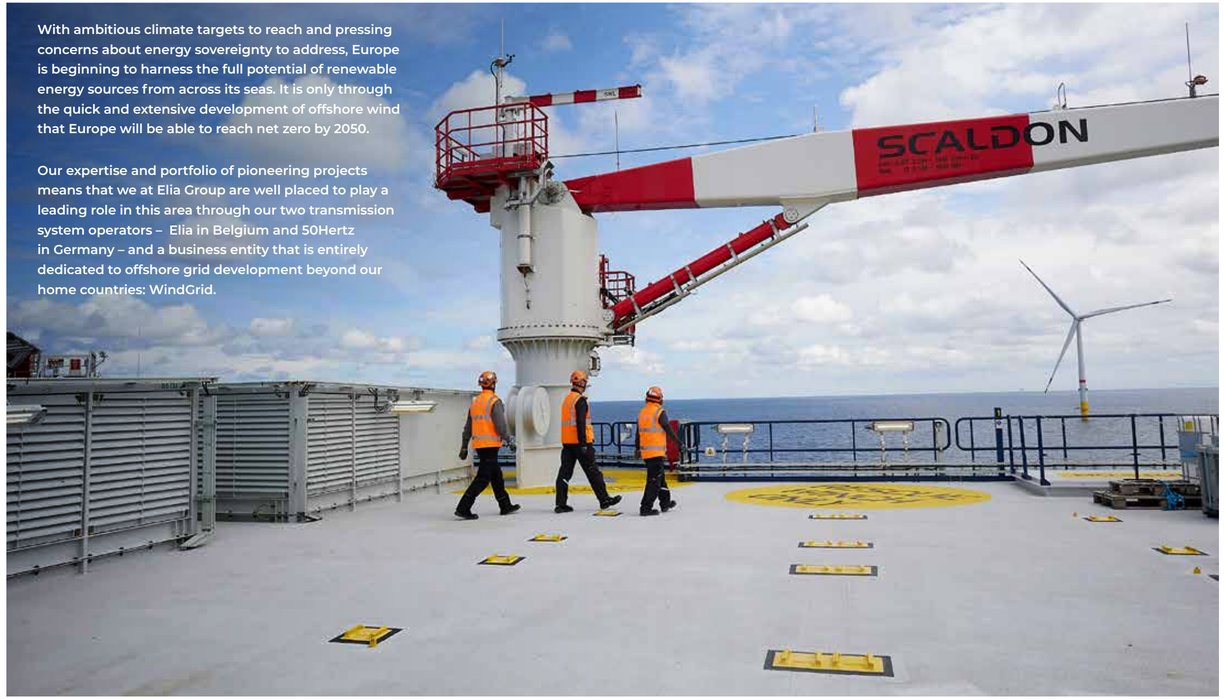

elia group
TRANSFORMING OUR SEAS INTO EUROPE'S SUSTAINABLE ECONOMIC ENGINE




With ambitious climate targets to reach and pressing concerns about energy sovereignty to address, Europe is beginning to harness the full potential of renewable energy sources from across its seas. It is only through the quick and extensive development of offshore wind that Europe will be able to reach net zero by 2050.

Our expertise and portfolio of pioneering projects means that we at Elia Group are well placed to play a leading role in this area through our two transmission system operators – Elia in Belgium and 50Hertz in Germany – and a business entity that is entirely dedicated to offshore grid development beyond our home countries: WindGrid.

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# ESTABLISHING A EUROPEAN MESHED OFFSHORE GRID

## OFFSHORE RENEWABLES: A CORNERSTONE OF EUROPE'S CLEAN ENERGY TRANSITION

The war in Ukraine and gas crisis have crystallised Europe's need to accelerate the energy transition. Electrification and access to renewable energy are understood to be beneficial for the climate, for offering long-term price stability, and for protecting consumers against inflation in gas and electricity markets.

To become the first climate-neutral continent in the world, secure its economic resilience and the prosperity of its citizens, Europe and its member states have raised their targets and sharpened their action plans. These aim to further reduce the continent's $CO_2$ emissions, develop renewable energy sources, encourage electrification and boost its green economy. Offshore renewable energy in particular is seen as the cornerstone of the Union's move to net zero.

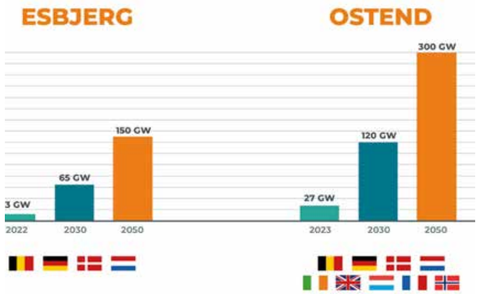
### ELIA GROUP SIGNS OFFSHORE RENEWABLE INDUSTRY DECLARATION

**During the 2023 North Sea Summit in Ostend, Elia and 50Hertz were among the signatories of the Offshore Renewable Industry Declaration. The latter states that whilst Europe's offshore industry welcomes Europe's commitments, it recognises that more can be done.**

**The declaration calls for large-scale investments in infrastructure and human capital to be undertaken, alongside the modernisation of permitting and financing processes and the fostering of political and industrial partnerships. It notes that the number of employees in Europe's offshore wind sector needs to grow from 80,000 today to 250,000 by 2030.**

READ THE DECLARATION HERE


**Collective offshore wind capacity commitments made during the first and second North Sea Summits in 2022 and 2023**




## STEPPING STONES ON THE WAY TO NET ZERO

**2020: European Green Deal**

A package of policy initiatives whose ultimate goal is to enable the EU to reach climate neutrality by 2050. The Green Deal Industrial Plan, which aims to provide a more favourable environment for the scaling up of the EU's manufacturing capacity related to net zero technologies and products, was published in 2023.

**2021: FIT FOR 55**

A legislative package which focuses on ensuring all sectors of the EU's economy work towards meeting its target of reducing its net greenhouse gas emissions by at least 55% (compared with 1990 levels).

**2022: REPowerEU**

Published in response to Russia's invasion of Ukraine, this plan aims to diversify Europe's energy supply, save energy, and produce clean energy, so reducing the EU's dependence on Russian fossil fuels.

**2022-2023: North Sea summits**

Two summits held in Esbjerg, Denmark (May '22) and Ostend, Belgium (April '23), which saw politicians, heads of state and industry leaders committing to transforming the North Sea into Europe's biggest power plant.

**2023: Green Deal Industrial Plan**

This plan aims to enhance the competitiveness of Europe's net zero industry and so accelerate the Union's transition to climate neutrality. It does so by fostering a more favourable environment for the scaling up of the EU's manufacturing capacity with regard to net zero technology and products.

**2023: European Wind Power Action plan**

This plan outlines 15 actions that can be quickly taken by the EU, Member States and industry to strengthen Europe's wind energy industry, enabling it to meet its climate and energy goals.

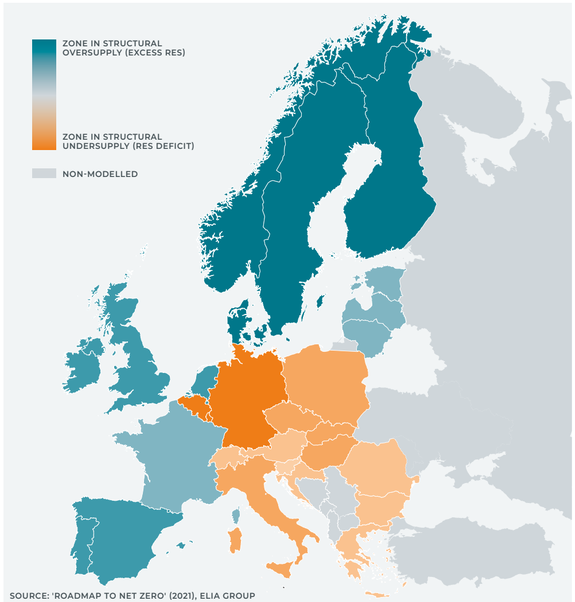
→ Countries around the Baltic Sea are intensifying their activities to harvest the offshore wind potential across borders to bring about socioeconomic benefits and reinforce energy sovereignty in Europe. That's why 50Hertz hosted the Baltic Offshore Wind Forum with the German Ministry of Foreign Affairs in May 2023, why we are planning to build the Baltic WindConnector with Elering from Estonia, and why we are implementing the Bornholm Energy Island project with our Danish counterpart, Energinet.

**Stefan Kapferer, CEO of 50Hertz**

# PARTNERSHIPS WHICH AIM TO HARVEST THE FULL POTENTIAL OF EUROPE'S SEAS

In Europe, countries are increasingly sharing their resources, knowledge and renewable energy potential. Whilst some states have access to high amounts of renewable energy, others need to import it to meet their climate goals. Interconnectors, which link up electricity grids across land borders and seas, are increasingly being built.

Indeed, in Belgium and Germany, Elia and 50Hertz foster fruitful partnerships with their neighbours. In addition to the 2022 and 2023 North Sea Summits, for example, Elia Group was involved in the Baltic Offshore Wind Forum organised in May 2023 in Berlin. This brought together high-level representatives of the Member States belonging to the Council of the Baltic Sea States. The forum aimed to further their energy sovereignty and protection of the climate through the construction of resilient and interconnected infrastructure.

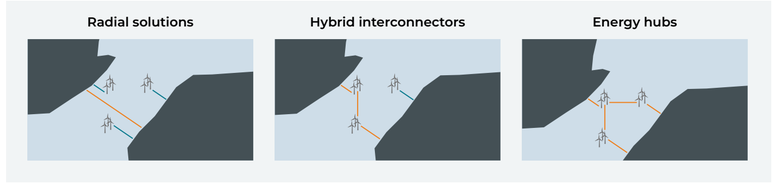

SOURCE: 'ROADMAP TO NET ZERO' (2021), ELIA GROUP



# EFFICIENCY IS THE NAME OF THE GAME

As the offshore wind sector develops, countries are exploring increasingly advanced methods for connecting countries to wind farms. Previously, radial (point-to-point) connections alone were used. Today, more complex approaches are being employed. Hybrid interconnectors link two countries together whilst also being connected to an offshore wind farm; and energy islands act as centralising energy hubs. Europe is aiming to establish meshed offshore grids across its seas, with both interconnectors and energy islands playing key roles in these.

50Hertz built the world's very first hybrid interconnector with Energinet from Denmark (**page 26**). Moreover, whilst Elia is working on the world's first artificial energy island (**page 14**), 50Hertz is working on the establishment of Bornholm Energy Island (**page 39**). Both will act as energy hubs: they will be linked to offshore wind farms and function as intermediary landing points for interconnectors with multiple countries.




THE INTEROPERA CONSORTIUM, LAUNCHED IN JANUARY 2023 BY THE EUROPEAN COMMISSION, AIMS TO ENSURE THAT FUTURE HIGH-VOLTAGE DIRECT CURRENT (HVDC) SYSTEMS USED ACROSS EUROPE WILL BE COMPATIBLE AND INTEROPERABLE BY DESIGN, SO ULTIMATELY SUPPORTING THE ESTABLISHMENT OF A MESHED OFFSHORE MULTI-VENDOR MULTI-TERMINAL HVDC GRID. ELIA GROUP IS A MEMBER OF THE CONSORTIUM, WHICH IS BEING COORDINATED BY THE SUPER GRID INSTITUTE. WE HOSTED ITS FIRST MEETING IN BRUSSELS IN JUNE 2023.

HEAR FROM INTEROPERA'S CONSORTIUM MEMBERS AS THEY ATTENDED THEIR FIRST MEETING IN JUNE 2023

→ The North Sea will become the engine of Europe's economy. This will only succeed if we develop the necessary infrastructure for it, which will look different compared with today. The future offshore grid needs new innovations such as hybrid interconnectors and energy hubs such as the first artificial island we are building in the Belgian North Sea.

**Frédéric Dunon, Deputy CEO of Elia**

# A LARGE PORTFOLIO OF CUTTING-EDGE PROJECTS

Over the past two decades, Elia Group has acquired a high level of expertise in offshore development.

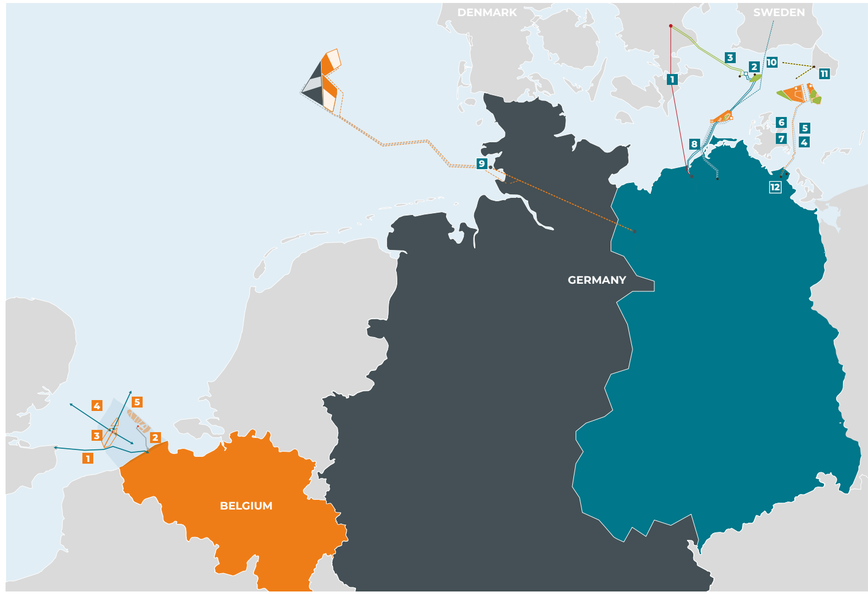
Beyond our portfolio of cutting-edge projects and techniques, we help to shape regulatory frameworks and European policy through official networks and the regular publication of position statements and research papers.

### THE GROUP'S NON-REGULATED ACTIVITIES

**In addition to Elia and 50Hertz's regulated work in Belgium and Germany, Elia Group also offers energy consultancy and engineering services to international clients through Elia Grid International (EGI). WindGrid, our newest subsidiary, was established to act as a conduit for the experience that we have gained over the past couple of decades in building and operating high-quality offshore assets. WindGrid is therefore working with governments, grid operators and renewable energy developers, helping to further the energy transition abroad through the planning and construction of offshore grids (see page 42).**



# ELIA AND 50HERTZ'S PROJECTS




**ELIA'S PROJECTS IN BELGIUM**

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# ELIA'S PROJECTS IN BELGIUM


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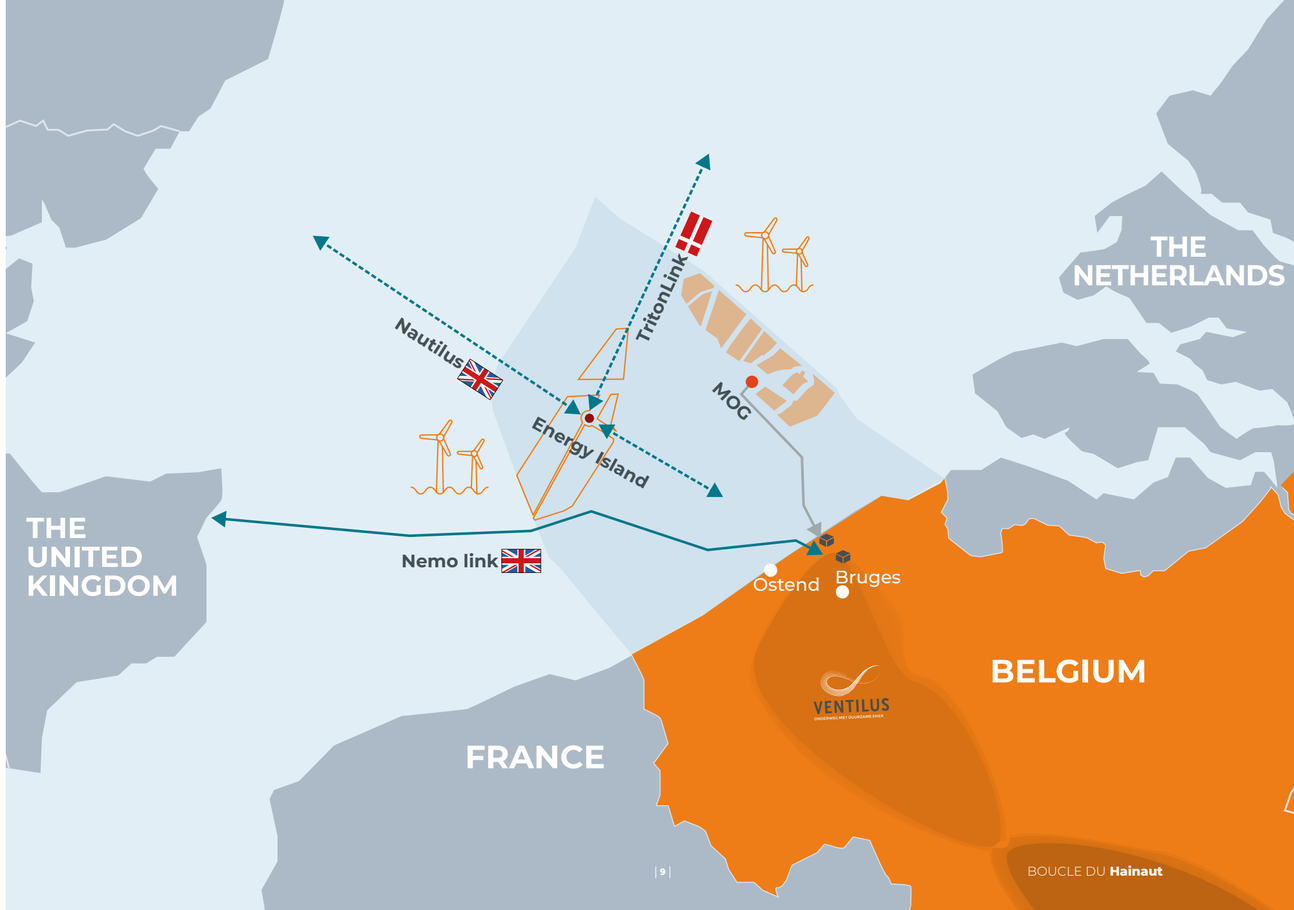


I am so proud of the Nemo Link project. For myself, for Elia and for Belgium. It is so innovative - because of its size and technology, and also because of the culture we created in collaboration with so many different stakeholders from many countries.

**Li Yang,**
**Lead Engineer, Secondary Systems at Elia**


NEMO LINK



# BELGIUM'S FIRST HVDC OFFSHORE INTERCONNECTOR

**Nemo Link, Belgium's first electricity interconnector, which links the country to the UK, has been operational since January 2019. The interconnector is a joint venture between Elia and a subsidiary of British utility National Grid.**

The interconnector was Elia's first project involving HVDC, which is best suited to exchanging electricity over long distances. Its cables, which run along a distance of 140 km from Richborough in the UK to Herdersbrug in Belgium, are linked to converter stations and high-voltage substations in both countries, allowing electricity to flow in either direction.

The project brought a number of international teams together: German company Siemens designed the link and built its two converter stations, whilst Japanese manufacturer Sumitomo Electric manufactured and installed the cable itself.

**THE INTERCONNECTOR IS KEY BECAUSE IT:**

- **enables energy to be exchanged between both countries, improving their security of supply;**
- **allows each country to access renewable energy generated in the other;**
- **allows consumers to access cheaper electricity from abroad.**

## Developing robots to assist asset inspections

Between 2021 and 2023, Nemo Link, Elia Group, Ross Robotics and Siemens Energy worked together to successfully develop an autonomous robot that is fully compatible with electromagnetic fields, allowing converter halls to be inspected without the need to switch them off. Since May 2023, this robot has been used to inspect the (switched on) HVDC converter hall that lies at the Belgian end of ALEGrO, the Belgian-German interconnector, marking the first time that an autonomous robot has been used in this way in Europe. In September 2023, an equivalent robot was installed and deployed in Nemo Link's Belgian converter hall. To find out more about Elia Group's approach to innovation in offshore development, **see page 50.**

**FIND OUT HOW NEMO LINK'S SUCCESS WAS BASED ON EXCELLENT COLLABORATION BETWEEN SEVERAL PARTNERS**

## KEY FACTS

**400 kV**

Nemo Link's DC cables have a voltage of ±400 kV and use cross-linked polyethylene (XLPE) as insulation - this combination makes them the first HVDC XLPE cables of their kind in the world

**1,012 MW**

The interconnector enables traders to buy and sell up to 1,012 MW of capacity in auctions over a number of different timeframes

**99.1%**

In 2022, Nemo Link's availability rate was 99.1%, making it one of the highest performing assets of its kind in the world

NEMO LINK'S INAUGURATION IN 2019

→ The key to completing the MOG on time and within budget was our driven and highly skilled teams. Elia looked beyond Belgium's borders to find the right people for the project. The combination of internal and external experience was a real success. A strong team spirit developed, which enabled us to move mountains, because everyone believed in the project.

**Markus Berger, Chief Infrastructure Officer at Elia**

# MOG

## ELIA'S FIRST OFFSHORE ELECTRICITY PLUG

**The commissioning of the Modular Offshore Grid (MOG) marked a true milestone in offshore wind development in the Belgian part of the North Sea, as evidenced by His Majesty King Philippe's visit in September 2019 as part of its inauguration.**



## KEY FACTS

**220 kV**
The MOG's three AC cables have a voltage of 220 kV and have a combined length of 125 km

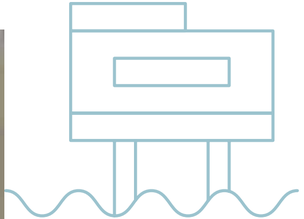
**2,000 tonnes**
The MOG's topside rises 41 m above sea level and weighs around 2,000 tonnes

**1 million**
The MOG took over one million person-hours to develop

Elia's offshore teams focused on reducing the MOG's impact on marine life and the seabed

The high-voltage switchyard platform, which is located 40 km off the Belgian coast, bundles electricity generated by four offshore wind farms together and then transmits it to Stevin, the high-voltage substation in Zeebrugge, through three export cables. Together, these four wind farms (Rentel, Northwester 2, Mermaid and Seastar) can generate up to 8 TWh of green electricity per year, which amounts to approximately 10% of the electricity demand in Belgium – so helping the country to meet its climate targets.

The MOG's design is more efficient and environmentally friendly than previous (radial) approaches to the connection of offshore wind farms to electricity grids: its design saved on the use of over 40 km of cabling that would have been needed if each wind farm had been connected to Stevin independently. Having three cables also guarantees that, should one of the cables become temporarily unavailable, wind power can continue to be transported to the mainland.



• THE MOG CONSISTS OF TWO PARTS: THE TOPSIDE, WHICH HOUSES ALL THE ELECTRICAL EQUIPMENT, CONTROL DECK AND HELICOPTER PAD; AND THE JACKET, WHICH SUPPORTS THE INFRASTRUCTURE AND ANCHORS IT TO THE SEABED.

**WATCH HIS MAJESTY THE KING'S VISIT TO THE MOG DURING ITS INAUGURATION**

→ The Energy Island in the Belgian North Sea is a unique project that will play a leading role in the energy transition. It will allow us to harvest the full potential of renewables in the modest space available in our waters. My team and I are very proud to be on the frontline of this exciting initiative and are fully committed to delivering the project in the best way we can with the highest regard for quality and safety.

**Tim Schyvens, Offshore Programme Manager at Elia**

# PRINCESS ELISABETH ISLAND

## THE WORLD'S FIRST ARTIFICIAL ENERGY ISLAND

**In December 2021, the Belgian Government approved the construction of the world's first artificial energy island: the Princess Elisabeth Island. The latter will be located in the Princess Elisabeth Zone (PEZ) – Belgium's second offshore wind zone in the North Sea, which, when completed, will have a nominal capacity of 3.5 GW.**

The island will act as a link between new offshore wind farms in the PEZ and Belgium's onshore grid. It will also be the first building block of the future European offshore grid, serving as an intermediary landing point for several new interconnectors, including Nautilus (**see page 16**) and TritonLink (**see page 18**). The island will therefore give Belgium access to offshore wind energy produced by the wind farms in the PEZ, will allow Belgium to trade renewable energy with other countries, and will enhance Europe's interconnectedness.

The area occupied by the energy island above the waterline will cover 6 hectares, with its area across the seabed stretching up to 25 hectares maximum (equivalent to 37.5 football pitches). The island, which will be designed and constructed by Belgian companies Jan De Nul and

**FIND OUT MORE ABOUT THE CONSTRUCTION OF THE ISLAND**



## KEY FACTS

**45 km**

The island will be located approximately 45 km off the coast of Belgium

**350 km**

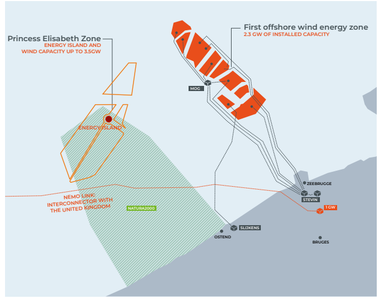
The island will be linked to the mainland via approximately 350 km of AC cables and 60 km of HVDC cables

**€99.7 million**

In December 2022, the Belgian Federal Government endorsed the island as a spearhead project and awarded it €99.7 million from the EU's Recovery & Resilience Facility, which aims to ensure Europe's recovery following the COVID-19 pandemic

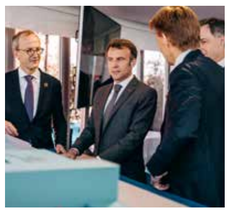
DEME, will be made of sand and will be surrounded by an outer perimeter of concrete caissons. A tall wall will also be built to protect the transmission infrastructure housed on the island from being flooded during rough sea conditions. The AC substations on the island will bundle the wind energy produced by the PEZ wind farms together, transform its voltage level, and transmit it back to the Belgian mainland via six AC export cabling systems and one HVDC export cabling system. The island will also host HVDC converter stations for the interconnectors that will land on it.

The construction of the island will run from early 2024 through to mid-2026, with the construction of the high-voltage infrastructure following soon after. In the meantime, offshore wind farm developers will start building their wind farms in the PEZ. The connection of these wind farms to Elia's onshore grid is linked to the commissioning of two projects which aim to reinforce Belgium's electricity backbone: Ventilus and Boucle du Hainaut. Elia is aiming to have the full capacity of the new offshore wind farms connected to its grid by 2030.




## Nature Inclusive Design

Since the PEZ lies in a Natura 2000 site in the North Sea, Elia wants to go beyond mitigating the impacts that the island will have on the marine ecosystem. It is working closely with nature conservation experts and scientists to explore how the island can have positive impacts on the surrounding area through the use of Nature Inclusive Design. **See page 47 for more information**.



**IN APRIL 2023, THE BELGIAN PRIME MINISTER AND MINISTER OF ENERGY – ALEXANDER DE CROO AND TINNE VAN DER STRAETEN – HOSTED EIGHT FOREIGN HEADS OF STATE AND GOVERNMENT AND THE PRESIDENT OF THE EUROPEAN COMMISSION DURING THE NORTH SEA SUMMIT IN OSTEND. PRIME MINISTER DE CROO AND CHRIS PEETERS PRESENTED A 3D MODEL OF THE ISLAND TO BELGIUM'S GUESTS DURING THE SUMMIT, INCLUDING EMMANUEL MACRON AND URSULA VON DER LEYEN.**

→ Belgium has been a pioneer in offshore wind for 15 years and is once again demonstrating its expertise through its first energy island - which is also a world first. Our offshore expertise is now recognised worldwide. By continuing to innovate, we are strengthening our position for the future.

**Tinne Van der Straeten, Belgian Minister of Energy**

We are pleased that Nautilus has been recognised as a Project of Mutual Interest, given the fact that it is a cross-border infrastructure project which will have a significant impact on market integration and will help the EU achieve its climate objectives. Along with the Princess Elisabeth Island, Nautilus will potentially form one of the world's first international multi-terminal offshore HVDC connections, so making it a technological tour de force.

**Bert Maes,**
**CEO of Nemo Link and CEO of Eurogrid International**

# NAUTILUS

## BELGIUM'S FUTURE HYBRID INTERCONNECTOR WITH THE UK

**Elia and National Grid Ventures (NGV), National Grid's commercial division, are developing plans related to the construction of Nautilus, a hybrid interconnector that will serve two simultaneous functions.**



Firstly, Nautilus will link Belgium and the UK together, allowing them to trade electricity with each other. Secondly, Nautilus will be linked to offshore wind farms in the North Sea, enabling electricity generated by these wind farms to be transported to either country. This hybrid design carries multiple benefits: it greatly reduces the amount of infrastructure required, so reducing both costs and the level of environmental disruption involved, whilst supporting national and European energy and climate targets.

The European Commission (EC) has noted that hybrid projects of this kind are an intermediate step on the way to the establishment of an integrated offshore European electricity grid, which is necessary for fully harnessing the potential of the North Sea and allowing Europe to reach net zero.

Elia and NGV are currently carrying out the required studies related to the HVDC link's exact route and scope. On the Belgian side, Nautilus will be connected to Belgium's new energy island (**see page 14**). The construction of the interconnector is due to start in 2025, with its commissioning due in 2030.

### ELIA GROUP'S WHITE PAPER ON PROMOTING HYBRID OFFSHORE INTERCONNECTORS

**The Russian invasion of Ukraine and record-breaking energy prices in 2022 returned a sense of urgency to the European energy security debate. Reaching net zero has never been as relevant as it is today. However, an important mismatch exists between European ambitions and the few structural actions that are actually being undertaken. In response, Elia Group published its white paper on hybrid interconnectors in April 2022. The combination of offshore wind farms and subsea interconnectors could enable Europe to harness the full renewable potential of the North and Baltic Seas while more effectively distributing the green electrons produced among its Member States.**


## KEY FACTS

**PMI**

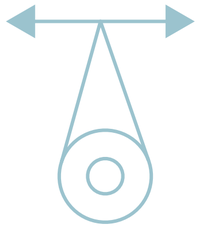
The European Commission has officially recognised Nautilus as a Project of Mutual Interest

**1.4 GW**

The interconnector's nominal capacity is due to be 1.4 GW

**2030**

Planned commissioning date



**READ ELIA GROUP'S WHITE PAPER ON HYBRID INTERCONNECTORS HERE**

→ Offshore wind is entering a new era. Connecting offshore wind projects to more than one country will improve electricity flows across Europe. By pooling generation and transmission infrastructure, these 'hybrid' offshore wind [projects] lower costs and save space. [This project] is good news for Belgium, Denmark [...] – and for all of Europe. We will need many more of these hybrid projects.

**Giles Dickson,**
**CEO of WindEurope**

# TRITONLINK



## FIRST INTERCONNECTOR LINKING BELGIUM TO A NON-NEIGHBOURING COUNTRY: DENMARK

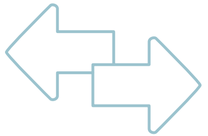
**Elia and its Danish counterpart, Energinet, are working on the construction of a hybrid interconnector that will link Belgium to Denmark. This will enable both countries to exchange power and will allow electricity from offshore wind farms to be transported to their respective onshore grids, ultimately incorporating renewable energy into Europe's onshore electricity system.**

TritonLink will therefore contribute to building the integrated offshore electricity grid that Europe is aiming to establish in the run-up to net zero. The interconnector will begin at an onshore HVDC converter station in Belgium; run through the Princess Elisabeth Island (**see page 14**); cross the North Sea to reach an offshore platform that Denmark will build off its coast; and end at an HVDC converter station on the Danish mainland.

Preliminary studies carried out in 2021 confirmed that the project is technically and financially possible, although noted that its construction will be challenging due to the technology it will involve and the distance it will cover.

The partners are currently undertaking technical studies related to the interconnector and the route it will follow. TritonLink will likely take four or five years to build after the final investment decisions have been taken and is due to be commissioned in 2031/32.

IN APRIL 2023, HIS ROYAL HIGHNESS THE CROWN PRINCE OF DENMARK WAS GIVEN A TOUR OF THE 3D MODEL OF THE PRINCESS ELISABETH ISLAND BY CHRIS PEETERS, THE CEO OF ELIA GROUP, AND STEFAN KAPFERER, THE CEO OF 50HERTZ, DURING THE 2023 WINDEUROPE CONFERENCE IN COPENHAGEN. TRITONLINK WILL RUN THROUGH PRINCESS ELISABETH ISLAND AND ACROSS THE NORTH SEA TO DENMARK.



## KEY FACTS

The interconnector is named after Triton, the ancient Greek god of the sea, who was half man, half fish; Triton has been depicted as the father of the little mermaid, whose statue sits in Copenhagen

**1,000 km**

It will run across a distance of almost 1,000 km from the Belgian mainland to the Danish onshore grid

**3 MGT**

TritonLink will result in an annual $CO_2$ reduction of almost 3 megatonnes, which is equivalent to the $CO_2$ production of approximately 900,000 cars

# 50HERTZ'S PROJECTS IN GERMANY

**22**
First interconnector to link Germany to Denmark


**24**
First connections to wind farms in the Baltic Sea


**26**
The world's first subsea hybrid interconnector

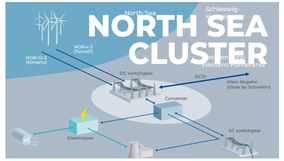

**28**
50Hertz's first shared cabling project


**30**
Harnessing wind energy off the coast of Rügen


**32**
First offshore substation fully owned by 50Hertz


**33**
50Hertz's first HVDC offshore grid connection


**34**
Connecting Germany to a 927 MW wind farm in the Baltic Sea


**36**
50Hertz gains access to the German North Sea

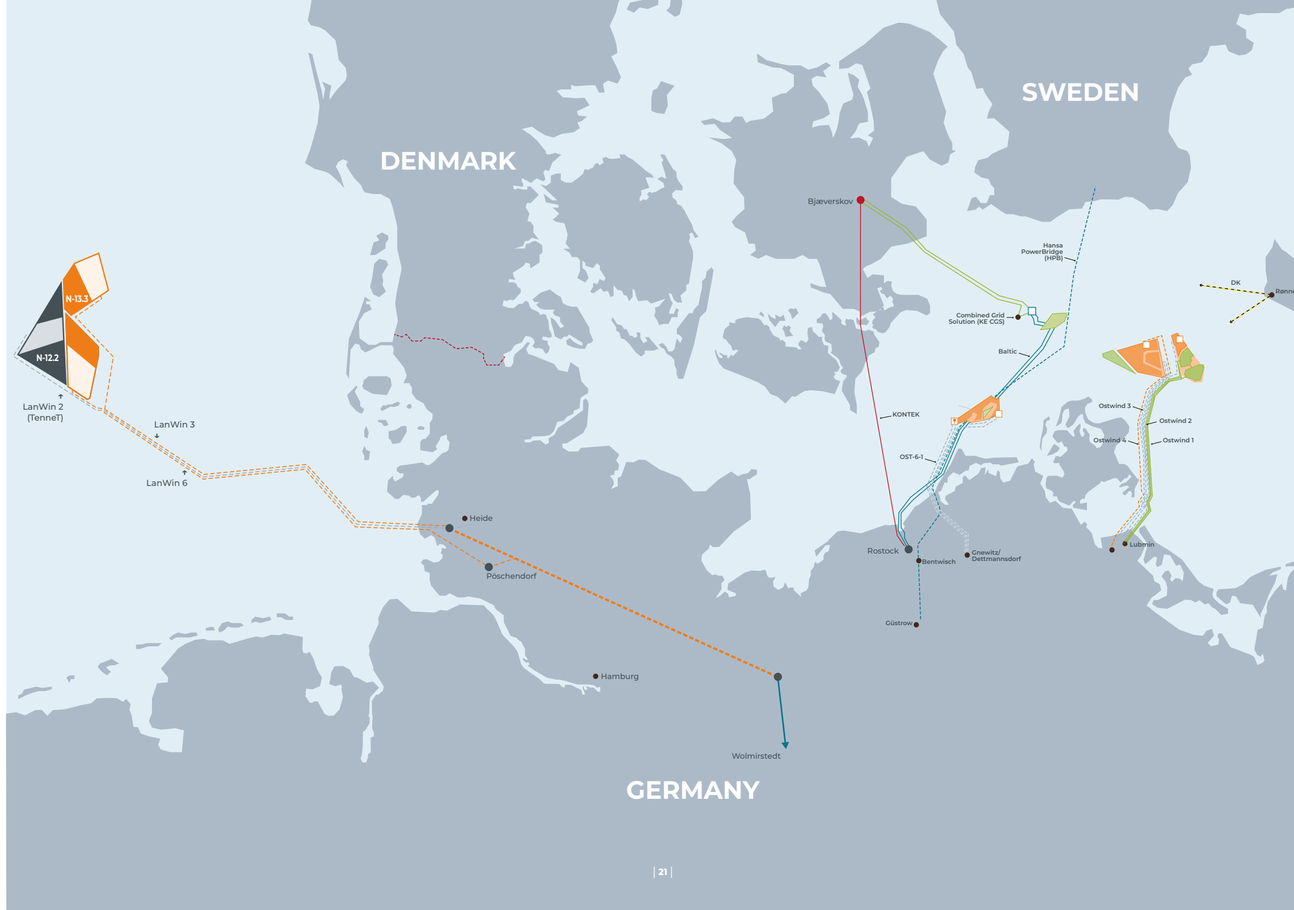
**38**
Interconnector linking German wind to Swedish hydropower


**39**
Energy hub in the Baltic Sea



**40**
Providing Europe with offshore wind energy from the Baltics





During the replacement of the land cable, the grid connection to the existing interconnector was always guaranteed. Nevertheless, with the new extra-high-voltage direct current cable on the German side, KONTEK continues to stabilise European grid infrastructure, secure the electricity supply in Germany and southern Denmark, and ensure the continuous integration of renewable energy into our electricity grid.

**Dr. Clemens Unger, Offshore project manager at 50Hertz**

# KONTEK INTERCONNECTOR



## FIRST INTERCONNECTOR TO LINK GERMANY TO DENMARK

**Germany and Denmark have been connected since 1995 via a point-to-point DC interconnector: KONTEK. Elkraft – a Danish transmission system operator which was Energinet's predecessor – was responsible for building the interconnector, which runs from Bjæverskov on the Danish island of Zealand, via the landing point on the German mainland, to the substation in Bentwisch near the city of Rostock.**

After about 25 years in operation, the subsea section of the cable, which is 150 kilometres long, had reached the end of its operational capacity and was replaced by Energinet. The interconnector had been designed and constructed before the liberalisation of the European electricity sector, meaning it was not as flexible as the modern age required.

The replacement of the land section of the cable in Germany, which is 50Hertz's responsibility, was officially approved by the Mecklenburg-Western Pomerania authorities in February 2022 and completed in the summer of 2023.


### KEY FACTS

**400 kV**
KONTEK's DC cables have a voltage of 400 kV

**600 MW**
KONTEK has a transmission capacity of 600 MW

**170 km**
The total length of the interconnector

→ Installing the first offshore grid connection (Baltic 1) and subsequently operating it, as well as being allowed to connect the second wind farm (Baltic 2) to the grid directly afterwards, were major challenges for 50Hertz and our partners. The pioneering work done, the experience gained from the installation and operation of the assets, and our good teamwork with the wind farm operator EnBW are valuable ingredients that we have implemented and further developed in subsequent projects.

**Marian Mügel,**
**Offshore Cable Manager at 50Hertz**


# BALTIC 1 / BALTIC 2



## FIRST CONNECTIONS TO WIND FARMS IN THE BALTIC SEA

**50Hertz's first projects that involved building offshore infrastructure were Baltic 1 and Baltic 2. These connections link two offshore wind farms in the Baltic Sea to the German onshore grid.**

The Baltic 1 offshore wind farm, which was built and is operated by the energy company EnBW, is Germany's first commercial offshore wind farm. It lies approximately 15 kilometres off the coast of Mecklenburg-Western Pomerania, north of the Darß peninsula. On 2 May 2011, then Chancellor Angela Merkel attended the inauguration of the wind farm in Zingst.

The construction of the grid connection for the wind farm was an offshore first for 50Hertz. The wind farm comprises 21 wind turbines and the Baltic 1 offshore substation, which is used by both 50Hertz and EnBW. The substation steps up the voltage of the electricity generated by the wind farm from 33 kV to 150 kV; following this, 50Hertz's subsea cable system transports the electricity across a distance of 60 kilometres to Markgrafenheide, to the east of Rostock. From there, the power is transported to the onshore substation in Bentwisch via a 14-kilometre land cable, where it is then fed into the 50Hertz transmission grid.

The Baltic 2 wind farm, which is also operated by EnBW, has been connected to the grid since 2015. Baltic 2 is located 32 km to the north of the island of Rügen. The wind farm covers an area of 27 square kilometres and can generate 1,200 GWh of electricity for approximately 340,000 households every year – saving 900,000 tonnes of $CO_2$ in the process. Baltic 2 is connected to the 50Hertz grid via the Baltic 1 cable system and three other subsea cables.

### KEY FACTS

**336.3 MW**

The Baltic 1 and Baltic 2 offshore wind farms have a combined capacity of 336.3 MW

**101**

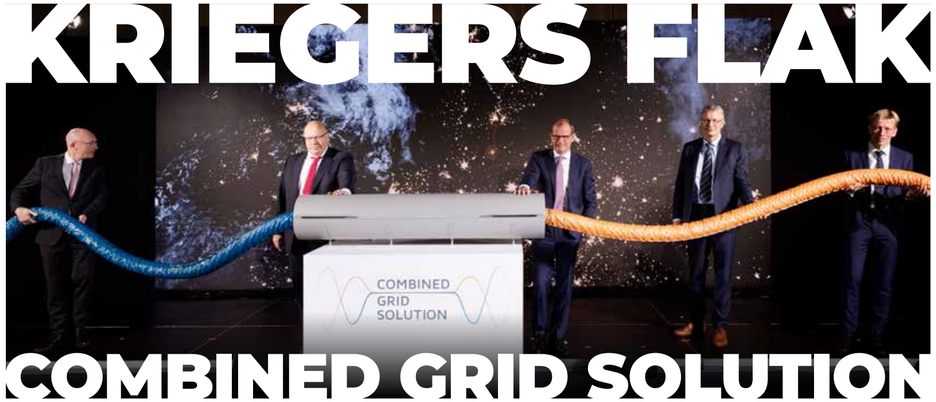
Together, the Baltic 1 and Baltic 2 wind farms comprise 101 wind turbines

The cables that link the Baltic 1 and Baltic 2 wind farms to the 50Hertz grid form part of the first hybrid interconnector built by 50Hertz and its Danish counterpart: the Kriegers Flak – Combined Grid Solution (**see page 26**)

→ The MIO allows us to make optimum use of offshore assets for the integration of wind into the system and make optimum use of the interconnector for the exchange of energy between Germany and Denmark. The MIO is a blueprint for future innovative offshore control systems for AC and DC grids.

**Dr. Anne-Katrin Marten, Head of Operational Systems Management at 50Hertz**

# KRIEGERS FLAK COMBINED GRID SOLUTION




## THE WORLD'S FIRST SUBSEA HYBRID INTERCONNECTOR

**The Kriegers Flak – Combined Grid Solution (KF-CGS), which was inaugurated in 2020, connects Denmark and Germany together. The interconnector, which gives both countries access to offshore wind produced in the Baltic Sea, is the first hybrid offshore interconnector in the world. It allows electricity to be traded between Germany and Denmark and, at the same time, is connected to three offshore wind farms, making the wind power they generate available for cross-border electricity trading. No comparable project has yet been completed anywhere else in the world.**



On the German side, the Baltic 1 and Baltic 2 wind farms (**see page 24**) are used as part of CGS. On the Danish side, one offshore wind farm (Kriegers Flak) and its radial connection are used as part of the hybrid interconnector. Two subsea cables, which are 25 km long and have a capacity of approximately 200 MW each, bridge the distance between the Danish and German sides by linking the Baltic 2 and Kriegers Flak substation platforms together.

### Master Controller for Interconnector Operation

The CGS consists of both hardware and software components. The Master Controller for Interconnector Operation (MIO), which was developed by 50Hertz and some of its partners, acts as the 'brain' of the hybrid interconnector. This digital control unit, which is located in 50Hertz's Control Center in Neuenhagen near Berlin, manages market-based electricity exchanges between Denmark and Germany. To do so, it must reconcile the requirements of the electricity market and the amount of electricity produced by the wind farms connected to CGS (which depends on wind conditions). The MIO aims to enable the most optimal use of the interconnector whilst preventing it from overloading. It employs weather forecasts, ensures the required voltage is kept stable and keeps the system in balance in real time. It makes use of the back-to-back-converter in Bentwisch in doing so.

### Back-to-back-converter station at Bentwisch

Since the German and Danish AC grids are asynchronous, a novel solution was employed to safely connect them: an HVDC back-to-back converter station located in Bentwisch. The first of its kind in Europe, it consists of two converters located in the same building.

## KEY FACTS

**25 km**

Two subsea cables, which are 25 km long, link Germany and Denmark together by providing a link between two offshore wind farms

The CGS is jointly owned and operated by Energinet (Denmark), and 50Hertz; the European Commission provided funding for it through a Grant Agreement and has recognised it as a Project of Common Interest

**15 m**

The converter hall in Bentwisch is half the size of a football field and almost 15 metres high

**400 MW**

The CGS has a transmission capacity of 400 MW

→ Working with our Danish partners was a great success. We will be able to use the experience we have built up with them as we continue to expand our offshore activities and further connect offshore wind in an efficient and flexible manner to different countries. Through the KF-CGS, we have demonstrated that we have the technology and the necessary project knowledge to harness the full potential of the Baltic Sea.

**Dr. Henrich Quick, Head of Offshore at 50Hertz**

WATCH A VIDEO OF THE INAUGURATION OF THE KF - CGS HERE

→ The elimination of a complete 90 kilometre-long cable system not only meant that an enormous amount of resources was saved (raw materials, time, budget), but also meant that we significantly reduced the amount of areas that the project impacted, including those located in ecologically sensitive areas such as the Bay of Greifswald. We were thus able to successfully demonstrate that economic and ecological considerations do not have to contradict each other, but can, in fact, complement each other.

**Dr. Wolfgang Thießen, Project Director Ostwind 1 at 50Hertz**

# OSTWIND 1




## 50HERTZ'S FIRST SHARED CABLING PROJECT

**The Ostwind 1 project, which was finished in 2019, was a first for 50Hertz. It involved building three cables for two offshore wind farms in the Baltic Sea, with one of these three cables being a shared cable.**

Ostwind 1 connects the Wikinger and Arkona wind farms to the 50Hertz grid, transporting the electricity they generate in a highly efficient, safe and sustainable manner. The wind farm developers and 50Hertz oversaw the construction of the offshore substations for each wind farm together.

One of the project's cables is used to transport the electricity generated by Wikinger to shore, whilst another is used to transport the electricity generated by Arkona to shore. The third cable is connected to both wind farm offshore substations, allowing the electricity from them to be transported to 50Hertz's onshore grid.

The Ostwind 1 project was the first of its kind for 50Hertz. It prevented the construction of a fourth cable – due to the fact that the cables leading from the offshore substations to the onshore substation have a transmission capacity of 250 MW – resulting in cost savings and a reduction in the impact of the project on the environment. This unique approach was only made possible due to the collaborative partnership that 50Hertz established with the two wind farm developers.

The project involved several international partners working together: Wikinger was constructed by Iberdrola (from Spain), whilst Arkona was constructed by Eon (from Germany) and Equinor (from Norway). Moreover, the two offshore substations for the wind farms were manufactured in France and Spain and the supplier of the cable systems, Prysmian, manufactured them in Italy and Finland.

The wind farms were commissioned in 2018 and 2019, earlier than planned due to 50Hertz's work on the cabling systems, and they have been running steadily ever since. In terms of time, quality and budget, Ostwind 1 was, and still is, a success story.



## KEY FACTS

**3 for 2**

Ostwind 1 involved 50Hertz building three cables for two offshore wind farms in the German Baltic Sea

**250 MW**

The three cables that link Wikinger and Arkona to 50Hertz's grid have a transmission capacity of 250 MW each

**735 MW**

Together, Wikinger and Arkona comprise 130 wind turbines and have a combined nominal capacity of 735 MW

→ The completion of the Ostwind 2 project will provide another substantial contribution to the delivery of offshore wind energy to households and businesses in Germany. The execution of this technically complex project reinforces the position of 50Hertz in the offshore infrastructure environment.

**Simon Deplace, Technical Project Director – Ostwind 2**

# OSTWIND 2



## HARNESSING WIND ENERGY OFF THE COAST OF RÜGEN

**Ostwind 2 comprises the construction of cables for two offshore wind farms located to the northeast of the island of Rügen: Arcadis Ost 1, built by Parkwind, from Belgium (now owned by JERA); and Baltic Eagle, built by Iberdrola. Whilst closely related to the Ostwind 1 project, Ostwind 2 uses the latest innovative techniques in offshore development.**

IN NOVEMBER 2022, BELGIAN PRIME MINISTER ALEXANDER DE CROO AND FEDERAL MINISTER OF ENERGY TINNE VAN DER STRAETEN VISITED THE CONSTRUCTION SITE OF THE BALTIC EAGLE OFFSHORE TRANSMISSION PLATFORM IN HOBOKEN, BELGIUM

50Hertz built three 220 kV subsea cable systems for the project. They were laid in 2021 and 2022 and run parallel to the Ostwind 1 cable systems, joining the German mainland via the same landing point in Lubmin.

Both Arcadis Ost 1 and Baltic Eagle have now been connected to the 50Hertz grid via these three cable systems. The Arcadis Ost 1 offshore substation was installed in June 2022, with its first wind turbines feeding electricity into the onshore grid in February 2023; it was commissioned in the autumn of 2023. Also in February, the Baltic Eagle offshore substation was successfully installed at sea. Two of the project's three subsea transmission cables were connected to it a few months later. Once it is commissioned in 2024, the Baltic Eagle wind farm is due to meet the electricity demand of half a million homes, so saving 800,000 tonnes of $CO_2$ each year.

**IN APRIL 2022, BELGIAN MINISTER OF ECONOMY AND EMPLOYMENT PIERRE-YVES DERMAGNE TOURED THE CONSTRUCTION SITE OF THE ARCADIS OST OFFSHORE PLATFORM IN AALBORG, DENMARK**

## KEY FACTS

**250 MW**

Each of Ostwind 2's three cables has a transmission capacity of around 250 MW

**2,090 tonnes**

The monopile (foundation) of the Arcadis Ost 1 offshore substation for Arcadis Ost 1 weighs 2,090 tonnes and has a diameter of 10 metres; built by 50Hertz and Parkwind, the monopile-based offshore substation is one of the largest of its kind across the world

**725 MW**

Together, Arcadis Ost 1 and Baltic Eagle will generate an output of approximately 725 MW

Ostwind 3 will contribute an additional 300 MW towards German and European climate targets and is the first project for which 50Hertz carries full responsibility for the offshore wind farm platform. Our project team is also responsible for the OST-6-1 grid connection, allowing us to create synergies. I am extremely proud of the team and their outstanding work – they have taken on these projects and challenges with high levels of commitment and a sense of enjoyment for what we are achieving.

**Manuel Wildmann, Technical Project Manager**

# OSTWIND 3

## FIRST OFFSHORE SUBSTATION FULLY OWNED BY 50HERTZ

**Ostwind 3 is 50Hertz's third offshore grid connection project that relates to wind farms located to the northeast of the island of Rügen. However, the project marks the first time that 50Hertz will carry full responsibility for and ownership of the offshore substation that is built for an offshore wind farm.**

The above follows a new regulation from the German Federal Maritime and Hydrographic Agency (Bundesamt für Seeschifffahrt und Hydrographie), which stipulates that transmission system operators are to bear full responsibility for offshore substations which enter into operation from 2026 onwards. Despite this development, cooperation between wind farm developers and transmission system operators will remain very important.

The Windanker wind farm, which Ostwind 3 will connect to the onshore grid, will be located to the north of the Wikinger and Arkona wind farms (**see Ostwind 1 project on page 28**) in the Westlich Adlergrund Cluster. The route of the cabling system for Ostwind 3 will therefore largely follow the same route as the cables for the Ostwind 1 and Ostwind 2 project. However, unlike for Ostwind 1 and 2, the cables for Ostwind 3 will land at a new substation which will be built in Stilow on the German mainland.

A 220 kV three-phase AC cable with a transmission capacity of 300 MW will be used for Ostwind 3, which is due to be commissioned in 2026.

### KEY FACTS

**300 MW**

The Windanker wind farm, which will be built by Iberdrola, will have a nominal capacity of 300 MW: enough electricity to power around 260,000 households

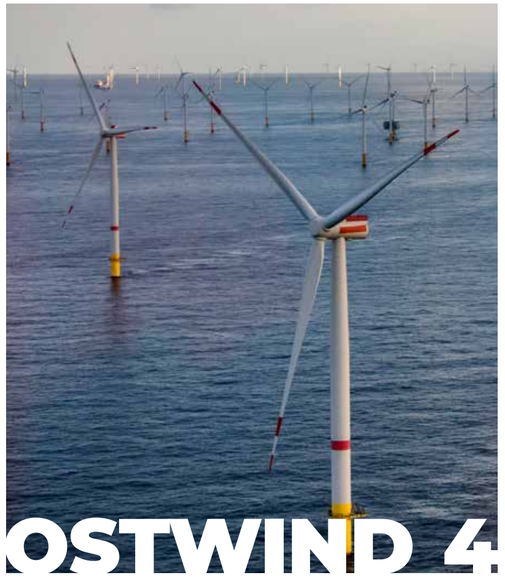
**40 km**

The offshore substation will be erected about 40 kilometres north-east of the island of Rügen

**1st**

For the first time, 50Hertz will carry full responsibility for and ownership of the project's offshore substation





# OSTWIND 4

## 50HERTZ'S FIRST HVDC OFFSHORE GRID CONNECTION

**50Hertz will be using DC technology to build its next generation of offshore grid connections. Ostwind 4 will be the first HVDC offshore wind grid connection system in the Baltic Sea. The wind farm that will be connected to Ostwind 4 will be able to supply as much wind energy as the Baltic 2, Wikinger and Arkona wind farms combined (see pages 24 and 28).**

Elia Group has a lot of experience with this technology in offshore development; for example, Nemo Link (**page 10**) uses HVDC. Moreover, other offshore HVDC projects such as Nautilus (**page 16**), TritonLink (**page 18**), Bornholm Energy Island (**page 39**) and Hansa PowerBridge (**page 38**) interconnectors are being planned.

### KEY FACTS

**HVDC**

Ostwind 4 will be the first offshore wind connection to be built using HVDC in the Baltic Sea

The wind farm connected to Ostwind 4 will be able to supply as much wind energy as the Baltic 2, Wikinger and Arkona wind farms combined

As 50Hertz's first HVDC connection in the Baltic Sea, the Ostwind 4 project makes an important contribution to Germany's goal of developing 30 GW of offshore wind capacity by 2030. 50Hertz is using its extensive experience from AC offshore wind grid connections and interconnector projects to realise the next generation of offshore wind grid connections. More power can be transmitted across fewer cable routes, reducing the impact on the environment.

**Tamara Landgraf, Programme Manager – Ostwind 4**

# OST-6-1



→ One particularity of the OST-6-1 project is that the team involved is also in charge of the Ostwind 3 grid connection [see page 32]. Managing two projects at the same time means that synergies can be created and efficiency can be encouraged across both. I'm proud of how committed the team is to ensuring both projects are a success.

**Marc Riudalbas, Programme Manager AC offshore Baltic Sea at 50Hertz**

## CONNECTING GERMANY TO A 927 MW WIND FARM IN THE BALTIC SEA

**The OST-6-1 project involves connecting 50Hertz's onshore grid to an offshore wind farm located approximately 15 kilometres north of the Fischland-Darß-Zingst peninsula. Once completed, the offshore wind farm, called Gennaker, will be huge: it will have a nominal capacity of 927 MW.**

This massive OST-6-1 project encompasses the construction of:

- three AC cable systems, which will include onshore and offshore sections and be up to 88 kilometres in length each;
- two offshore substations, both connected via a 220 kV cable, forming a mini grid to transport the generated power in the most efficient way;
- a new onshore substation in Gnewitz, 30 kilometres to the east of Rostock in Mecklenburg-Western Pomerania.

In December 2022, the Dutch-Belgian consortium HSM Offshore Energy, Smulders, and Iv-Offshore & Energy was officially awarded the contract to construct the two offshore substations for the project. In March 2023, Eurogrid GmbH (50Hertz's parent company) secured a €600 million green loan to finance OST-6-1. Also in early 2023, 50Hertz began holding a series of public consultation events in relation to the project. As of the summer of 2023, 50Hertz had awarded the contracts for the construction of the project's cables to Hellenic Cables and Jiangtsu Zhongtian Technology Submarine Cable. It was also preparing to submit the documents needed for the two planning approval processes relating to the project. These are due to be submitted in 2024, with planning approval due to be obtained 12 months afterwards.

### KEY FACTS

**220 kV**
The voltage of the three AC cable systems will be 220 kV

**927 MW**
The wind farm will have a nominal capacity of 927 MW

**252 km**
The combined length of the three AC cable systems will be up to 252 km long

**2**
The project will involve the construction of two offshore substations, which will both be used to collect the power generated by Gennaker; these substations will be connected by a cable which will distribute electricity loads in a flexible and highly efficient manner

→ The innovative concept of this program aims for nothing less than kicking off a new era of offshore wind development in Europe. The set-up in HVDC multi-terminal technology will be a major step forward towards our overall vision of creating a meshed DC offshore grid that increases security of supply and cost efficiency, while at the same time reducing the use of maritime space. This will be key for achieving the German and European offshore wind expansion targets.

**Stefan Westhues, Programme Manager for the North Sea Connector at 50Hertz**




# 50HERTZ GAINS ACCESS TO THE GERMAN NORTH SEA

**The North Sea Connector project will, for the first time ever in 50Hertz's history, connect its onshore grid to two offshore wind farms located in the North Sea. The project, parts of which will be jointly built by 50Hertz and TenneT, includes two main strands: the North Sea Connector 1 Program and the North Sea Connector 2 Program.**

The North Sea Connector 1 Program will involve the construction of an onshore section (the NordOstLink) and an offshore cable system (LanWin3), complete with an offshore HVDC substation for one offshore wind farm. The North Sea Connector 2 Program will comprise an onshore cable system (DC32) and an offshore cable system (LanWin6) that will include a second HVDC substation for another offshore wind farm.

The NordOstLink will run from the west of Schwerin (the capital of Mecklenburg–Western Pomerania in 50Hertz's control zone) to a multi-terminal hub in the area near Heide on Germany's North Sea coast, which lies in TenneT's control zone, and to which LanWin3 will be connected. 50Hertz and TenneT will construct both the NordOstLink and the multi-terminal hub together, safely connecting their HVDC networks via the latter.

The multi-terminal hub, or DC switchgear, will be among the first of its kind in Europe. It will sit between the HVDC converters of both 50Hertz and TenneT's systems, deviating from the classic 'converter-pair' configuration which has been used to date. The hub will be connected to 50Herzt's offshore cable system Lanwin3 and to TenneT's offshore cable system LanWin2, which will each connect one wind farm to the mainland. The technology for the multi-terminal hub is being developed by an innovation partnership that includes key contributors from the HVDC converter industry.

The NordOstLink, for which both 50Hertz and TenneT will be the final permit holders, is currently undergoing a fast-track approval process led by the German authorities. This faster process – which applies to grid construction – was implemented by the German Government in 2023. It followed emergency regulations that the European Union adopted at the end of 2022 to speed up the permitting process for renewable energy projects. As of the summer of 2023, the auction process for the site connected to LanWin3 had been completed.

The exact route of the cables as part of the North Sea Connector 2 Program is currently being planned out. To accelerate the energy transition, and encourage a reduction in the number of permitting processes that grid expansion projects must undergo, the DC32 part of the program has been included in the permit procedure for the NordOstLink. LanWin6 will then be linked to the 50Hertz control zone via DC32, so connecting another 2 GW offshore wind farm from the North Sea Cluster to its grid.

### NORTH SEA CLUSTER

The North Sea Connector project is one of several projects that aim to link future offshore wind farms in the North Sea to Germany's onshore grid. In addition to 50Hertz and TenneT, Amprion is also exploring projects that would connect it to the offshore North Sea Cluster zone.



## KEY FACTS

**2 GW**

The offshore wind farms connected to LanWin3 and Lanwin6 will have a nominal capacity of 2 GW each

**~250 km**

The anticipated length of the NordOstLink once its route has been fully planned out

**525 kV**

The NordOstLink's DC cables will have a voltage of 525 kV and a transmission capacity of 2 GW

# HANSA POWERBRIDGE

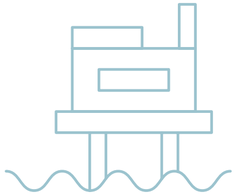
## INTERCONNECTOR LINKING GERMAN WIND TO SWEDISH HYDROPOWER

**The Hansa PowerBridge is an interconnector that 50Hertz and its Swedish counterpart Svenska kraftnät are planning to build. The interconnector will give Germany indirect access to storage for electricity produced from renewable sources, since Sweden has large amounts of controllable hydropower.**

The interconnector, a 300 kV DC connection, is due to run from the Güstrow substation in Mecklenburg-Western Pomerania to Hurva in Sweden.

The German section of the project will consist of: a subsea cable that will run for 105 kilometres through the German exclusive economic zone; a cable section station in Dierhagen; a 70-kilometre land cable route; and a converter station in Lüssow that will be connected to the Güstrow substation.

As of mid-2023, the routes for the on- and offshore sections of the German cabling systems had been submitted to the authorities for approval. The interconnector is due to be commissioned towards the end of the decade.



### KEY FACTS

**700 MW**

The Hansa PowerBridge will have a transmission capacity of 700 MW

**300 km**

The interconnector will run across a distance of 300 kilometres



→ By connecting Bornholm Energy Island to the Danish and German grids, it is possible to fully exploit the potential for offshore wind energy production around the island of Bornholm. At the same time, the island will contribute to the establishment of a meshed offshore grid in the Baltic Sea. Indeed, its hub design will enable further interconnectors and offshore wind farms to be connected to it in future.

**Dettmar-Wilhelm Knieriem, Programme manager – Bornholm Energy Island**

# BORNHOLM ENERGY ISLAND

## ENERGY HUB IN THE BALTIC SEA

**Drawing on the experience gained through their work on the Kriegers Flak - Combined Grid Solution project (see page 26), 50Hertz and Energinet are, once again, collaborating on a distinctive project in the Baltic Sea. The Danish island of Bornholm – which is located 88 kilometres from the German coast and 135 kilometres from the Danish coast – will be transformed into an important power hub. It will provide electricity to consumers in both countries, depending on the market and demand in Germany, Denmark and Europe more widely.**

As part of the project, a hybrid interconnector will be built; this HVDC connection will run across 200 kilometres from the island of Zealand in central Denmark, via Bornholm, to the coast of Mecklenburg-Western Pomerania in northeastern Germany. A joint energy hub with converters and substations for the distribution of electricity to either country will be built on Bornholm itself. The energy hub will therefore allow electricity to be traded between both countries, including green electricity generated by two Danish offshore wind farms which will be built off the coast of the island.

In June 2023, the German and Danish governments signed an agreement which allows Energinet and 50Hertz to allocate responsibility for different tasks related to the realisation of the energy hub, including the construction of the several hundreds of kilometres of offshore and onshore cable systems. As stipulated in the agreement, both transmission system operators will split the infrastructure costs for the project, the target renewable energy amounts produced by the offshore wind farms, and the congestion revenues linked to the cables leading to either country in an equal manner.

### KEY FACTS

**525 kV**

The HVDC hybrid interconnector, which will connect two asynchronous grid areas together via the island of Bornholm, will have a voltage of 525 kV; the technical nature of the energy hub will be much more demanding than previous projects 50Hertz has worked on, requiring new solutions for controlling electricity flows to be developed

**3 GW**

Bornholm Energy Island have a production capacity of 3 GW, of which up to 2 GW will be transmitted to the German grid

**TO FIND OUT MORE, VISIT THE PROJECT WEBSITE**

The Baltic Sea holds a lot of offshore wind potential, meaning opportunities therefore exist for cross-border projects such as hybrid interconnectors or energy islands to develop it. Cooperation with the Baltic States and strengthening their ties to Continental Europe's electricity system are important for the continent to reach climate neutrality and for its energy sovereignty. The Baltic WindConnector could constitute an important step in this regard.

**Moritz Wienhold, Asset and Offshore Regulation Department**




# PROVIDING EUROPE WITH OFFSHORE WIND ENERGY FROM THE BALTICS

**In May 2023, 50Hertz and its Estonian counterpart Elering signed a letter of intent outlining their plans to build a hybrid interconnector: the Baltic WindConnector. As well as joining Germany to Estonia, if the project goes ahead, this interconnector will be linked to large offshore wind farms located off the Estonian coast. In addition to enabling cross-border electricity trade to occur, including of offshore wind power, both the Baltic States and Central Europe will benefit from increased security of supply. Moreover, the interconnector will provide Estonia with the opportunity to become an exporter of green electricity to the European electricity market whilst enabling Germany to diversify its of green electricity supply as it aims to achieve climate neutrality by 2045.**

## KEY FACTS

**800 km**

The Baltic WindConnector will be around 800 kilometres long

**2045**

The year Germany aims to reach climate neutrality by

The agreement relating to the Baltic WindConnector was signed during the Baltic Offshore Wind Forum. Held in May 2023, this brought politicians and TSO representatives from nine of the ten Member States belonging to the Council of the Baltic Sea States (Estonia, Latvia, Lithuania, Denmark, Finland, Poland, Norway, Sweden and Germany) together to further their energy sovereignty and protection of the climate.

A second letter of intent was signed during the forum by 50Hertz, Elering and their counterparts from Latvia and Lithuania. In this, the four partners pledged to foster their cooperation with a view to integrating increasingly higher levels of renewable energy into their grids – ultimately, by establishing a meshed offshore grid off the coasts of the Baltic States.

WindGrid (see page 42) is working with Elering to raise the project's profile amongst Estonian offshore wind developers.

**WATCH THE HIGHLIGHTS FROM THE BALTIC OFFSHORE WIND FORUM 2023 HERE**

The energy transition is most efficient when a strong focus is placed on electricity and cross-sector conversions being reduced to a minimum. However, this requires different sources of renewables to be combined in the electricity system, both in terms of their type and regional distribution. This project is a great example of how to turn this vision into reality and strengthen European integration at the same time.

**Dr. Klaus von Sengbusch, Head of Strategic Grid Planning**

# WINDGRID



## APPLYING THE GROUP'S EXPERIENCE IN THE U.S. AND THE BALTIC, NORTH AND IRISH SEAS

**In 2022, WindGrid, Elia Group's newest subsidiary, was formed. Markus Laukamp, its CEO, explains how the company is leveraging the Group's experience in offshore development to accelerate the energy transition outside of the Group's regulated businesses in Belgium and Germany. The company is specifically focused on the U.S. market, since this is due to grow rapidly over the next few years.**

**WindGrid's launch generated a lot of positive feedback from the offshore sector. What in particular has attracted the attention of energy sector actors?**

**ML:** Potential partners in new markets, like the U.S., are impressed with Elia Group's portfolio, skills, and proven experience in offshore project development. They have been keen to explore how WindGrid could harness and apply these strengths in new environments. The U.S., which currently has a relatively small amount of installed offshore capacity, has demonstrated a particular interest in WindGrid: the country holds an enormous potential for offshore wind development, especially in the Northeast.

WindGrid is a channel for a decade's worth of experience and skills that the Group has built up in Europe. At the same time, we understand the importance of local know-how in order to ensure that the offshore transmission projects we work on are shaped to respond to regional needs and contexts. This was a key reason for founding a new office in the U.S. Our staff there are engaging with regulators, suppliers and grid operators to foster the development of offshore grid infrastructure.

**What added value can WindGrid bring to its customers?**

**ML:** WindGrid is seen as a solid partner for governments, grid operators and renewable energy developers, whether as a designer, owner or operator of offshore transmission assets. This has been demonstrated by the agreements we signed with two U.S. partners: NextEra Energy Transmission MidAtlantic (NEETMA) and PPL Corporation.

The MoU WindGrid signed with NEETMA (a subsidiary of NextEra Energy Transmission LCC) covered the submission of a joint proposal to develop and construct offshore wind transmission infrastructure for the state of New Jersey. We are currently exploring future possible collaborations with them.

Moreover, WindGrid is working with PPL Corporation (through its subsidiary PPL TransLink LLC) and New England to shape regulation related to the establishment of an offshore grid that would help the states meet their offshore wind ambitions.

**In addition to the U.S., WindGrid has also been working with partners in Europe to support the continent's move to net zero. What has this work involved?**

WindGrid is identifying and answering to market demands in areas which are not covered by our regulated entities. We are working on the development of projects across Europe, including new interconnectors. As part of this, we are engaging with local TSOs; for example, we have been supporting Estonia's TSO to raise the profile of the Baltic WindConnector project amongst Estonian wind farm developers (**see page 40**). This has delivered political momentum for the project's progression.

Through the projects it works on, WindGrid will unlock further revenue streams for Elia Group and allow the latter to acquire further experience which it can then offer to the European market. This will allow the Group to remain at the forefront of offshore wind development and maintain its relevance for driving the energy transition forwards in the long run.

→ **As the U.S. seeks to accelerate the development of offshore wind to advance a cleaner energy future, it's essential that we prepare to integrate that wind as reliably and efficiently as possible to strengthen grid resilience and keep energy affordable. Both PPL and Elia Group are at the forefront of grid innovation. We intend to leverage our shared vision and deep expertise to propose solutions that advance decarbonisation goals, enhance energy security and drive value for consumers.**

**Vincent Sorgi, President and CEO of PPL Corporation**


# SUSTAINABLE APPROACHES TO OFFSHORE GRID DEVELOPMENT



**Offshore grid development activities disturb local marine environments and can have an impact on marine ecosystems. Elia and 50Hertz therefore undertake mitigation and compensation measures that aim to avoid, reduce and offset any negative impacts generated by their activities. These measures are outlined in the environmental impact assessments that both companies prepare as part of permitting processes. In Belgium, Elia has chosen to go one step further as part of the development of its artificial energy island (see page 14), through the adoption of Nature Inclusive Design.**


Both Elia and 50Hertz have built up solid experience in implementing mitigation and compensation measures, including nature restoration measures, through research on international best practice and through collaboration with local partners and organisations such as the Renewables Grid Initiative (RGI), which promotes fair, transparent and sustainable grid development in Europe. Both companies are also signatories of RGI's Marine Grid Declaration, which sets out guiding principles for avoiding, minimising and (where possible) eliminating negative impacts on the marine environment.

**As outlined in the Group's ESG programme, ActNow, Elia has aligned its sustainability-related goals with the United Nations' Sustainable Development Goals (SDGs). Dimension 2 of ActNow, Environment & Circular Economy, is linked to three SDGs, of which SDG 14: "Life below water". The conservation and sustainable use of marine resources for sustainable development is therefore a key principle that Elia, 50Hertz and their contractors adhere to.**

## Mitigation and compensation measures

**Mitigation measures** - these are adopted as part of a project to reduce or avoid any negative impacts the latter may have on the surrounding environment, including particularly sensitive areas.

For Elia Group, mitigation measures include taking into account valuable habitat areas when defining new cable routes and the location of substations, as well as seeking to construct infrastructure which is efficient by design. Both in Belgium and Germany, the installation of offshore platform foundations (known as 'pile driving') is halted between specific dates every year, to protect marine animals that inhabit the North and Baltic Seas during those periods. Further measures include 'slow starts' – when piling power is gradually built up, giving marine life some time to adjust to the activity and leave the area being worked on. Acoustic deterrent devices are also used; these keep animals away from the area being worked on and so avoid their being physically harmed by it.

Further examples of mitigation measures undertaken by 50Hertz include minimising the noise that is generated as it prepares the seabed for its activities. Indeed, in the Baltic Sea, thousands of tonnes of munitions and chemical weapons dumped during World War II lay along the seabed. 50Hertz must report contaminated sites to the authorities and call upon specialised bomb disposal teams for help, who decide whether to recover or undertake controlled detonations of bombs that are found. If these teams decide that a bomb should be safely detonated underwater, bubble curtain technology is employed: using specialised technology, compressed air is released from the seabed upwards, creating a curtain of air bubbles around the bomb. This curtain acts as a barrier against the sound waves that are produced when the bomb is detonated, so protecting sea life.

**Compensation measures** are steps taken to offset the adverse effects that offshore activities can have on marine life. In Germany, compensation measures for these disturbances must be undertaken in a zone that stretches 12 nautical miles away from its coastal states. In Belgium, if a habitat is disturbed or lost during a project, the habitat must be restored either in the same location or within the vicinity of the project.

Examples of compensation measures undertaken by 50Hertz include the dismantling of the artificial dam that lay between the island of Görmitz and the German mainland, which was originally built in the 1960s. The dismantling of the dam was a compensation measure adopted as part of the construction of Ostwind 1 (**see page 28**). The dam's demolition has allowed more oxygen to flow to previously cut-off areas of the Bodden waters (Achterwasser) and marine life such as otters to move around more freely in the area. On the island of Görmitz itself, a habitat for ground nesting birds was also created.



→ **The co-creation process undertaken by Elia and marine experts has proven to very enriching. It has allowed us to make important contributions to the field of NID and offshore infrastructure, and we will continue to learn and gain insights into these as the island is constructed and our approaches are monitored. Our discussions focused on finding the right balance between the encouragement of biodiversity, technical feasibility and cost efficiency. I hope our approach and work on the island will inspire other actors to work with nature conservation experts from the very start of their projects, so acting responsibly and for the benefit of society.**

**Nicolas Beck,**
**Head of Community Relations at Elia**

## Nature Inclusive Design

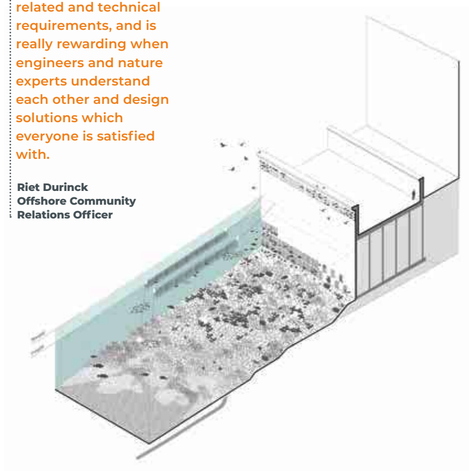
In Belgium, Elia has chosen to apply Nature Inclusive Design (NID) in its approach to the construction of its first energy island in the North Sea (**see page 14**). This means that, in collaboration with conservation experts, it is designing the island in such a way that it will have a positive influence on marine ecosystems and will encourage biodiversity.

The measures that Elia has chosen to adopt include the construction of:

- small ledges along the island's floodwall. These will attract black-legged kittiwakes: a species of seagull which lives and breeds on rocky cliffs. The ledges will mimic such cliffs, providing the kittiwakes with 2.6 kilometres of breeding habitat – enough space to accommodate over 5,000 nests.
- an artificial reef which will allow marine life to flourish. A diverse and complex scour protection system will be installed around the island, with fine gravel beds and boulders concentrated around each of its four corners.
- structures to support oyster beds. These oysters release larvae that could then settle within this meticulously designed habitat, kick-starting the formation of a biogenic oyster reef.
- relief panels which will be attached to the lower parts of the island's foundations. These will provide small organisms and fish with places to shelter and forage for food.

→ **It challenging to combine nature-related and technical requirements, and is really rewarding when engineers and nature experts understand each other and design solutions which everyone is satisfied with.**

**Riet Durinck**
**Offshore Community Relations Officer**



# OFFSHORE OPERATIONS AND MAINTENANCE

## ADAPTIVE MAINTENANCE AND REPAIR PREPAREDNESS

**Once an offshore asset has been built and the asset has been put in service, our Offshore Assets Team takes on the job of operating it, ensuring it is maintained, and keeping it functional. Offshore development – including operations and maintenance work – carries its own particular challenges. These encompass dealing with volatile and challenging weather conditions; the additional safety risks associated with offshore work; managing how the harsh marine environment exposes our assets to increased levels of corrosion, UV and mechanical stress; and the fact that asset redundancy is lower in offshore environments than it is in onshore ones, so increasing the impact of possible asset failure. Geert Moerkerke, Head of Assets Offshore at Elia, explains how his team and the Group continue to develop their approach as part of this relatively recent area of its activities.**



### What does asset management at Elia Group involve?

**Geert Moerkerke:** Broadly speaking, our goal is to facilitate security of supply by ensuring our infrastructure is kept running at peak performance, reducing the possibility of asset downtime and maximising the lifespan of our assets whilst minimising the cost for society. Our work therefore covers preventive, curative and adaptive maintenance. The first of these is undertaken at regular intervals and involves increasingly remote monitoring activities; it reduces the possibility of issues arising and assets failing and causing interruptions to the availability of renewable energy produced by offshore wind farms. Curative maintenance occurs after an event or fault has developed and needs to be fixed. Finally, adaptive maintenance involves adding or replacing individual components with newer models or technology which are safer, more efficient, reliable, or require less upkeep.

Our operations and maintenance plan therefore comprises all the activities we need to undertake to keep our infrastructure and assets running as they should. This plan is continuously being adapted as our pool of offshore assets grows and we take on responsibility for new infrastructure, learn to preserve it, and learn to anticipate the ways in which faults might occur. In case our assets do break down, our repair preparedness plans make sure we are able to significantly curb their outage time by ensuring we know where to source support, resources and spare parts from.

### What specific challenges does offshore asset management entail?

**GM:** One of the biggest challenges is the fact that there is currently very little – if any – redundancy in the offshore grid. This means that if one of our cables fails, it has an immediate impact on our capacity to transport green energy back to the mainland. The impact of a failure is therefore immediately felt across the grid. Then, of course, there is the fact that our assets are quite isolated, meaning they are expensive and dangerous to access. Any visits we undertake have to be carefully planned out, with factors such as the weather, method(s) of transportation and availability of qualified experts to consider. The fact that the emergency services are located on the mainland means that our team need the skills to deal with medical emergencies, or other kinds of urgent situations. We need to undertake our work in the fastest, most efficient way possible, whilst minimising the costs and impact of our activities on the environment. These challenges all mean that we are required to plan out our activities well and make the most of the time we spend out at sea. Moreover, given the fact the weather can change quite dramatically, a high degree of flexibility is required from our team to ensure the work can be properly rescheduled and executed.

### How is your team's approach to offshore asset management changing?

**GM:** Our team at Elia is relatively new: it was established five years ago, with high- and low-voltage technicians from our onshore teams undertaking offshore safety training. Since then, it has grown: engineers from different disciplines have joined us, enhancing our collective skillset. Indeed, one particular feature of our team is that we have maintained direct responsibility for many of our activities – meaning that if an incident occurs, our staff are both qualified to address it and are on hand at short notice. Our team therefore carries a lot of flexibility and an increasing amount of technical expertise. It is our staff – both in Belgium and Germany – who make our projects as successful as they are. Their focus on safety, attention to detail, skills and knowledge, and passion for their work make them a uniquely dedicated crew.



† **Geert Moerkerke, Head of Assets Offshore at Elia**

### ELIA PLANS OFFSHORE OPERATIONS CENTRE IN THE PORT OF OSTEND

**By the end of 2025, Elia is due to have built a new offshore operations centre in the Port of Ostend. It is from here that its team of offshore experts will design and manage its growing pool of offshore assets, including the Princess Elisabeth Island (see page 14). The building will house an offshore operations room, offices, a dedicated warehouse and centre of expertise. Up to 30 individuals will work on the site itself, of which two thirds will be made up by technicians who carry out offshore work.**

READ MORE ABOUT ELIA'S OFFSHORE OPERATIONS CENTRE

# INNOVATION IN OFFSHORE ACTIVITIES

**Elia Group has built up a strong track record in offshore development since the early 1990s, when 50Hertz's predecessor built and commissioned the KONTEK interconnector with its Danish counterpart (see page 22). Today, we are a European leader in the area, as exemplified by our fresh practices and projects in both Belgium and Germany. Henrich Quick, the Head of Offshore at 50Hertz, explains how the Group optimises its offshore tools, methods and assets.**

## Why is innovation so key in offshore development?

**Henrich Quick:** Offshore development is a relatively new area for transmission system operators, and carries its own distinct challenges compared with onshore projects. Just like onshore grid development, however, it requires new approaches to be regularly explored and adopted, so that projects remain effective, secure, valuable and sustainable. We therefore continuously optimise the tools and methods we use and the assets that we deploy. This ensures that our projects meet the needs of the energy transition in more ways than one: firstly, by their very nature, they support Europe's climate targets, since they connect countries and offshore generation assets together in increasingly powerful ways; secondly, the methods we employ to complete them are ever-more efficient, as we seek out ways to minimise out carbon footprint, limit the impact of our activities on surrounding environments, increase the safety of our staff, and reduce the cost of our work.



↑ **Dr. Henrich Quick,**
**Head of Offshore at 50Hertz**

To date, our projects include some of the world's first ever assets of their kind, such as the Krieger's Flak – Combined Grid Solution (**page 26**) and Princess Elisabeth Island (**page 14**). Moreover, as outlined overleaf, we have adopted the use of fresh technologies and methods such as robots, mixed reality headsets and a diving bell to carry out our operations and maintenance work.

## How does Elia Group approach innovation in its offshore development activities?

**HQ:** Elia and 50Hertz coordinate their offshore activities to ensure that learning and expertise is shared and the positive impact of the activities we undertake in the North Sea and Baltic Sea can be maximised. Our staff interact both through formal and informal channels; this covers exchanging best practice and recommendations on a day-to-day basis through to regular cross-departmental meetings. The experience gained in one of our home countries can be easily shared with teams based in the other and then, in many cases, adapted to fit local circumstances and the local regulatory environment. Our staff are passionate about the work they do and have cultivated a strong team spirit; this, coupled with the demand there is for innovative ways to approach offshore development, is the perfect climate for fostering new ideas.

## What is the Group currently focusing on at the moment?

**HQ:** Both 50Hertz and Elia are working on plans to establish their own offshore operations centres along the German and Belgian coasts (**see page 49**). 50Hertz is also exploring the development of a holistic digital approach to its offshore operations. Watch this space!

## OFFSHORE MOONSHOT

**As part of the Group's drive to continuously optimise our tools, processes, activities and assets, in 2021, we launched our moonshots programme. Each of our five moonshots covers one key innovation area, as follows: system operations; infrastructure; asset management; consumer centricity; and offshore. As part of our Offshore Moonshot, our Innovation Team and System Operation Department are focusing on the development of a 'mother optimiser': software which will support the automatic system operation of our offshore assets. The need for this master controller is clear, given the increasing complexity of our offshore assets and Europe's ambition to establish meshed offshore grids across its seas. The tool will contribute to optimising the flow of power across Europe's offshore grids by maximising the integration of wind power into the system, reducing congestion, and encouraging price convergence across different countries.**

→ We are building increasingly complex and sophisticated offshore assets that cannot be operated by static models. We are therefore developing the offshore moonshot optimiser that will support the system's operation and optimisation of these assets with dynamic models.

**Arya Fazilat,**
**Innovation Manager**

**TO FIND OUT MORE ABOUT ADDITIONAL PROJECTS, INCLUDING OUR SECOND ROUND OF MOONSHOTS, VISIT OUR INNOVATION WEBSITE**

## USING MIXED REALITY FOR MAINTENANCE ACTIVITIES

**Given its location off the Belgian coast, the MOG (see page 12) is not always accessible to external contractors who need to be called upon when issues arise. The Elia offshore maintenance team were therefore trained to use mixed reality smart glasses. This allows staff to receive video calls from said experts, who can share blueprints and technical documents with them on screen: the glasses overlay this digital content on top of the live feed of the MOG.**

→ As a technician, the smart glasses have helped me in two ways. First, there is a much quicker response time when trying to resolve a problem, because I have a remote expert by my side who can guide me through the process. Second, preparation for maintenance work can be carried out in a very detailed way, improving risk analyses and levels of safety.

**Ludovic Moulaert,**
**Operations Team at Elia**

## UNMANNED VEHICLE SURVEYS SUBSEA CABLES 40 KM INTO THE NORTH SEA

**In June 2022, for the first time, Elia Group successfully tested out an unmanned surface vehicle with advanced sensors to survey the MOG's cables and its topside as part of routine maintenance activities. The vehicle was developed by TideWise, the winner of the Group's 2021 Open Innovation Challenge.**

**WATCH THE FIRST UNMANNED INSPECTION OF THE MOG'S CABLES**



## MOBILE X-RAY SYSTEM USED TO INSPECT ASSETS

→ Following tests undertaken in 2022, 50Hertz is exploring the possibilities linked to the regular use of a mobile X-ray system as part of our asset maintenance activities. The technology was tested out both in a laboratory environment and at one of our offshore platforms in the Baltic Sea, allowing our team to inspect our assets without needing to dismantle or cut them open. The technology would allow our team to undertake detailed looks at some of the components of our installed assets and so perform site evaluations, reducing the costs and impacts associated with more traditional maintenance methods.

**Marian Mügel,**
**Offshore Cable Manager at 50Hertz**

## DIVING BELL USED FOR CABLE REPAIR WORK

→ In the summer of 2022, 50Hertz used a diving bell to carry out maintenance activities along one of our subsea cables. This created an air-filled chamber for staff to work in along the sea floor, so avoiding the need for a section of the cable to be cut and lifted to the surface to be examined. Compared to conventional methods (where the cable is lifted onto a vessel), this approach reduced the time assets needs to be shut down for during the work, reduced the impact of the work on the seabed, and enabled the costs of the work to be reduced. Our testing out of the method confirmed that it's a useful way of quickly and efficiently undertaking work that concerns minor, specific issues which would otherwise involve the use of many resources.

**Marian Mügel,**
**Offshore Cable Manager at 50Hertz**

## SPARKY, ELIA'S ROBOT DOG

**In addition to using an autonomous robot for inspecting Nemo Link's converter hall (see page 10), Elia Group has officially adopted its own robot dog from Boston Dynamics: Sparky. Elia Group's Internet of Things Centre of Excellence tested Sparky out in 2023 in two of its substations: Stevin, located in the coastal village of Zeebrugge, Belgium; and the Bentwisch substation near Rostock on the German coast. Sparky, which helps staff to inspect hard-to-reach locations, is due to be deployed on the MOG in November 2023 as part of a first pilot scheme.**

**SEE SPARKY BEING TESTED OUT IN STEVIN**

# WORKING AMONGST THE ELEMENTS: WIND, WATER AND WAVES

**A critical moment in the connection of offshore wind farms to the mainland grid or the construction of interconnectors is cable laying: securely embedding cabling systems into the sea floor along their established route. This work is challenging, not least because cables are both fragile and heavy; indeed, they can weigh up to 130 kg per metre. Moreover, staff rely on good weather and calm conditions at sea to undertake this work.**




Once an offshore cable's route has been determined – taking factors such as marine ecosystems, sites of historical interest and other offshore infrastructure into account – and the project has been granted the necessary permits, debris, large boulders and unexploded ordinance have to be cleared from the sea floor. The cable is then loaded onto the carousel of a cable laying vessel: a large drum-like structure with a vertical axis in its centre, around which the cable is wound. In cases where the cable will be used to connect the mainland grid to an offshore wind farm platform, the vessel will either start from the mainland and sail out to the platform, or start from the platform and work its way back to the coast.

Vessels which start near the mainland and set off for an offshore platform have to stay some distance from the shoreline due to their draft. As a consequence, one end of the cable has to be pulled ashore, with floats used to keep it from sinking under water. Once the cable has been secured on land, the floats are removed and the vessel begins its journey, laying the cable along the seabed in metre-long sections. A special guide track and precise offshore positioning is used to release the cable into the water, so it lands in the right spot along the sea floor in a controlled manner. Cable joints are used to connect different sections of cable together; depending on the weight and diameter of the cables in question, these joints appear every 30-70 km or so.

**Most projects in Belgium have involved the cable being pulled onto the offshore platform first, after which the vessel departs for the mainland. In this way, as the vessel approaches the coast, the vessel's load is lightened – this means it can come closer to the shore and can be used to lay sections of the cable along the seabed for longer.**

Different methods and tools are used to excavate the cable trench in accordance with the nature of the seabed. For example, an underwater plough is used to plough through hard and stony sea floors. For softer seabeds (made of sand, mud or clay), jet trenchers are used: as part of this cable burial process, offshore cables are lowered onto the seabed and then buried underneath natural sedimentation or rock aggregate installations. This technique can also be used to further embed offshore cables which have already been laid. The time it takes to lay each cable section varies, depending on the installation method employed and the conditions of the seabed.

Once the cable laying vessel has reached the offshore platform, the cable is pulled onto the platform using a technically demanding procedure: since the cable itself is heavy but needs to be delicately handled, large amounts of force are required to pull the cable onto the platform. The teams on the vessel and platform must be well prepared for the procedure and must closely cooperate as it is performed. The weather adds an element of uncertainty to the operation: the teams need good weather and thorough contingency plans in place to be able to complete it successfully. Once in place, the cable is then connected to the electrical infrastructure on the platform.

# SAFETY AT SEA

**Elia Group has a clear goal when it comes to health and safety: whilst undertaking all of its activities - onshore and offshore - it aims for zero accidents. Both Elia and 50Hertz are ISO 45001 certified; the latter is an international standard for occupational health and safety which covers onshore and offshore work. The safety measures outlined below focus on operational safety in offshore development, but the Group also ensures that health and safety matters are embedded throughout its processes - from including safety considerations in its tendering processes through to the regular monitoring of construction methods and incident reporting, investigation and follow-up.**

Staff working in offshore environments must complete specific training sessions related to safety at sea, including first aid; surviving at sea; working at height; and dealing with hazards such as fires. Staff must also undergo regular medical examinations to check that they are fit and well. They are required to wear personal protective equipment – including helmets, life jackets, gloves, appropriate footwear and immersion suits – whenever they leave mainland Belgium or Germany.

Elia and 50Hertz's offshore teams regularly undertake practice rescues, both from vessels and from offshore infrastructure, to ensure that staff are ready to deal with emergency situations of all kinds. Combined practice exercises are also organised with external partners, including maritime organisations. Offshore construction work is preferably carried out during the day, but in some cases, round-the-clock work is needed, such as when an offshore cable is being laid or when emergency repair work needs to be undertaken, meaning the work is much riskier.

In Germany, a helicopter rescue team based on the island of Rügen is on hand 24 hours a day, 7 days a week to carry out rescue missions related to 50Hertz work being undertaken on offshore platforms or projects. The helicopter is also called upon to undertake emergency rescue operations that can involve members of the public along the coast. In Belgium, the Maritime Rescue and Coordination Centre (MRCC) in Ostend and maritime police are on call 24 hours a day, 7 days a week. The MRCC are the first port of call when an incident at sea has occurred.

**See page 50** to find out how new technologies are increasingly being used by Elia Group to reduce the risks associated with carrying out offshore work and accessing assets.

**WATCH THE BELGIAN MINISTERS OF ENERGY AND OF THE NORTH SEA TAKE PART IN AN OFFSHORE TRAINING SESSION IN OSTEND IN EARLY 2022:**

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