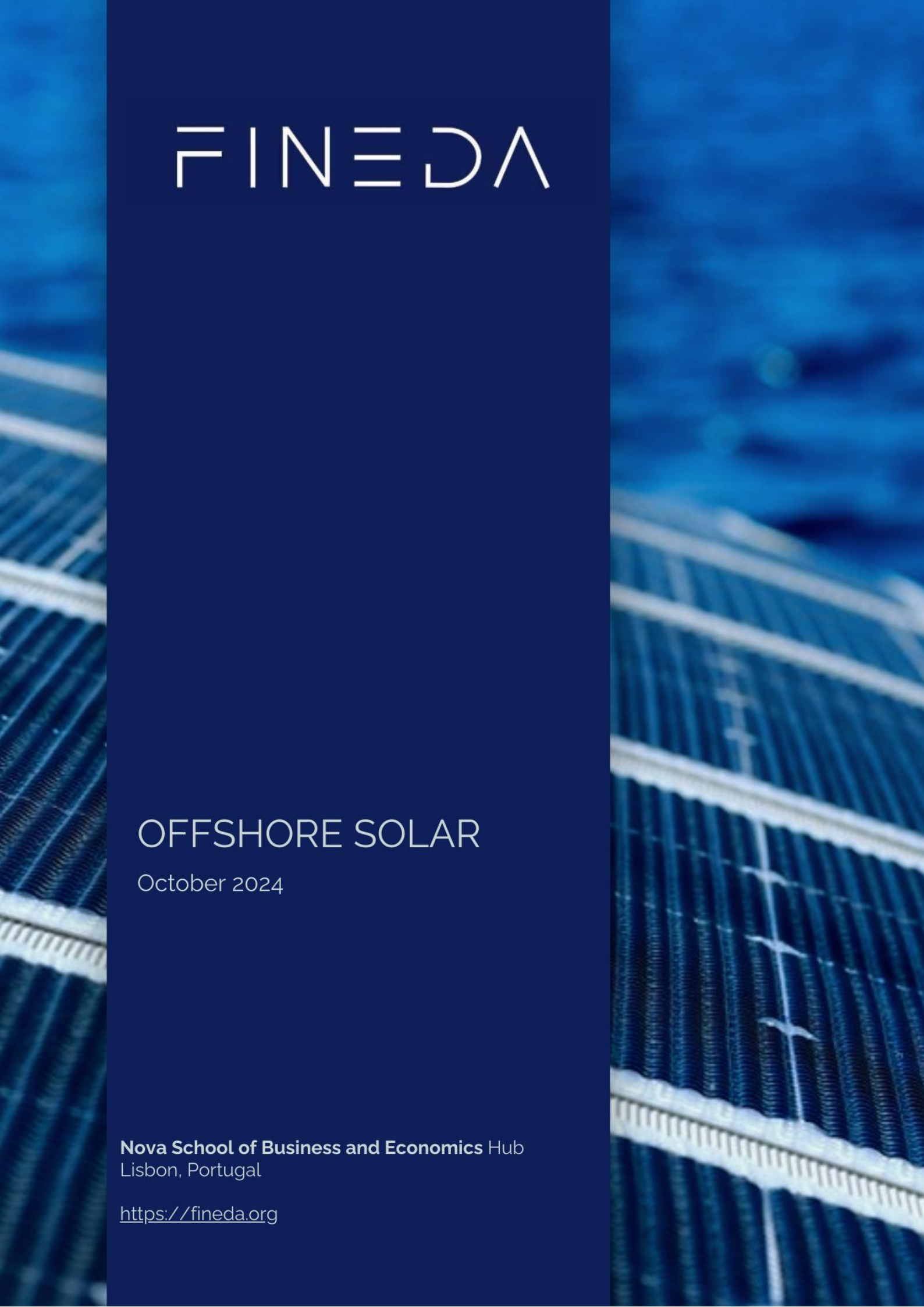


FINEDA

# OFFSHORE SOLAR

October 2024

**Nova School of Business and Economics** Hub
Lisbon, Portugal

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## A brief summary of offshore solar

The biggest obstacle to the growth and success of renewable solar energy farming is the **limited availability and cost of available land for solar farms**. With 71% of our planet's surface covered by seas and oceans, offshore solar energy farms present a viable solution to this problem.

Offshore solar is an innovative approach to harnessing renewable energy, utilizing vast, unutilized **water surfaces like seas, oceans, and large lakes**. Solar panels are mounted on floating structures made of buoyant materials, ranging from simple pontoons to complex platforms designed to withstand harsh marine conditions. **This method employs photovoltaic (PV) technology similar to land-based solar but mounts the modules and inverters on floating substructures**. These substructures are anchored to the seabed with robust mooring lines and anchors, ensuring stability against high waves and strong winds. Electricity generated from these offshore installations is transmitted to shore via subsea cables. The design and materials of these substructures are specially selected to endure the harsh marine environment, including saltwater corrosion and dynamic sea conditions, distinguishing them significantly from lake-based floating PV systems.

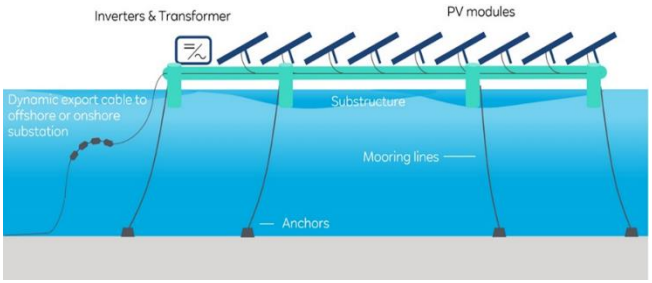



*Figure 1:Visual representation of a floating PV*

Offshore solar energy boasts various advantages over inland solar farming. **One significant benefit is the utilization of water surfaces, which reduces the need for land space**—often scarce, expensive, and associated with high opportunity costs. A more surprising advantage is the **increased efficiency of solar energy farming on water due to the cooling effect of water**. For instance, EDP, a Portuguese utility company, built a floating solar farm on the country's Alqueva reservoir. According to Pedro Oliveira, the company's Director of Innovation, their floating photovoltaic (FPV) farm has seen an **efficiency increase of up to 10% and an average annual productivity increase of around 4% thanks to this cooling effect**. Finally, when comparing offshore solar with offshore wind, while **offshore solar farms can be designed and built in 8-12 months**, and pushing these platforms to the sea is a fast and efficient process, **offshore wind farms can take anywhere between 6-10 years** before being ready to operate and require extensive ongoing maintenance, which turns **offshore solar a more attractive investment in the short run.**

However, several obstacles hinder the widespread adoption of offshore solar. **Growth may be constrained by the high demand for lithium**, a limited resource essential for the manufacturing of solar panels. Moreover, **little information exists about the impact of offshore solar structures on nearby ecosystems**. The presence of aquatic life near these structures could lead to **problems such as bird droppings on the panels, reducing their effectiveness**. Offshore solar installations also **need to withstand rough seas, including large waves and strong winds**. A study published by researchers from The Australian National University suggests that **most countries are unsuitable for practical offshore solar installations** due to extreme maritime conditions, with waves larger than 10 meters (33 feet) and wind speeds exceeding 20 meters per second (45 mph) over the past 40 years. This study indicates that the **ideal locations for offshore solar farms are within the planet's equatorial zones, such as Southeast Asia and Northwestern Africa**. Southeast Asian countries are already taking advantage of these favorable conditions, as is noticeable in the graph below.

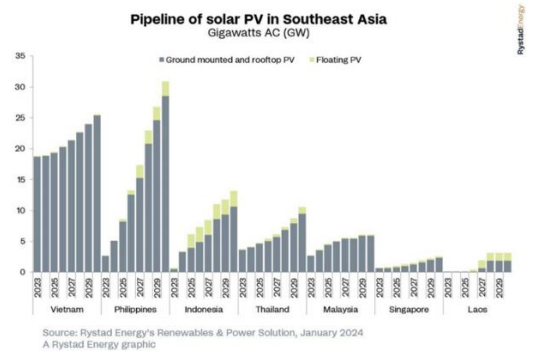



*Figure 2: Southeast Asia's pipeline of solar PV projects*

While offshore wind farms benefit from robust, established technologies like those used for oil rigs and floating wind turbines, **developing materials and structures for offshore solar that can endure constant wave action, sea spray, and UV rays is complex**. Nevertheless, this challenge is not insurmountable. Hybrid projects that combine wind and solar energy present several advantages. By sharing grid infrastructure and operational equipment, they can significantly reduce the overall amount of infrastructure and equipment needed, leading to cost savings. These projects also offer a solution to the intermittency issues associated with renewable energy sources. **Wind energy can be harnessed at night when solar energy is unavailable, while solar energy can be captured during the day, even on non-windy days**. This complementary relationship between wind and solar energy ensures a **more stable and reliable energy supply**, ultimately enhancing the efficiency and effectiveness of the plant.

Offshore solar could pave the way for hybrid projects in regions with limited space but good wind and solar resources. Time will tell whether it will fill in the shoes.

## Recent Transactions in the Sector

### SolarDuck

SolarDuck is a Dutch-Norwegian company founded in 2020. **The company operates mostly in The Netherlands, Japan and Norway,** although it is targeting other coastal regions in Africa and Southeast Asia.

**SolarDuck recently received €15m of funding for further development in its offshore floating solar farms.** Its business mission is to accelerate the growth of offshore floating solar energy by deploying over 1GW annually from 2030 onwards.

The **funding has been provided by both existing and new investors**. Among these, we can find an international consortium comprising **Katapult Ocean, Green Tower, Energy Transition Fund Rotterdam, and Invest-NL,** all sharing SolarDuck's commitment to accelerating a sustainable supply of offshore energy.

### Sunseap

Sunseap has been a leading renewable energy champion, founded in 2011 based out of **Singapore, with over 11 years of experience in renewables in the APAC region**. In February 2022, **EDP Renewables acquired a 91% stake in Sunseap for a deal worth $813.2m**.

Besides this recent change to its shareholding structure, **Sunseap has signed an agreement to develop the 2.2GW floating solar farm on the Duriangkang Reservoir with BP Batam.** It will be a $2bn project that is expected to become the largest in the world, with 1,600 hectares of water surface covered. A 4,000MW energy storage system will also be part of the project.

### EU funding for offshore renewables

The **Innovation Fund (IF)** is designed to scale up innovative clean tech and to finance the demonstration of first-of-a-kind highly innovative projects. **The IF will provide around €38bn of support over 2020-2030**, available to offshore solar initiatives.

**Indeed, there has been investment from this fund in offshore solar technologies through the EU's Horizon Europe initiative**. This program encourages the development of innovative technologies to meet the EU's climate and energy targets. Some specific projects for floating solar platforms (which could be extended to offshore applications) have been supported.

## Future trends

### Trends for offshore solar energy

The offshore solar energy sector is expanding globally, as the need to diversify renewable energy sources intensifies. Major players like **RWE, Iberdrola and EDP Renewables (EDPR)** are actively seeking opportunities in this sector. RWE is steadily expanding its renewable energy projects across Europe, while Iberdrola continues to invest heavily in both solar and wind. EDPR has secured permits for large solar projects and is likely to explore offshore options. Companies like **Neoen** and **Voltalia** are also looking to take advantage of the growing offshore solar market. The renewable energy sector is expected to expand from $**1,085bn in 2023 to $2,449bn by 2032**. Although offshore solar accounts for just a smaller share of the industry at the moment, its growth is expected to pick up speed as countries such as Portugal and the Netherlands concentrate on using their resources to expand and enter this sector.

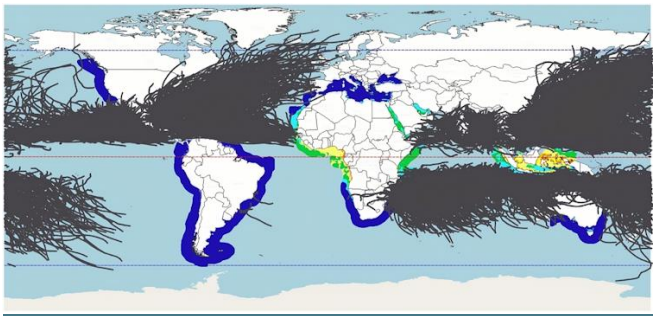
One of the main drivers of future growth is capacity expansion; it is anticipated that worldwide renewable capacity would rise by more than **5,520 GW between 2024 and 2030**, with offshore wind and solar PV accounting for 95% of this increase. Due to favourable legislation and falling costs, solar PV alone is **predicted to triple its growth pace**. Looking more specifically at the worldwide solar market, it is expected to expand at a compounded annual growth rate (CAGR) of around 22%, from 447 GW in 2023 to 876 GW by 2028. Furthermore, as seen in Portugal, where capacity might reach **10.8 GW during the same timeframe, surpassing the nation's objective of 7 GW**, floating solar systems could exceed national targets. This trend is anticipated to be repeated in other areas with appropriate water bodies.

### Equatorial line investment

As mentioned in the introduction to this report, **countries along the equatorial line are best positioned for the development of offshore solar energy solutions.** These regions benefit from calm weather conditions, with minimal tropical storm activity, making them perfect for solar panel installations. This reduces the need for extensive protective engineering, lowering costs and increasing project feasibility.

This happens due to **wind currents from the northern hemisphere colliding with the trade winds of the southern hemisphere, cancelling each other out.** As such, these regions are marked by low wind generation potential, high population density, and rapid growth in energy demand. In particular, the areas within 5 to 12 degrees of latitude from the Equator, especially the **Indonesian archipelago and the Gulf of Guinea near Nigeria, have the greatest potential for floating solar farms.**

Their relatively intact ecosystems also make them unsuitable for large-scale land-based solar farms, further highlighting the advantages of offshore floating solar solutions.



Heatmap for offshore floating solar panels. Red areas are best, followed by yellow, green and dark blue. The grey lines show tropical storm tracks. Author-supplied, using OpenStreetMap base.

*Figure 3: Regions in the Equatorial line with the most potential for offshore solar projects*

### Government Regulations

Government regulations are essential to the worldwide expansion of offshore solar. Nations are establishing **aggressive goals for renewable energy**. As an example, the European Union wants to use **27% renewable energy in its power generation by 2030**, including offshore solar. Governments are increasing investment through subsidies, tax breaks, and competitive auctions, and expediting project approvals through streamlined regulatory procedures.

Environmental laws that reduce ecological disturbance and promote sustainable development include mandatory impact assessments. These changing regulations are contributing to the

development of a favourable environment for sustained investment and growth in the global offshore solar energy market.

## Portuguese projects in offshore solar

Even though Portugal is in the vanguard of technological development in the renewable energy sector, **it still lacks in what concerns offshore solar projects ready to be implemented**.

Nevertheless, **Portugal is a great candidate for investment in this department**. The suitability of any given country's geography for the installation of offshore solar farms depends on several factors, including **solar irradiance, water depth and stability, wind and wave conditions,** and **tidal influence**. Since Portugal is **one of the European countries with the highest solar exposure**, and has the **5th largest economic zone in Europe, 3rd in the EU**, such characteristics make it a good candidate.

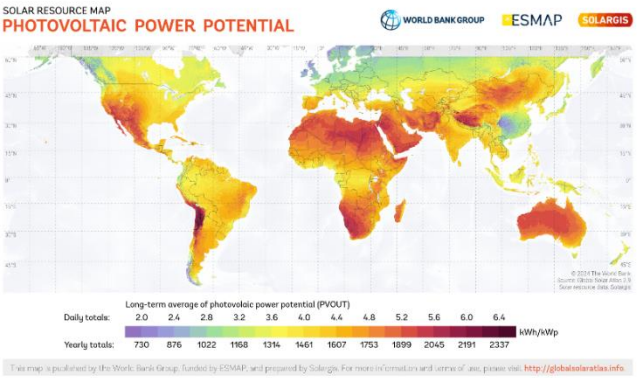



*Figure 4: Map representing the countries in the world with the highest Photovoltaic Power Potential*

However, because of its exposure to the Atlantic, the Portuguese coast is **considerably exposed to strong tides, winds, and waves**. Consequently, the oceanic conditions in Portugal may make the installation of PV modules problematic.

The first step in opening this industry in Portugal has already been made with the previously mentioned **floating solar farm in Alqueva, carried out by EDP in 2022.** This project had an **initial total investment of €6m** and is currently considered to be the **largest European floating solar project in a reservoir**. It involved installing **12,000 floating solar panels**, supplying 1,500 families with **an annual capacity of 7,5GWh**. This solar farm has been supplying **30% of the energy usage of households in the region**.

Still, EDP took further steps forward. In a partnership with Amorim Cork Composites and Spanish manufacturer Isigenere, it was able to improve the **floating devices in the farm by using a unique mix of cork and recycled plastic**, thus reducing **platform weight by 15%** and **slashing the carbon footprint of floater production by 30%**.

EDP is not the only player investing in floating PV technology, however. Other **Portuguese companies** have also **contributed with significant developments in the space.** A clear example is Solaris Float.

**Solaris Float** is a Portuguese company that specializes in floating solar technology, with innovative patents for floating platforms that carry tracking capabilities, PROTEVS. The company describes them as "**modular, detachable, scalable, reliable solution**, with an **easy installation process".** One of the biggest developments made with PROTEVS is that **these islands track the sun by slowly rotating during the day**. By **only consuming 0.5% of the energy produced**, it is able to **extract 40% more energy** than floating fixed-tilt systems. Its **pilot project was deployed in 2020 on Oostvoornse Meer**, a lake in the Netherlands. This installation was **initially made out of 130 PV modules, with 50.7kWp**. In 2022, it was reported to have **expanded into 180 PV modules**, with a total **capacity of 73kWp**.



*Figure 6: The PROTEVS technology developed by Solaris Float in the Netherlands*

**Internationally, BayWa r.e**. is player which can be interesting to keep track of for the future. The German Company **has established Germany's largest floating-PV system**, Quarzwerke GmbH. BayWa r.e has already installed this infrastructure in other countries, such as in Austria, the Netherlands, and Thailand. It has operations in as close as Spain and some **already existing offshore wind farms in Portugal**. Potential future investment in the country may be brewing.

## An important project in the sector

**Nautical SUNRISE: World´s Largest Offshore Floating Solar Power Development**



*Figure 7: A visual plan of the project*

The **Nautical SUNRISE** project is set to support the world's largest offshore floating solar power installation in the Netherlands. The **€8.4m project**, supported with **€6.8m of the Horizon Europe programme**, kicked off in December 2023 to execute research and development on offshore floating solar systems and its components.

This project is **aiming to design, build, and showcase a 5MW offshore floating solar system using the modular solution of Dutch floating solar company SolarDuck**. RWE will be providing the investment for the installation and deployment. The system is planned to be electrically integrated, certified, and located within RWE's OranjeWind farm off the west coast of the Netherlands.

Prior to the offshore deployment, the **Nautical SUNRISE** consortium will conduct extensive research and testing to ensure the reliability, survivability, electrical stability, and yield of offshore floating solar systems. A comprehensive scale-up plan will address the challenges and create opportunities to drive forward the **commercialisation of offshore floating solar systems.**

The project is a pioneering initiative in offshore solar energy and stands out as the **world's largest offshore solar project.** While there are larger solar projects in terms of power generation, which exceed 400MW in capacity, these projects are predominantly located on inland bodies of water like reservoirs, lakes, or even nearshore environments where conditions are more controlled.

Though its capacity may be smaller compared to some of the world's largest floating solar farms, this project is **breaking new ground by going further offshore than any other solar project globally**. This makes it not just a solar energy initiative but a **trailblazer for the future** of floating renewable energy systems in more extreme environments. It is this innovative, offshore focus that makes the **SUNRISE project** a **unique and world-leading effort** in the realm of renewable energy.

The project is made possible via a collaboration of its partners: project lead Dutch Marine Energy Centre (DMEC), SolarDuck, RWE, Blunova - a Carlo Maresca Group company, Bridon-Bekaert The Ropes Group, Deltares, Hasselt University (UHasselt), KU Leuven, Oxford PV, SINTEF Industry, SINTEF Ocean, The Catalonia Institute for Energy Research (IREC-CERCA), INESC TEC, and WavEC Offshore Renewables.

If successful, this project will **enable the large-scale deployment and commercialization of offshore floating solar systems in the future,**

**both as standalone systems and integrated into offshore wind farms.**

## Our view

Throughout this report, it has become clear the benefits that offshore/floating solar brings. Amongst others, **offshore solar offers the ability to free up land space for other purposes**, together with a **greater efficiency** following from the water cooling of the solar panels as well as **quicker and simpler installation process** compared to offshore wind. Still, it carries many disadvantages which ultimately make it a risky investment as of now. For one, it is still **undetermined how long lasting a solar farm will be at sea or in water surfaces**, following from an exposure to tough sea conditions **which may hinder its load factor** (not only at a certain point in time but also gradually throughout time).

**We thus believe that offshore solar should be seen as a technology in its infancy**. It has great potential to help the world address growing energy needs, but further tests need to be carried out to ensure the viability of the technology. Thankfully, many projects (of which we address EDP's Alqueva project and Nautical SUNRISE) are being carried out to assess this suitability. One potential platform for offshore solar to succeed is **through hybrid structures together with offshore wind**, attempting to address the intermittency associated with each technology when assessed on its own. It is also worth mentioning that there are several drivers that can foster the growth of this technology, **from government regulations to the attractiveness of the equatorial line as a hub for the installation of floating PV, next to EU investment in the sector.** Trends such as those mentioned in this report will prompt further development in the space.

Ultimately, all left to do is wait. Undoubtedly many startups will attempt to tackle the multiple issues that offshore solar carries, and it will definitely be exciting to follow what they deliver.

## Newsrun

**Selected headlines, please see full text below:**

- Taiwan's offshore floating solar set for next year's debut by Sun Rise E&T
- Swedish renewable firm Novige seeking €12 million backing to scale wave, wind, and solar hybrid technology
- Saipem starts Xolar floating solar energy trial in Norwegian fjord
- Mocean Energy and SubCTech to test coupling wave and solar energy with batteries for subsea applications
- Shangai unveils plan to co-locate offshore wind and solar, first offshore PV auction planned by year-end
- Early planning submitted for offshore floating solar development in Scotland
- Inauguration of China's First 400 MW Offshore Photovoltaic Park

**Taiwan's offshore floating solar set for next year's debut by Sun Rise E&T** (Offshore Energy, 22 October 2024)

Taiwan's Sun Rise E&T, a manufacturer of floating solar systems, is gearing up to install the first offshore floating solar system next year off the coast of Pingtung, marking a step in local renewable energy expansion. The floating solar platform is designed to endure the challenging conditions of the open sea, withstanding waves reaching heights from 7 to 14 meters. This project aligns with Sun Rise's expertise in marine applications, leveraging the company's experience in mooring systems and aquaculture technology, noted the company.

This latest initiative builds on Sun Rise's established presence in the renewable energy market, where over 400 MW of power plants globally have adopted the company's floating solar systems. According to the company, its approach combines environmental sustainability with technical resilience, aiming to set new standards for offshore solar infrastructure in the coming years. Commercial operations are expected in 2026.

**Swedish renewable firm Novige seeking €12 million backing to scale wave, wind, and solar hybrid technology** *(Offshore Energy, 30 September 2024)*

After securing the SEK 1 million (around $99,210) Startup4Climate award for the power plant in February, NoviOcean is now focused on expanding the hybrid solution, which combines wave and wind power, as well as offshore solar photovoltaics. NoviOcean said it aims to co-locate the wave power plants alongside offshore wind farms to increase overall energy output while sharing infrastructure costs, ultimately making the solution more economically viable. "Our NoviOcean machine maximizes renewable energy by combining wave, wind, and solar power in a single solution, ensuring energy generation even when the sun isn't shining and the wind isn't blowing. Each unit can power over 1,000 households a day." said Jan Skjoldhammer, CEO of NoviOcean.

The Swedish company is now seeking €12m to advance the technology readiness level of the NoviOcean device to full-scale production. The company said it plans to attract investors and partners interested in pioneering a scalable hybrid renewable energy system, offering potential financial returns alongside the device's environmental benefits.

**Saipem starts Xolar floating solar energy trial in Norwegian fjord** (*Offshore Energy, 11 September 2024)*

Developed by Saipem's Norwegian subsidiary Moss Maritime, with the Norwegian manufacturer Kystteknikk and other subcontractors, the full-scale prototype was lifted and launched at sea at Kystteknikk's facilities in Dyrvik on the island of Frøya, where it will remain for about a year. During that year, XolarSurf's performance and production capacity will be monitored. Designed to withstand waves up to eight meters, this is said to be the first full-scale test and a "key milestone" in the readiness of the product.

According to Saipem, XolarSurf is a modularized floating solar technology that focuses on design and engineering services for offshore energy and ocean-based sectors. The technology has undergone a full industrialization process to benefit from cost reductions linked to repeated and scalable production. The solution generates electricity from solar panels mounted on floaters built for marine environments. Its modular design allows for flexibility, with islands consisting of multiple smaller floaters that create a secure area for the photovoltaic panels. Each floater is capable of generating up to 35 to 45 kWp of installed power.

**Mocean Energy and SubCTech to test coupling wave and solar energy with batteries for subsea applications** *(Offshore Energy, 4 September 2024)*

Scottish wave energy company Mocean Energy and German subsea and marine technology company, SubCtech, have signed a memorandum of understanding (MoU) to explore how wave and solar energy can be coupled with batteries to deliver low-carbon solutions for a range of subsea technologies. According to Mocean Energy, the agreement outlines plans to combine their technologies and expertise to develop customizable solutions for global customers. The firms will also share system engineering, analysis, and offer engineering support as needed.

**Shangai unveils plan to co-locate offshore wind and solar, first offshore PV auction planned by year-end** *(Offshore Energy, 28 August 2024)*

The Shanghai Municipal Development and Reform Commission released a new plan on August 26 2024 that will lead to China's largest city opening an allocation round by the end of this year for at least 1 GW of offshore solar energy capacity that will be co-located with offshore wind. The focus areas for offshore solar plants will be at the existing and under-construction offshore wind farms around the East China Sea Bridge, Lingang, Jinshan, and Fengxian, with plans and layouts for

offshore photovoltaics to be based on the “wind and solar on the same site” approach.

The municipal power company will ensure grid connection and route to consumers, and investors are encouraged to configure energy storage on demand.

**Early planning submitted for offshore floating solar development in Scotland** (*Solar Power Portal, 27 August 2024)*

Green Cat Renewables has submitted a letter to the Westmorland and Furness Council with proposals for a floating solar farm off the coast of Scotland. The consultancy firm has asked the council for a screening opinion on the 35-40MW project, which would cover around 60 hectares of water at Cavendish Dock at the Port of Barrow. Early development plans suggest that the panels “will be mounted on floating pontoons fixed at an optimum angle for the solar panels” and will be anchored to the base of the dock. The developers suggest that construction will require activity over a nine to twelve-month period “as a worst-case”, with minimal ongoing visits from maintenance personnel required once completed.

**Inauguration of China’s First 400 MW Offshore Photovoltaic Park** (*EV Wind, 22 August 2024*)

Grand Sunergy reached a decisive milestone in China with the commissioning of the Yantai Zhaoyuan project, the country’s first large-scale offshore photovoltaic park. Located in Laizhou Bay, this solar park with an AC capacity of 400MW and an installed DC capacity of 540MW marks a milestone in the integration of renewable energies in the maritime environment. The modules used, from Grand Sunergy’s Seapower series, are specifically designed to meet the environmental challenges of coastal areas, such as humidity, salt corrosion and UV radiation.