Annual Report 2024

Belgium

Photo: *Offshore wind parks in Belgium. (Source: Sirris)*

Author: Jo Robbelein, FPS Economy, SMEs, Self-Employed and Energy, Directorate-General Energy, Belgium

By the end of 2024, the total land-based installed capacity in Belgium had reached 3.332 GW and offshore wind 2.3 GW, which is an only land-based increase of 240 MW in 2024. All Wind power statistics of Belgium in 2024 can be found in Table 1.

The first offshore zone has been fully built and in 2024, the 399 wind turbines, spread over 9 offshore zones, produced approximately 7.196 TWh (9.3% of the total electricity demand in Belgium).

The second offshore zone is in the development phase, where a total capacity of 3.15 to 3.5 GW can be installed. A first tender for the first zone of 700 MW will be relaunched in the first quarter of 2026.

In 2024, Belgium allocated significant resources towards advancing offshore wind technologies, optimizing onshore wind farm performance, and intgrating wind energy into the national grid either via provincial or regional innovation subsidies but also via the federal Energy Transition Fund (ETF) framework.

The latter is specifically focusing on the offshore wind and offshore grid infrastructure.

Total (net) installed wind power capacity	5.594 GW
Total offshore capacity	2.262 GW
New wind power capacity installed	0.240 GW
Decommissioned capacity (in 2024)	0.126 GW
Total electrical energy output from wind	13.97 TWh
Wind-generated electricity as percentage of national electricity demand	18.1 %
Average national capacity factor	29.1% (est. By avg capacity)
Target (Offshore Project Formation)	N/A
National wind energy R&D budget	N/A

Table 1. *Key Statistics 2024: Belgium*

Highlights

- Wind generation share of electricity demand exceeded 18%, with offshore wind providing more than 9% of the electricity demand.

- Next offshore zone, Princess Elisabeth Zone, the first tender of 700 MW will be relaunched the first quarter of 2026.

Market Development

Targets and Policy

The federal government began planning the first Belgian offshore wind farm in the North Sea in 2003, and in 2004 created a 156 km² area in the Belgian Exclusive Economic Zone (EEZ) in international waters for wind farms. The first wind turbines were installed in this area in 2009.

Regarding offshore wind power, the transmission system operator (TSO), Elia, is obliged to buy green certificates from generators at a minimum price set by federal legislation. This system was established in 2002 and amended multiple times over the years.

Purchase agreements must be approved by the regulator, CREG. Purchase obligations apply for a period of 19 or 20 years depending on multiple parameters. They may not exceed the depreciation period. Construction works are ongoing for the building of the Princess Elisabeth Island, which will connect the planned offshore wind farms in the western Princess Elisabeth Zone (see Figure 1).

It has been decided that the Princess Elisabeth Zone can be divided into three parcels, where a total capacity of 3.15 to 3.5 GW can be installed. For now it has been decided the first two parcels will be tendered. The tender for the first zone of 700 MW will be relaunched the first quarter of 2026. The indicative timeline of the tender of the first lot is indicated in Figure 2.

The tender criteria have been published on beforehand [2]. The second parcel will be tendered later, the exact date depends on the permitting of the necessary reinforcements of the transmission grid onshore and the political decision. To facilitate the development of the new offshore wind energy zone, the Belgian government has decided to carry out a number of preliminary studies which are published [3].

Development beyond the second offshore wind zone will be difficult and Belgium is exploring the option of interconnection with or developing new offshore wind capacity in the waters of other countries.
In February 2021, Belgium and Denmark signed a memorandum of understanding for the development of an electricity interconnector from an energy island Denmark plans to build in the North Sea. The interconnector would connect Belgium to large offshore wind farms off the Danish coast. Power from the wind farms would be transmitted to both countries. This project has been selected for grants in the field of the trans-European energy infrastructure under the Connecting Europe Facility following the call for proposals launched on 11 April 2024.

Progress and Operational Details

Land-based wind capacity remained low until 2004. By the end 2024, the total land-based installed capacity in Belgium had reached 3,332 MW.

Offshore wind-generated electricity first began in 2009 and progressed rapidly to a total of 2,262 MW in 2020 which is comparable to the capacity of the two largest nuclear reactors (Doel 4 and Tihange 3) combined

All nine wind farms (399 wind turbines) in the Belgian North Sea are fully operational since December 2020. This means that 2024 is the fourth year with fully installed generation capacity for this major Belgian power plant. During these four years, the annual produc-

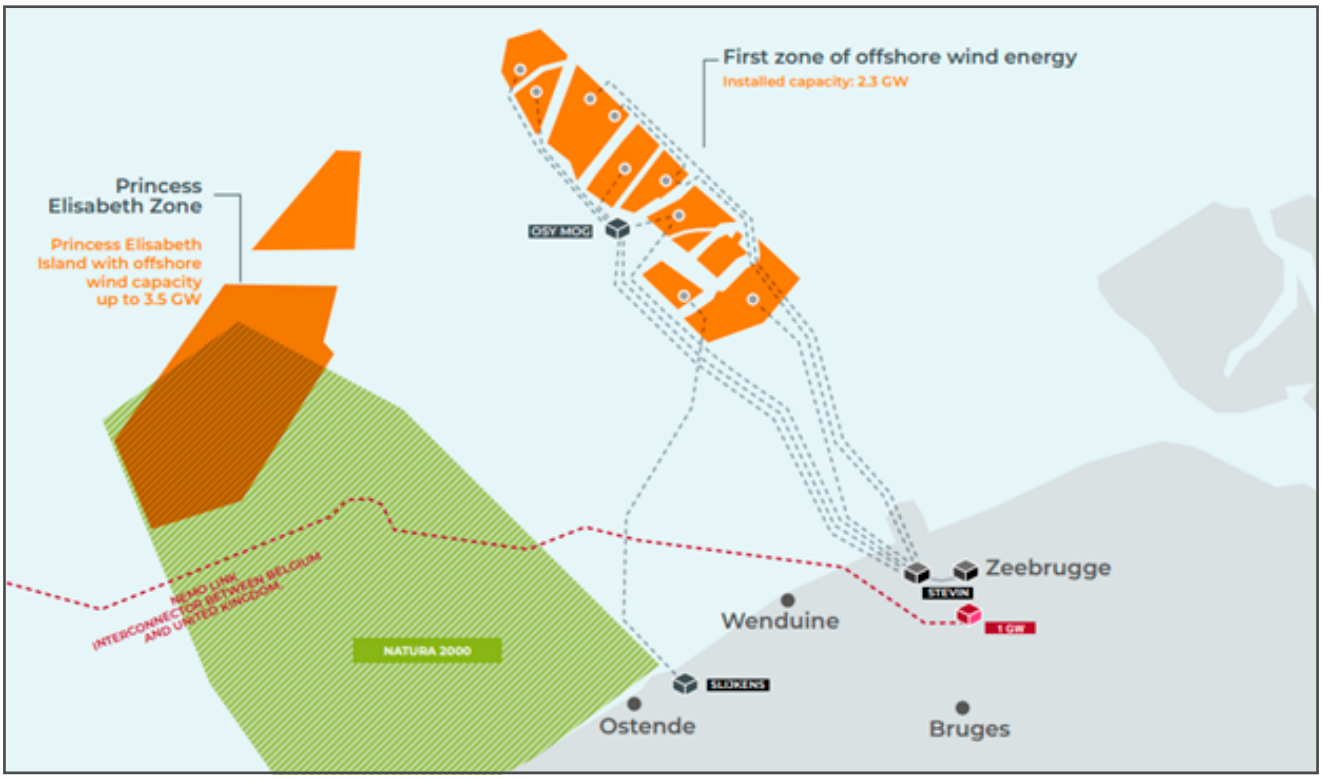

Figure 1: *Location of the different phases of offshore development in the Belgian North Sea.* (Source: Elia Group)

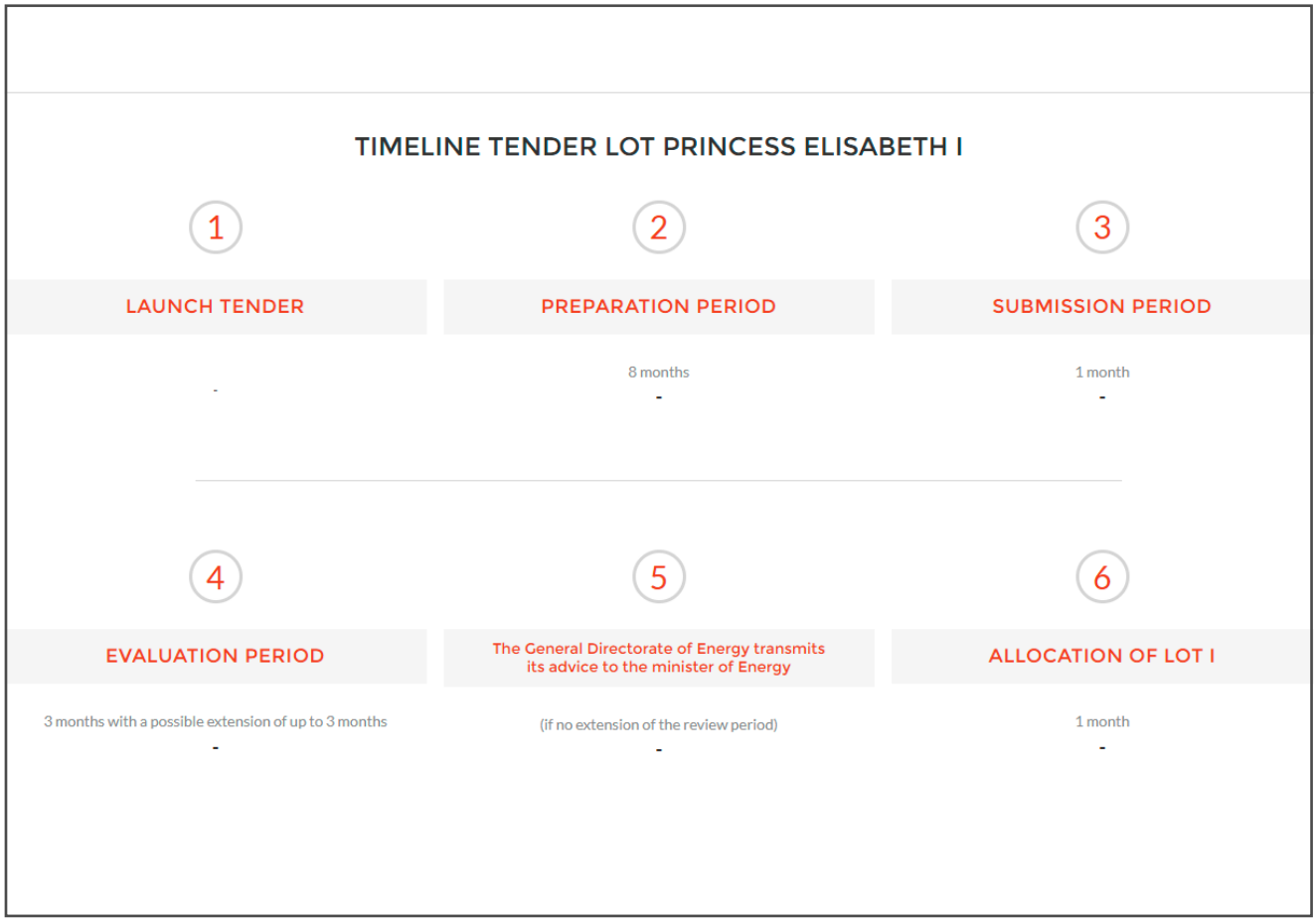

Figure 2: *Timeline Tender Lot Princess Elisabeth I.* (Source: Federal Public Service Economy of Belgium.)

tion of green electricity has remained relatively constant the first two years around 6.6-6.9 TWh, had larger production of 8 TWh in 2023 and fell back to 7.2 TWh in 2024. This corresponds to the annual electricity needs of nearly 2.4 million households, or about 9.35% of the total electricity demand in Belgium.

Matters Affecting Growth and Work to Remove Barriers

The different governments within Belgium continue the work to remove barriers to new wind energy projects. Such barriers include spatial planning limitations (i.e., military, aeronautical, or traffic-related restrictions) and lengthy permitting procedures. The federal administration has created a 'one-stop-shop' aimed at simplifying and speeding up the license procedures.

Lengthy legal procedures also affect the sector. For example, cases where local communities appealed against the construction of wind energy facilities have taken years to resolve. Such legal cases could potentially be avoided by involving the local communities more closely at the project planning stage and by offering them the opportunity to take part in investments through cooperatives.

The main issue affecting growth for wind is the number of judicial appeals filed at the State Council, which has severely hindered the development of land-based wind farms both in the Flemish and Wallonia regions. Belgium has limited space for wind energy compared to many other countries.

RD&D Activities

National R, D&D Priorities and Budget

Belgium continues to prioritize both onshore and offshore wind energy as a key component of its renewable energy strategy. The National Research & Development and Demonstration (RD&D) Priorities and budgets for wind energy innovation reflect a strong commitment to innovation and sustainability in all Belgian regions. In 2024, Belgium allocated significant resources towards advancing offshore wind technologies, optimizing onshore wind farm performance, and integrating wind energy into the national grid either via provincial or regional innovation subsidies but also via the federal Energy Transition Fund (ETF) framework. The latter specifically focusing on the offshore wind and offshore grid infrastructure.

The RD&D programs focus on different improvements such as turbine production efficiency gains using AI, enhancing predictive maintenance technologies, and minimizing environmental impacts through e.g. Nature Inclusive Design. The programs encourage collaborative efforts between government, academia and industry to drive technological advancements and cost reductions. An example of such collaboration is described in the OWI-Lab collaboration framework.

The budget for wind energy RD&D has seen a marked increase, emphasizing Belgium's dedication to achieving its renewable energy targets and contributing to the global energy transition. In the Flemish region, wind energy R&I is funded through bottom-up funding programmes, there is no specific R&I funding programme for wind. As a result, public R&I expenditure for wind energy fluctuate from year to year: EUR 4.9 million (2022); EUR 6.7 million (2023); EUR 3.48 million (2025).

The Blue Cluster, a cluster organization funded by the Flemish Government, supports Flemish companies in setting up partnerships with other companies, knowledge centres and government agencies with the aim of facilitating and supporting innovation in all offshore economic activities (including wind energy). On the Federal level (offshore wind) EUR 6.312 million was allocated via The Energy Transition Fund. This strategic approach ensures that Belgium remains at the forefront of (offshore) wind energy innovation and deployment.

National Research Initiatives and Results

OWI-Lab is a specialized research and expertise collaboration framework dedicated to advancing offshore wind energy technology. The initiative was already set-up in 2010 by Sirris (Belgian technology centre) and the two universities VUB and UGent. The partners support the Belgian wind industry (mainly the offshore industry) through a combination of research, development, and innovation services. Every year the initiative submits local and national funded RD&I projects based on the needs of the industry.

In October 2024, the **OWI-CREATE** project (involving all OWI-Lab members) was launched with the objective of establishing a national centre of excellence dedicated to offshore wind within a timeframe of three years. By 2027, the initiative aims to consolidate expertise, promote innovation, and position the centre as a leading hub for offshore wind knowledge and development.

In 2023 the **Energy Transmission Competence Hub (ETCH)** was founded by EnergyVille/KU Leuven and funded by the Flemish Government (EUR 14 million). ETCH will conduct pioneering research in the field of future-proofing electricity networks with large-scale integration of High Voltage Direct Current HVDC technology and underground cables.

Test Facilities and Demonstration Projects

The Blue Accelerator platform off the coast of Ostend is a yellow monopile-mounted structure serving as an open-sea test facility for offshore renewable energy prototypes. In late 2024, the Blue Accelerator underwent a significant infrastructure upgrade as part of the EU-funded Test@Sea project aimed at improving offshore testing methods and accommodating floating and submersible structures in the future.

Several R&D measurement campaigns in the Belgian offshore wind farms Northwester and Norther continue as part of the **SuperSized 4.0 project** focusing on "Smart O&M for a fleet

of SuperSized wind turbines in Industry 4.0 context". New advanced SHM (structural health monitoring) and CM (condition monitoring) techniques using 5G IOT sensors are set-up with the aim.

As part of **the Rainbow project** (Flemish Region), focusing on "Optimized prediction and decision support for rain erosion and lightning-driven degradation of blades", a microphone test set-up, as shown in Figure 3, has been installed at the Rentel offshore wind farm which will be used in an experiment to 'listen' to blade erosion sound.

Wind turbine gearbox and drivetrain manufacturer ZF Wind Power, located in Lommel invests in a new test and-prototype centre including a **30MW validation test bench,** as shown in Figure 4, said to be the most powerful in the world, supported by the Flemish agency Flanders Innovation and Entrepreneurship.

The test bench will be used to test and validate the durability and lifetime of multi-MW prototypes that need to operate in extreme offshore conditions.

Figure 3: *Microphone test set-up at Rentel offshore wind farm.* (Source: Sirris.)

New projects to highlight (non-exhaustive list)

ETF OWI-CREATE: This project aims to strengthen the Belgian offshore wind sector nationally and internationally by accelerating innovation. It will consolidate all R&D initiatives—new, ongoing, and completed—into a single Offshore Energy Center of Excellence.

ETF BE-WISE: BE-WISE is developing policy recommendations to boost the competitive edge of the Belgian offshore wind sector. It conducts a detailed political and economic analysis of industrial policy strategies in Europe, such as direct state support, auction pre-qualification rules, and trade protection measures.

Figure 4: *ZF Power validation test bench.* (Source: ZF Power.)

ETF FISSCK: Stiff clay samples from the Princess Elisabeth Zone show faults and fissures at different scales, impacting the clay's strength and stiffness. This study investigates the geological origins of these features and uses lab testing and numerical modelling to assess their effect on the soil surrounding monopile foundations. This understanding is crucial to optimise the amount of primary steel needed and to monitor foundation performance over time via a digital twin model.

ETF MAVERICK: Airborne wind energy (AWE) offers a promising way for Belgium to meet offshore renewable energy targets by capturing stronger winds at higher altitudes with less material use. It also allows the reuse of old turbine foundations. MAVERICK will carry out a flight demonstration with a 12-metre wingspan AWE system to generate validation data, supporting the development of simulation tools and research into offshore repowering.

ETF CROCODILE: This project aims to de-risk offshore infrastructure investments by analysing offshore grid market designs related to day-ahead markets, balancing, reserve sizing, and long-term incentives like PPAs. It considers the perspectives of large off-takers, citizens, SMEs, and local governments. CROCODILE will provide recommendations to maximise the welfare impact of offshore energy investments.

cSBO FIRMEST: FIRMEST develops fast, reliable tools for fatigue (re)assessment of welded joints in offshore wind turbine substructures. It focuses on creating high-fidelity FE models from 3D scans, refining fatigue life predictions, and improving non-linear damage modelling. A single-sensor virtual sensing approach and a digital twin data architecture are also developed to better predict and extend offshore infrastructure lifetimes.

cSBO WIN-CE: The project develops a chemical recycling process for end-of-life wind turbine blades, enabling full recovery of both glass fibres and resin. It combines mild solvolysis with catalytic ammono-/aminolysis to create high-value products. The project focuses on preserving fibre quality, co-valorising the resin, and assessing scalability, economic, and sustainability performance to support a more circular wind energy sector.

ERDF OASIS: OASIS helps SMEs tackle offshore renewable energy challenges by supporting the development of system integration and storage solutions. It assists SMEs in technology development, commercialisation, and sustainable design, identifies development gaps, provides market insights, and connects them with key players. OASIS aims to accelerate the market entry of 30 SMEs.

The Coastal and Ocean Basin (COB) at Ostend Science Park, operational since 2023 and managed by UGent, KU Leuven, and Flanders Hydraulics Research, features a unique L-shaped narrow paddle wavemaker. Since 2024, it has also been equipped with a bidirectional current system, enabling the generation of high-quality short-crested waves at nearly any angle relative to the current. This setup allows COB to offer advanced testing services and create a wide range of wave-current combinations in any relative direction. For instance, an eco-friendly scour protection system for offshore wind foundations from the company ECOncrete was tested for stability trials.

The Blue Cluster

Collaborative research

The Federal Public Service of Economy joined IEA Wind Technology Collaboration Programme (IEA Wind TCP) in 2015, and Belgium is active in several tasks of IEA Wind:

Task 11: Wind SCOUT (Strategy, Collaboration & Outreach on Urgent Topics of Wind Energy Research).

Task 34: WREN - Working Together to Resolve Environmental Effects of Wind Energy.

Task 41: Distributed Wind

Task 42: Wind Turbine Lifetime Extension.

Task 46: Erosion of Wind Turbine Blades.

Task 48: Airborne Wind Energy.

Task 50: Hybrid Power Plants

Impact of wind energy

Economic Benefits

The wind energy sector creates excellent economic opportunities. Being active in this industry has also created opportunities for export. In addition to wind farm constructions, there is a need to build grid infrastructure, grid connections, and connections with neighbouring countries.
Belgium's offshore wind industry supports around 16,000 jobs in construction, operations, maintenance, and exports, contributing significantly to the energy sector's 50,000 direct employment positions.

Environmental Impact

In addition to adding sustainable energy capacity, offshore wind energy developments also increase biodiversity, specifically organisms such as sea corals and plants. Offshore wind turbine foundations form artificial reefs, where mussels and other sea life grow. The foundations also contribute to the growing fish population, providing many opportunities to further develop the marine culture in the Belgian North Sea.

Next Term

Belgium will relaunch the first tender for the second offshore zone the first quarter or 2026. The awarding of the Tender is foreseen by the beginning of 2027.

References

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[3] *economie.fgov.be/en/themes/energy/belgian-offshore-wind-energy/preliminary-studies-carried*