horizon would be desirable. Thus, a prototype ultra-long range LiDAR, also known as the XXL-LiDAR, has been undergoing onshore piloting since the end of 2025.

The XXL-LiDAR has the potential to nearly double the forecast horizon. It is currently being tested at an onshore location on a North Sea dyke in Schleswig-Holstein, Germany. Testing is expected to continue at an offshore site once the onshore tests have been successfully completed later in 2026.

One year into the OranjeWind project, the argument for system integration is more relevant than ever. If the geopolitical developments of the past five years have taught us anything, they have surely driven home the need for strategic autonomy in the field of energy supply.

As manufacturing ramps up, OranjeWind is providing some real-world answers to real-world problems, creating a blueprint for connecting offshore wind energy production with the onshore asset base in a transformational manner.

In a project of this scope, it is clear that not every potential innovation can be brought to full technological maturity. The insights of the past twelve months have strengthened the case for many core aspects of our concept, while indicating the immaturity of certain other technologies. It is good to have learned these lessons, both the positives and the negatives, and I sincerely hope that certain solutions currently adjudged impracticable might be brought to full maturity at some point in the future.

"We are showing how we can **strengthen the energy system** as a whole."

Harnessing innovation – and standardisation
We want to make the North Sea a powerhouse. This involves harnessing both innovation and standardization. Innovation offers solutions to previously insoluble challenges, but it is standardization that can translate those solutions into reality by making them practical and affordable. With so much experimentation behind us, we are incorporating standardization into many dimensions of OranjeWind, thereby offering a blueprint not only for efficient design and construction but also for cost-effective scale-up.

For OranjeWind itself, next year will be showtime, as actual construction commences on a large scale. There will of course be challenges along the way as we operationalize our plan, but I have every confidence that we have the right people and the right attitude to solve them. The team spirit throughout the project remains exemplary, and RWE's partnership with TotalEnergies goes from strength to strength. We made the right choice of partner for this ambitious undertaking, and we receive confirmation of that fact on a daily basis. The team spirit also shows in our highly innovative OranjeWind Knowledge programme, which is successfully reaching out to so many different parts of society, all of which have a role to play in making our vision work.

A blueprint for flexibility
The offshore wind sector has experienced quite some challenges in recent years. It is encouraging that, in uncertain times, governments across Europe have stepped up with supportive policies. We are showing how we can produce sustainable, clean energy from our own territory and – by means of system integration – strengthen the energy system as a whole. The next step will involve creating reliable demand for this transformative energy source through electrification and flexibility. With its innovative system integration approach, OranjeWind is providing a blueprint for that.

I would like to thank everyone who has contributed to the advancements of the past year: let us approach the coming one with energy and confidence!

Marinus Tabak | COO RWE Generation and Country Chair RWE Netherlands

I firmly believe that a worldwide multi-energy approach is not a choice, but a necessity. No single energy source alone can deliver the improvements in affordability, reliability and sustainability that the world needs.

Having taken on the role as Country Chair for TotalEnergies in the Netherlands six months ago, I'm impressed by how deliberately OranjeWind has been set up as a system integrated project. Grid connection, industrial offtake and flexibility options are being developed in parallel. We are working at the frontier of offshore wind and system integration. OranjeWind is exciting precisely because it allows us to test this multi-energy reality in practice – and to learn what works, what doesn't, and how to scale it.
Our collaboration with RWE is a key strength here. For TotalEnergies, OranjeWind is our first offshore wind farm in the Netherlands, and we learn from RWE's experience in developing, building and operating offshore wind. At the same time, we bring decades of exploration and production expertise in the North Sea. That combination of capabilities is helping us build an asset that performs well technically, integrates effectively into the wider energy system, and is anchored locally. For TotalEnergies, this is at the heart of our *"More energy, less emissions"* strategy.

Building something that matters
People involved in OranjeWind genuinely feel they are building something that matters – not just for their companies, but for the Dutch energy system. The deliberate choice to share insights – including challenges – accelerates learning far beyond OranjeWind itself. The Knowledge Programme has already proven its value by creating a shared language between engineers, researchers, policymakers, and market players. It lowers the barrier between theory and practice. That is exactly how innovation spreads.
Colleagues who are indirectly involved also demonstrate strong interest and engagement. For example, internal webinars on OranjeWind consistently attract high participation rates across TotalEnergies.

"OranjeWind will have **a positive influence** far beyond its physical footprint."

From insight to impact
I hope we continue to move from insight to impact. That means scaling what works, being honest about what doesn't, and translating lessons learned into concrete contributions to policy, market design, and future projects. If we do that well, OranjeWind will have a positive influence far beyond its physical footprint.
OranjeWind shows that the energy transition is not about choosing between growth and emissions reduction. With the right partnerships and system-level thinking, one can deliver both more energy and less emissions. That is exactly the balance TotalEnergies is working towards, and OranjeWind is a powerful example of how that ambition can be translated into practice.

I would like to thank our partners RWE for our cooperation in OranjeWind, Air Liquide, with whom we are developing a 250MW electrolyser, and all other stakeholders involved, including the OranjeWind team.

It's really happening in the Netherlands!

Alex Barendse | Managing Director TotalEnergies Marketing Netherlands & Country Chair TotalEnergies Netherlands

Colophon

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RWE

RWE is leading the way to a modern energy world. With its investment and growth strategy, RWE is contributing significantly to the success of the energy transition and the decarbonisation of the energy system. Around 20,000 employees work for the company in over 20 countries worldwide. RWE is one of the leading companies in the field of renewable energy. RWE is investing billions of euros in expanding its generation portfolio, in particular in offshore and onshore wind, solar energy and batteries. It is perfectly complemented by its global energy trading business. Thanks to its integrated portfolio of renewables, battery storage and flexible generation, as well as its broad project pipeline of possible new builds, RWE is well positioned to address the growing global demand for electricity, particularly driven by further electrification and artificial intelligence. RWE is decarbonising its business in line with the 1.5-degree reduction pathway and will phase out coal by 2030. RWE will be net zero by 2040. Fully in line with the company's purpose - Our energy for a sustainable life.

TotalEnergies

TotalEnergies and electricity

TotalEnergies is building a competitive portfolio that combines renewables (solar, onshore wind, offshore wind) and flexible assets (CCGT, storage) to deliver clean firm power to its customers. TotalEnergies has more than 36 GW of gross renewable power generation capacity and aims to achieve over 100 TWh of net electricity production by 2030.

About TotalEnergies

TotalEnergies is a global integrated energy company that produces and markets energies: oil and biofuels, natural gas, biogas and low-carbon hydrogen, renewables and electricity. Our more than 100,000 employees are committed to provide as many people as possible with energy that is more reliable, more affordable and more sustainable. Active in about 120 countries, TotalEnergies places sustainability at the heart of its strategy, its projects and its operations.

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