REPORT

HARNESSING THE SEAS: THE RISE OF OFFSHORE WIND POWER

BÜŞRA ZEYNEP ÖZDEMİR

SEPTEMBER 2025 | NUMBER: 268

SETA

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SETA Publications 268
ISBN: 978-625-5703-10-1

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Layout: Said Demirtaş

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ABSTRACT

Growing concerns about global warming and climate change worldwide have led to an increase in the share of renewable energy sources in countries' energy mixes for over two decades. Offshore wind energy, which plays a key role in this regard, is one of the rapidly developing and investment-attracting renewable energy sectors on a global scale. The opportunity to harness the higher wind potential found in open seas compared to land, combined with technological advances, has led to a rapid increase in installed capacity in this field.

This report analyzes the development of offshore wind energy, its advantages and disadvantages, the current technological situation, global investments, and Türkiye's current status in this field. Recommendations have also been developed considering Türkiye's potential sites, legal regulations, work carried out with the World Bank, and support mechanisms.

INTRODUCTION

In recent years, the fight against global warming and climate change has gained prominence on the global agenda, leading to the widespread adoption of low-carbon economy targets. This economic model, in which renewable energy sources play a key role, has also accelerated the development of new technologies. Essentially, the efforts focused on renewable energy, led mainly by developed countries, have been based on the goal of reducing dependence on imported energy sources for a long time. Renewable sources, which began to gain ground in installed capacity based on traditional methods such as hydroelectric, biomass, and geothermal energy, have gradually acquired a new identity.

Since the 2000s, the rapid increase in energy demand in developing countries and the accompanying rise in greenhouse gas emissions have added a new dimension to the discussions on the environmental impact of energy consumption that have been on the international agenda for the past two decades. Efforts to slow down global warming triggered by the increase in emissions have elevated the importance of renewable energy sources to a different level. In addition to increasing energy security through diversification, the contribution of renewable sources to reducing the environmental impacts caused by fossil energy sources has rapidly increased their importance. New technologies in the fields of solar and wind energy have accompanied traditional renewable sources, and efforts have been accelerated for countries to produce energy using all possible domestic resources. Renewable energies, which have become the backbone of the low-carbon economy model, have become the area with the most investment in the energy sector worldwide.

Offshore wind energy, as a sub-sector of wind energy, is one of the sectors receiving the most investment worldwide after solar energy. Applications have also begun in open seas to generate electricity from higher wind speeds than those used on land, and offshore wind energy plants are becoming increasingly attractive. Offshore wind energy, which originated in Europe, is now a technology being invested in other parts of the world, led by Asian countries. Türkiye, which is among the countries that benefit most from renewable energy sources in its immediate vicinity and in Europe, is working to expand its wind energy activities to the offshore wind energy sector.

Following the information shared on the development of offshore wind energy technologies, this report examines the current state of the technology, points to consider during project planning, and the advantages and disadvantages of offshore wind energy. The study, which also covers the countries with the highest investment in offshore wind energy worldwide, concludes with recommendations after analyzing the work in the field of offshore wind energy in Türkiye, our country's potential, and developments in this area.

THE DEVELOPMENT OF OFFSHORE WIND ENERGY

The use of wind energy, one of the oldest energy sources utilized by humanity, for electricity generation began in the late 1800s. The first systems that generated electricity from wind were established to illuminate rural areas, and the first wind turbine was built in Denmark in 1891.[1] At the beginning of the 1900s, approximately 2,500 wind turbines with a total installed capacity of 30 megawatts (MW) were established in Denmark.[2] Wind energy systems, which are mentioned among modern renewable energy sources, began to industrialize in the 1980s following the oil crises of the 1970s.[3] The search for alternative energy sources,

1According to French engineer Philippe Bruyerre, the first windmill was introduced at the Vienna Electricity Exhibition in 1883, while many sources indicate that the first wind energy production system was established in Scotland in 1887. For more information, see "140 Years of Wind Power," World Wind Energy Association, July 31, 2023, https://wwindea.org/140-years-of-wind-power-as-the-world-reaches-1-mio-mw-new-discovery-shows-that-the-worlds-first-wind-generator-was-installed-in-1883 (Accessed June 25, 2025).

2 Zachary Shahan, "History of Wind Turbines", Renewable Energy World, November 21, 2014, https://www.renewableenergyworld.com/storage/grid-scale/history-of-wind-turbines/#gref, (Accessed June 26, 2025).

3 "Wind Energy", IRENA, https://www.irena.org/Energy-Transition/Technology/Wind-energy, (Accessed: June 20, 2025); "Wind Explained – History of Wind Power", U.S. Energy Information Administration (EIA), April 20, 2023, https://www.eia.gov/energyexplained/wind/history-of-wind-power.php, (Accessed June 20, 2025).

coupled with the supply problem of imported commodities, accelerated the shift towards domestic resources and gave momentum to the development of renewable energy technologies.

Wind power plants, initially established on land, were eventually moved to offshore areas as a result of efforts to increase efficiency. The world's first offshore wind power plant was established in 1991 off the coast of Vindeby, Denmark, to take advantage of the stronger winds found in open seas. With 11 wind turbines and a total installed capacity of 5 MW, the plant met the electricity demand of approximately 2,200 households per year and was built close to the shore in shallow waters using small-scale turbines, as required by the conditions of the time. Over the following decade, power plants established off the coasts of Denmark, the Netherlands, Sweden, and the United Kingdom (UK) were similarly constructed in areas close to the shore, consisting of turbines anchored to the seabed with installed capacities ranging from 0.5 to 2.3 MW.[4]

Advances in technology, accompanied by numerous research and development (R&D) studies, now allow for installation in locations further from the coast.[5] In addition, larger turbines enable higher electricity production with fewer wind turbines. In fact, a single offshore wind turbine today can generate more electricity than the entire Vindeby Wind Power Plant.[6]

Thanks to rapidly advancing technology, an offshore wind turbine installed in 2010 could reach a capacity of 3 MW and a height of approximately 100 meters, while today, offshore wind turbines with a capacity of over 25 MW and a height of over 200 meters are being produced.[7] Turbines that grow in size can also generate more electricity by moving over a wider

4 "Making Green Energy Affordable –How the Offshore Wind Energy Industry Matured– and What We Can Learn from It", Ørsted, (June 2019), https://orsted.com/-/media/WWW/Docs/Corp/COM/explore/Making-green-energy-affordable-June-2019.pdf, (Accessed: July 4, 2025).

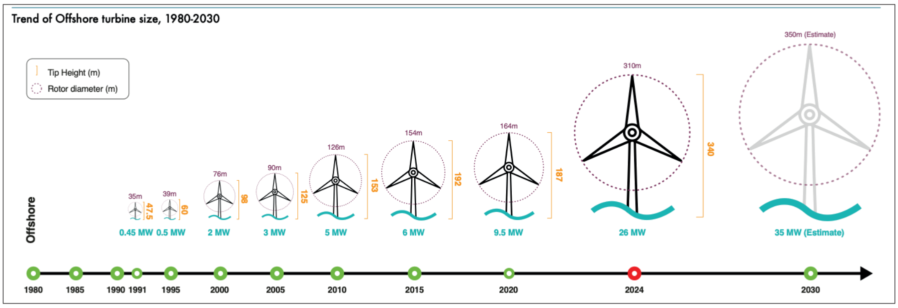
5 While the power plant in question was built approximately 3 kilometers from the coast, wind farms can now be built at distances of more than 120 kilometers.

6 "The World's First Offshore Wind Farm is Retiring," State of Green, March 15, 2017, https://stateofgreen.com/en/news/the-worlds-first-offshore-wind-farm-is-retiring, (Accessed August 10, 2025).

7 "Wind Turbines and Energy Production", Business Norway, November 13, 2024, https://businessnorway.com/articles/wind-turbines-and-energy-production, (Accessed: July 4, 2025); Lin Xiaoyi and Yang Ruoyu, "World's Largest Single Capacity Offshore Wind Turbine Successfully Installed", *Global Times,* June 28, 2023; Joe Salas, "Planet's Largest Wind Turbine Record Broken again at 26MW", New Atlas, October 23, 2024, https://newatlas.com/energy/world-record-offshore-wind-turbine-dongfang-26-mw, (Accessed: July 4, 2025).

area at greater heights. This means that newly built power plants have a higher "capacity factor."[8,9]

FIGURE 1. DEVELOPMENT TREND OF OFFSHORE WIND ENERGY TURBINES (1980-2030)



Source: "Global Offshore Wind Report 2025."

8 "Capacity factor" is obtained by dividing the total energy produced by a power plant over a certain period by the energy it can produce at full capacity. While the capacity factor of offshore wind power plants varies depending on the wind quality at the plant's location, it should be emphasized that offshore wind power plants have the highest capacity factor compared to other renewable energy technologies.

9 "Offshore Wind Outlook 2019", IEA, (November 2019), https://www.iea.org/reports/offshore-wind-outlook-2019, (Accessed: August 10, 2025).

KEY CONSIDERATIONS IN PLANNING OFFSHORE WIND ENERGY PLANTS

As with all power plants, there are certain key considerations that must be taken into account during the planning of offshore wind power plants to ensure that investors can invest with confidence. The most important of these is the environmental impact assessment. The potential effects on human health and all living creatures during the construction, operation, and decommissioning of the plant must be investigated. Once the necessary environmental conditions are met, wind potential is examined. Since efficiency will be low in areas with low wind potential and low wind speeds, winds of at least medium or high speed are expected.

While a wind speed of at least 6.0 m/s is required under current technological conditions, it is also thought that turbines suitable for lower wind speeds will be developed as technology advances. In order to clearly understand the potential, it is of great importance to measure wind speeds in open seas and to clearly present the data based on measurements taken over many years. The main institution conducting wind measurements at sea in Türkiye is the Turkish State Meteorological Service. In addition to meteorological measurements, determining the physical and chemical properties of seawater is also important for the suitability of the sites.[10]

In areas where there is sufficient wind, the grid connection possibilities, sea depth, distance from the coast, and seabed conditions must be evaluated in order. The lack of grid capacity will result in additional investment costs, while increasing depth and distance from the coast will also increase costs. In areas where the depth is suitable and wind speeds are moderate to high, the main considerations include military training areas, flight safety over sea areas, and continental shelves, as well as areas under environmental protection that are important for fishing, maritime transport, tourism, and the hydrocarbon sector. These areas must be taken into account due to their economic value. It is also recommended that offshore wind farms not be built in areas where submarine cables laid for communication purposes and fault lines are present.[11]

Finally, the issue of land ownership in the areas where the plant is planned to be built is another important factor in terms of investment security. Since expropriation may be necessary, obtaining the consent of the landowners is one of the required conditions for the project to be implemented.

10 "Guide to an Offshore Wind Farm", Offshore Renewable Energy Catapult, (January 2019), https://www.thecrownestate.co.uk/media/2860/guide-to-offshore-wind-farm-2019.pdf, (Accessed: July 10, 2025); "Denizüstü Rüzgar Enerjisi Türkiye Yol Haritası", *Wind Energy Magazine,* June 7, 2024; Travis Benn, "How to Start a Wind Farm: The Ultimate Guide", Lumify Energy, June 3, 2025, https://lumifyenergy.com/blog/how-to-start-a-wind-farm, (Accessed: July 10, 2025).

11 Murat Durak et al., "Denizüstü Rüzgar Elektrik Santralleri Türkiye Yol Haritası", DÜRED, (January 2024), http://dured.sanalsal.com/wp-content/uploads/sites/6/2025/03/offshore-wind-power-plants-Türkiye-roadmap.pdf, (Accessed: July 10, 2025).

OFFSHORE WIND ENERGY TECHNOLOGIES

Today, there are two main types of offshore wind energy plants in terms of installation: fixed-bottom plants and floating plants. Fixed-bottom plants consist of wind turbines anchored to the seabed with structures made of steel and similar metals in open seas where the depth is less than 60 meters. Today, the world's offshore wind energy capacity consists mainly of power plants with turbines fixed to the seabed.[12]

Floating power plants, on the other hand, are power plants where wind turbines are built on floating platforms in areas where the depth exceeds 50 meters, and the platforms are anchored to the seabed with materials such as cables, chains, and ropes. These power plants, consisting of turbines that can move according to the direction of the waves, provide the ability to generate electricity in deeper waters compared to turbines anchored to the

12 "Global Offshore Wind Report 2024", World Forum Offshore Wind (WFO), (April 2025), https://wfo-global.org/wp-content/uploads/2025/04/WFO_Global-Offshore-Wind-Report-2024_final.pdf, (Accessed: July 4, 2025).

seabed.[13] Furthermore, floating power plants broaden the potential areas for offshore wind energy projects in regions where coasts are used for tourism, fishing, and similar purposes.

The first floating offshore wind turbine, with an installed capacity of 2.3 MW, was installed in Norway in 2009, 10 kilometers offshore.[14] Another early example was commissioned off the coast of Marseille, one of France's tourist attractions. France's and the Mediterranean region's first example, a power plant consisting of three turbines with an installed capacity of 8.4 MW, which will be fully operational in June 2025, is planned to meet the electricity demand of 45,000 people per year.[15] In addition to Norway and France, the UK, China, and Portugal are also countries where floating offshore wind power plants are prominent.[16]

Hybrid offshore wind power plants, which use both technologies, are being discussed as a third method. These plants can be installed in different locations within a single site, where the depth varies between 50 and 60 meters, allowing for both fixed and floating turbines. The use of turbines of different sizes in hybrid plants aims to generate electricity even in areas where offshore wind energy potential is relatively limited.[17]

All offshore wind power plants transmit the electricity they generate to the nearest grid onshore via cables (high-voltage transmission lines) buried in the seabed. These cables, which are thicker than those used for

13 "Top 10 Things You Didn't Know about Offshore Wind Energy", Wind Energy Technologies Office of U.S. Department of Energy, August 21, 204, https://www.energy.gov/eere/wind/articles/top-10-things-you-didnt-know-about-offshore-wind-energy, (Accessed: July 1, 2025).

14 "World's First Floating Offshore Wind Turbine Goes to Sea Off Norway Coast", Power Engineering, June 8, 2009, https://www.power-eng.com/renewables/wind-energy/worlds-first-floating-offshore-wind-turbine-goes-to-sea-off-norway-coast, (Accessed: July 4, 2025).

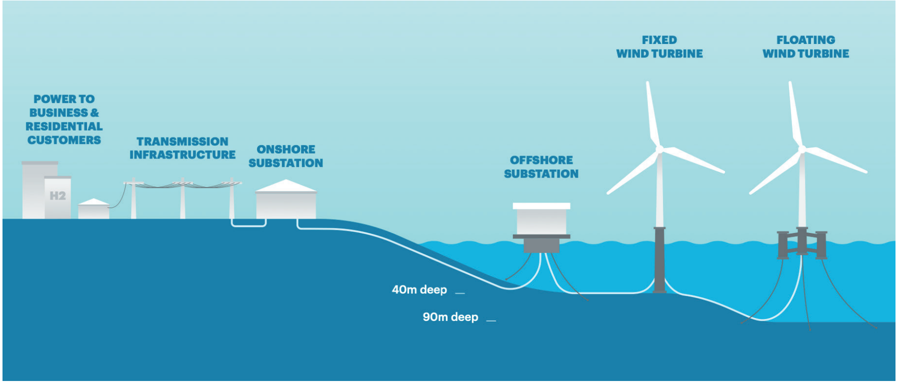
15 "Floating Offshore Wind," SBM Offshore, https://www.sbmoffshore.com/what-we-do/floating-offshore-wind, (Accessed: July 2, 2025); "Provence Grande Large: Full Commissioning of the First French Floating Offshore Wind Farm," EDF, June 5, 2025, https://www.edf.fr/en/the-edf-group/dedicated-sections/journalists/all-press-releases/provence-grand-large-full-commissioning-of-the-first-french-floating-offshore-wind-farm (Accessed: July 2, 2025); Adnan Memjia, "First Floating Offshore Wind Farm in France Fully Commissioned," Offshore Wind, June 5, 2025, https://www.offshorewind.biz/2025/06/05/first-floating-offshore-wind-farm-in-france-fully-commissioned, (Accessed July 2, 2025).

16 "Global Offshore Wind Report 2025," GWEC, (June 2025), https://www.gwec.net/gwec-news/offshore-wind-installed-capacity-reaches-83-gw-as-new-report-finds-2024-a-record-year-for-construction-and-auctions, (Accessed: July 4, 2025).

17 Miriam Noonan, "The Benefit of Hybrid Bottom-Fixed and Floating Wind Sites", ORE Catapult, (January 2021), https://cms.ore.catapult.org.uk/wp-content/uploads/2021/01/AI-paper-Floating-hybrid-sites-final-2021.01.11.pdf, (Accessed: July 2, 2025).

communication, are wrapped in several layers of metal and laid on the seabed using special ships to protect them from damage caused by natural phenomena such as earthquakes and underwater currents, or from human-induced hazards. These lines, whose environmental impact is highly controversial, are expected to increase further with the growing use of wind energy in the open sea.[18]

FIGURE 2. TYPICAL EXAMPLE OF AN OFFSHORE WIND FARM



Source: "Offshore Wind Energy", Offshore Infrastructure Regulator, (December 2023), https://www.oir.gov.au/sites/default/files/Offshore%20Wind%20Energy%20Brochure.pdf, (Accessed: August 7, 2025).

While the costs of renewable energy-based power plants have declined over the years, offshore wind power plants stand out from other plants due to their relatively high cost.[19] In 2010, the total installation cost of offshore wind power plants worldwide was $5,518/kW, with a capacity factor of 38 percent and a levelized cost of electricity[20] (LCOE) was $0.208 kWh, while in 2024, the total installation cost has decreased to $2,852/kW, the capacity factor has increased to 42 percent with advancing technology, and the LCOE has decreased to $0.079/kWh (Table 1).[21]

18 Andrienne Bernhard, "How Undersea Cables May Affect Marine Life", BBC, February 2, 2023.

19 The data in the table is for offshore wind farms fixed to the seabed.

20 LCOE is used to calculate the unit energy cost of power plants, and the unit price of electricity is calculated by taking into account the initial investment cost, operating and maintenance expenses, and fuel costs.

21 "Renewable Power Generation Costs in 2024," IRENA, (July 2025), https://www.irena.org/Publications/2025/Jun/Renewable-Power-Generation-Costs-in-2024, (Accessed: August 16, 2025).

TABLE 1. TOTAL INSTALLATION COST, CAPACITY FACTOR, AND LEVELIZED ELECTRICITY COST CHANGES OVER THE YEARS (2010-2024)

	Total Installation Cost (2024 USD/kW)			Capacity Factor Percentage			LCOE (2024 USD/kWh)		
	2010	2024	Change (%)	2010	2024	Change (%)	2010	2024	Change (%)
Bioenergy	3,082	3,242	5	72	73	1	0.086	0.087	1
Geothermal	3.083	4,015	30	87	88	1	0.055	0.060	9
Hydraulic	1.494	2,267	52	44	48	9	0.044	0.057	30
Photovoltaic	5,283	691	-87	15	17	13	0.417	0.043	-90
Concentrated Solar Panel	10,703	3,677	-66	30	41	37	0.402	0.092	-77
Onshore Wind	2,324	1,041	-55	27	34	26	0.113	0.034	-70
Offshore Wind	5,518	2,852	-48	38	42	11	0.208	0.079	-62

Source: “Renewable Power Generation Costs in 2024”.

It is predicted that demand for offshore wind energy will increase in the future as R&D efforts and technology continue to advance, and that prices will decline further, similar to other renewable energy technologies.

ADVANTAGES AND DISADVANTAGES OF OFFSHORE WIND POWER PLANTS

Despite their high cost compared to onshore wind power plants, offshore wind power plants are one of the technologies attracting investment due to the advantages they offer. It can be said that these plants provide all the advantages offered by onshore wind power plants and other renewable energy plants. As with all renewable energy plants, their primary advantage is that they generate electricity without causing greenhouse gas emissions. Another important advantage is that they contribute to the diversification of installed electricity capacity, thereby increasing supply security. Moreover, it also contributes to the labor market and employment by creating new job opportunities throughout the entire process, from the construction of the plant to its commissioning, including technology production, installation, operation, service maintenance, and support services.

In addition to the advantages of renewable energy sources, offshore wind power plants have their own unique advantages. The biggest advantage offered by these plants is that they enable higher electricity production thanks to the stronger winds blowing at sea. This allows them to generate more electricity compared to onshore wind power plants. Studies show that electricity generated by winds blowing at 15 miles per hour (mph)[22] is approximately twice as much as that generated by winds blowing at 12 mph.[23]

Another advantage of offshore wind farms is that they can produce more sustainable electricity thanks to the higher consistency of winds in open seas and oceans compared to winds on land. This means that they contribute more to energy security than onshore wind farms.

Thirdly, seas and oceans offer more unused, suitable areas than land. This allows for the installation of a greater number of wind turbines and power plants. In countries/cities where settlements are densely concentrated on the coast, the demand for electrical energy can be met by offshore wind power plants installed in coastal areas. Furthermore, the proximity of the power plant to the point of consumption also makes energy supply more secure. As in distributed power generation, producing the required electricity near areas of high consumption or close to consumption centers facilitates the prevention of losses due to reduced distance, ensuring a more secure energy supply.[24]

Finally, when examining the environmental impact assessment of offshore wind power plants, it is seen that they benefit the marine ecosystem. Studies have proven that closing the areas where power plants are located in the open sea to shipping traffic not only prevents pollution but also helps protect marine life. It is also stated that suspending fishing activities in the areas where the power plants are located contributes to the continued existence of fish.[25]

22 m/s: meters per second. 15 m/s = 24.1 km/h, while 12 m/s = 19.3 km/h.

23 "What are the Advantages and Disadvantages of Offshore Wind Farms?", American Geosciences Institute, https://profession.americangeosciences.org/society/intersections/faq/what-are-advantages-and-disadvantages-offshore-wind-farms, (Accessed: July 4, 2025).

24 "Advantages and Disadvantages of Offshore Wind," Business Norway, November 13, 2024, https://businessnorway.com/articles/advantages-and-disadvantages-of-offshore-wind, (Accessed: July 4, 2025).

25 Ibon Galparsoro et al., "Reviewing the Ecological Impacts of Offshore Wind Farms", *NPJ Ocean Sustainability*, Volume: 1, (2022).

Like other renewable energy sources, offshore wind power plants have certain disadvantages as well. The fact that renewable energy sources are still susceptible to seasonality today causes power plants to produce varying amounts of electricity periodically. Just as hydroelectric power plants produce more electricity during periods of heavy rainfall and less during periods of low rainfall, wind power plants produce more electricity during periods of high wind and less during periods of low wind. Until recently, the UK, which had the world's largest installed capacity, had to activate fossil fuel power plants used as backup capacity and base load during periods when offshore wind power plants produced less electricity than expected due to the seasonality factor.[26] As shown in Table 1, although the capacity factor of renewable power plants has increased with advancing technology, it is still below 50 percent, especially in wind power plants.

Another disadvantage of offshore wind power plants, as with other renewable power plants, is the environmental damage caused during the production of their technology. Today, rare earth elements and critical minerals, along with iron, steel, aluminum, and copper, are used in the production of clean and renewable energy technologies; ensuring the continuity of the production of these minerals is also necessary for the sustainability of the industry in question. The process of extracting and producing minerals can cause greenhouse gas emissions as well as environmental and water pollution. Furthermore, the pollution generated during the production of these technologies also raises questions about the "environmental sustainability" of renewable technologies. The fact that China, currently the world's largest producer of energy technologies relies heavily on coal for its electricity production clearly highlights the environmental impact caused during the production process.

As with other renewable power plants, a disadvantage of offshore wind energy plants arises after the plants completed their lifespan. While recycling turbine parts is easy for metals such as aluminum, iron, steel, and copper, there are still parts that cannot be recycled. There is concern that the long-

26 Jasper Jolly, "Renewable Energy Firms Warn of Difficult Conditions Amid Slow Winds", *The Guardian*, November 3, 2021; Darrell Proctor, "UK Restarts Coal-Fired Units as Temperatures, Power Demand Rise", *The Power Mag*, June 13, 2023.

term increase in renewable installed capacity on a global scale could lead to significant environmental pollution.[27]

Finally, the careful selection of sites, which applies to all power plants as well as renewable ones, is also valid for offshore wind farms. Power plants can also cause socio-economic damage in the region where they are built. Selecting coasts where economically important sectors such as tourism and fishing operate for offshore wind energy plants carries the risk of hindering the income generated from these sectors. This situation can cause various negative consequences for countries whose economies depend on these sectors, as well as causing discomfort among the local population.[28]

Offshore wind farms also differ from other power plants due to their high installation costs. The technology used in offshore wind farms is more expensive than that used in onshore wind farms, resulting in higher financing requirements during installation. Costs also increase as the depth of the sea increases in the areas where the power plants are installed.[29]

In addition to the installation costs of offshore wind power plants, maintenance and repair costs are also higher than those of onshore wind power plants. This is because the violent waves and fast winds in the open seas and oceans cause more damage to wind turbines than to turbines located on land and require more frequent maintenance.[30]

Some studies have shown that offshore wind farms may also have negative effects on marine and ocean life. It has been observed that both the materials used to manufacture wind turbines and the noise pollution caused during installation and operation can harm marine life and underwater ecosystems in the region.[31]

27 "Advantages and Disadvantages of Offshore Wind".

28 "What are the Advantages and Disadvantages of Offshore Wind Farms?".

29 "Advantages and Disadvantages of Offshore Wind".

30 "The Pros and Cons of Onshore & Offshore Wind", Brunel, May 19, 2021, https://www.brunel.net/en/blog/renewable-energy/onshore-offshore-wind, (Accessed: August 11, 2025); "Onshore vs Offshore Wind Energy: What's the Difference?", National Grid, March 30, 2022, https://www.nationalgrid.com/stories/energy-explained/onshore-vs-offshore-wind-energy, (Accessed: August 11, 2025); "What are the Advantages and Disadvantages of Offshore Wind Farms?", American Geosciences Institute, https://www.americangeosciences.org/critical-issues/faq/what-are-advantages-and-disadvantages-offshore-wind-farms, (Accessed: August 11, 2025); "Global Offshore Wind Farm Database and Intelligence", TGS, https://www.4coffshore.com/windfarms, (Accessed: August 11, 2025).

31 "Offshore Wind Geospatial Analysis", IEA, November 14, 2019.

FACTORS AFFECTING POWER PLANT INVESTMENTS

Legal procedures are undoubtedly the most influential factor affecting the development of offshore wind energy installed capacity in countries. A study conducted by a world-renowned US-based investment consulting firm shows that, approximately 80 percent of offshore wind energy power plant projects that have been implemented and commissioned are directly related to the policies of governments or affiliated political authorities.[32] When it comes to the policies pursued and the legal regulations developed by countries in this field, Northern European countries are of particular importance as they were the first to invest.

Denmark, which built the world's first offshore wind farm, has developed regulations over time that serve as a model for other countries. The Copenhagen government manages the entire plant

32 "Global Offshore Wind Capacity to Reach 330GW By 2030", ReNews.biz, May 18, 2022, https://renews.biz/77932/global-offshore-wind-capacity-to-reach-330gw-by-2030, (Accessed: August 11, 2025).

construction process through the Danish Energy Agency, a public institution established in 1976. The agency, known as a *one-stop-shop*, has been granted the authority to issue permits and approvals for offshore wind energy projects. This agency is responsible for the planning, commissioning, and decommissioning of power plants after they have reached the end of their lifespan. It brings together permit requirements from different areas such as maritime safety, radar systems, and the fishing industry to offer a single license for the implementation of power plant projects. In this way, it speeds up the project approval process, making it easier for investors to obtain licenses, while also reducing risks by ensuring transparency and accountability.[33]

The United Kingdom is another country with an exemplary legal framework in this area. The government provides a fixed price guarantee to private/legal entities that will generate electricity from renewable energy sources through the Contracts for Difference (CfD) mechanism. Payments are made from revenues collected through taxes on consumer bills. Under this mechanism, if electricity prices in the market fall below the specified amount, the difference is paid to the producer by the state. If prices in the market exceed the specified amount, the difference is returned to the state by the producer. The aim is to protect both the producer and the state against price fluctuations.

As of July 2025, the 15-year fixed price purchase guarantee has been extended to 20 years to increase investor confidence in the market. In addition to this regulation, the UK government has committed to making extra payments for the use of domestic technology in power plant construction through a support scheme called the Clean Industry Bonus, which will only apply to offshore wind farm projects, in order to encourage investment in the domestic supply chain.[34] However, the 20-year extension of the feed-in

33 "Danish Experiences from Offshore Wind Development", Danish Energy Agency, (March 2017), https://ens.dk/sites/default/files/media/documents/2024-11/offshore_wind_development_0.pdf, (Accessed: July 17, 2025); "One-Stop-Shop to Accelerate Offshore Wind Permitting", State of Green, April 7, 2025, https://stateofgreen.com/en/news/one-stop-shop-to-accelerate-offshore-wind-permitting/?utm_source=chatgpt.com, (Accessed: July 17, 2025); Ceciel Nieuwenhout, "Developing Offshore Wind Farms – a Comparison and Analysis of the Legal and Governance Frameworks of the North Sea Coastal States", *European Journal of Comparative Law and Governance,* (December 2023).

34 The decision taken in December 2024 is planned to be effective as of July 2025. "Contracts for Difference and Capacity Market Scheme Update 2024", UK Government Department for Energy Security and Net Zero, https://www.gov.uk/government/publications/contracts-for-difference-and-capacity-market-scheme-update-2024/contracts-for-difference-and-capacity-market-scheme-update-2024?utm_source=chatgpt.com, (Accessed: July 18, 2025).

tariff only applies to fixed-bottom and floating offshore wind farms, onshore wind farms, and solar power plants. The extension of the law's validity period is thought to be influenced by the project recently suspended by Orsted, citing uncertain global economic conditions. Finally, it is estimated that the fixed purchase price of £58.87/MWh set for offshore wind farms in 2022 will be £85/MWh, reflecting the current inflation differential.[35]

The Netherlands, similar to Denmark, is one of the countries that encourages renewable sources without subsidies. In this example, after determining the areas for offshore wind energy projects, the state encourages investors by carrying out the necessary work for project planning, such as preliminary feasibility studies, environmental impact assessments, ground surveys, and on-site wind measurements. Auctions are held using the compiled data, and contracts are signed with the investor offering the lowest price.[36]

Although China entered the offshore wind energy field later, it has become the country with the highest installed capacity thanks to the high-capacity power plants it has added to its installed capacity. However, China follows a different approach than European countries. As a state policy, China has been implementing a large portion of its offshore wind energy plant investments through state-owned companies, as it has done in almost every sector, particularly energy, in recent years. The country, which has a state system, allows local governments to plan their own offshore wind energy plants without needing approval from the central government. By 2024, eleven provinces have implemented their own offshore wind energy plans. National companies are responsible for establishing the supply chain infrastructure, as well as constructing power plants and facilities such as ports for logistics.[37]

The length of the permitting process is another important criterion affecting investor behavior. Denmark offers one of the shortest times in Europe at 4.5 years, while France has the longest permitting process at 11 years.[38] The

35 "Contract for Difference (CfD)", IEA, (2019), https://www.iea.org/policies/5731-contract-for-difference-cfd, (Accessed: July 18, 2025); Jim Pickard and Rachel Millard, "UK Extends Subsidy Contracts in Boost for Wind and Solar Developers", *Financial Times,* July 15, 2025.

36 "Wind Farms Zones", Netherlands Enterprise Agency, https://offshorewind.rvo.nl, (Accessed: July 18, 2025).

37 "Global Offshore Wind Report 2025".

38 "Developing Offshore Wind Farms – a Comparison and Analysis of the Legal and Governance Frameworks of the North Sea Coastal States."

permitting process for onshore wind power plants can take up to 10 years in Croatia and up to 8 years in Belgium, Greece, Spain, and Sweden. To increase the share of renewable energy sources in installed electricity capacity more rapidly and achieve the Net Zero Emissions target by 2050, the EU updated its Renewable Energy Directive in 2021. The updated Directive has required countries to implement a *one-stop-shop* permit process similar to Denmark's and to ensure that the entire process is completed within 2.5 years.

The process, updated once again in 2022 with the RePowerEU package, is planned to have a maximum of 3 years for offshore wind energy projects and 2 years for onshore projects. In areas designated as *renewables acceleration areas*, the process for offshore wind energy plants to be built in selected areas more quickly has been set at a maximum of one year.[39] As of July 2025, it cannot be said that member states have yet complied with this directive. Germany shortened the permitting process for onshore wind energy projects to 18 months in 2023. As of November 2025, it is preparing to launch a digital application that will handle all processes from a single point of contact (*one-stop-shop)*. Spain, on the other hand, has implemented regulations that reduce the permitting process to 2 years for projects under 150 MW.[40]

39 "Enabling Framework for Renewables," European Commission, https://energy.ec.europa.eu/topics/renewable-energy/enabling-framework-renewables_en?utm_source=chatgpt.com, (Accessed: July 18, 2025).

40 "RePowerEU – 3 Years on", European Commission, https://energy.ec.europa.eu/topics/markets-and-consumers/actions-and-measures-energy-prices/repowereu-3-years_en, (Accessed: July 18, 2025).

COUNTRIES INVESTING IN OFFSHORE WIND ENERGY

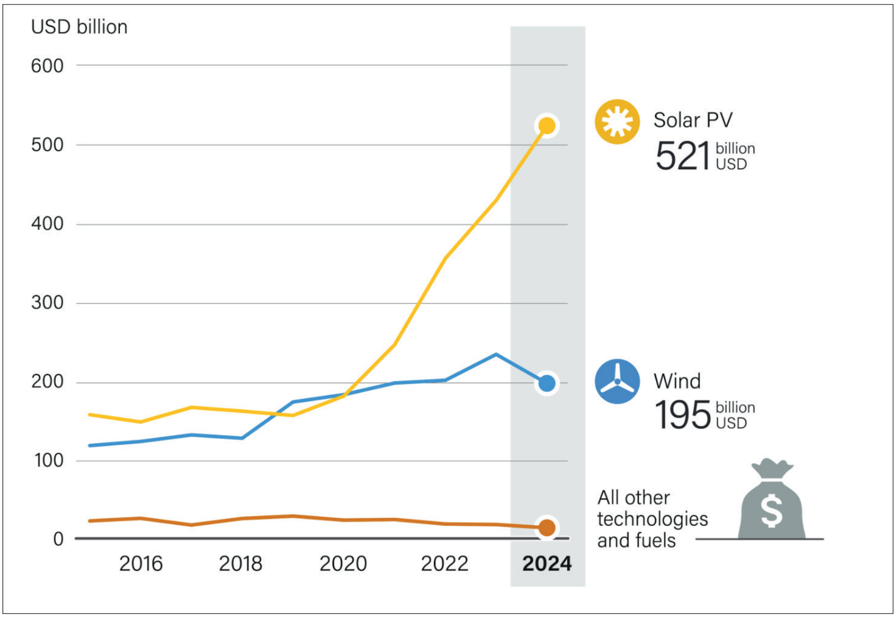
Wind energy, along with solar energy, has been among the renewable energy sources receiving the most investment globally in recent years.[41] The fact that panels enabling electricity generation from solar energy require a more limited area compared to turbines used to generate electricity from wind, and can even be installed on roofs, makes solar energy a viable option for end consumers.

Due to high costs in the wind energy sector, financing and projects are primarily focused on onshore wind energy. Although the first offshore wind power plant was established in 1991, offshore wind power capacity was only 67 MW out of a total global wind power capacity of approximately 17,000 MW by 2000. This amount corresponded to only 0.4 percent of the world's to-

41 "World Energy Investment 2025", IEA, (June 2025), https://www.iea.org/reports/world-energy-investment-2025, (Accessed: July 4, 2025); "Energy Transition Investment Trends 2024", Bloomberg NEF, January 30, 2024; "Global Status Report 2025", REN21, (June 2025), https://www.ren21.net/gsr-2025, (Accessed: July 7, 2025).

tal wind power capacity and only three European countries owned it. These countries are Denmark (50 MW), Sweden (13 MW), and the UK (4 MW).[42]

GRAPH 1. GLOBAL RENEWABLE ENERGY INSTALLED CAPACITY INVESTMENTS (2015-2024, BILLION DOLLARS)



Source: "Global Status Report 2025".

While it is known that nearly 3 billion people worldwide live within 100 kilometers of the coast, a study by the International Energy Agency (IEA) shows that the global technical potential of offshore wind energy is 18 times greater than global electricity demand.[43] The highest technical potential is in the 27-member European Union (EU), followed by the US, Japan, China, and India.[44]

The global offshore wind energy market, which grew by approximately 30 percent annually between 2010 and 2020, has seen investments primarily from the UK, Germany, and Denmark. However, China has been the coun-

42 "Data - Country Rankings," IRENA, https://www.irena.org/Data/View-data-by-topic/Capacity-and-Generation/Country-Rankings, (Accessed August 16, 2025).

43 The report published in 2019 was based on the global electricity demand in 2018.

44 "Offshore Wind Outlook", IEA, October 25, 2019, https://www.iea.org/reports/offshore-wind-outlook-2019, (Accessed: August 16, 2025).

try investing the most in offshore wind energy, similar to other renewable energy sources, and has added the most new capacity in this field globally (Table 2).[45]

TABLE 2. GLOBAL OFFSHORE WIND ENERGY INSTALLED CAPACITY DEVELOPMENT BY COUNTRY (2000-2024, MW)				
COUNTRY	2000	2010	2020	2024
Denmark	50	868	1,701	2,813
Sweden	13	163	203	193
United Kingdom	4	1,341	10,383	14,745
Netherlands		228	2,460	4,748
Belgium		197	2,262	2,262
China		100	8,990	39,10
Germany		80	7,787	9,215
Finland		26	32	32
Ireland		25	25.2	25
Japan		25	59	290
South Korea			136	136
Taiwan			128	2,963
Vietnam			99	1,104
France			14	1,487
Norway			2	90
Portugal			25	25
Spain			5	5
USA			29	171
TOTAL	**67**	**3,053**	**34,340**	**79,404**

Source: IRENA

According to the Global Wind Energy Council's 2024 report, a record 8 gigawatts (GW) of new capacity was added to the world's offshore wind energy installed capacity and 56 GW of new capacity was allocated in the last year. Including plants that have been completed but not yet commissioned, installed capacity has reached 83 GW.[46] With an annual electricity produc-

45 "Offshore Wind Outlook 2019".

46 Edward Peters, "2024 a Record Year for Offshore Wind as Capacity Surpasses 83GW Worldwide", 4C Offshore, June 27, 2025, https://www.4coffshore.com/news/2024-a-27record-year27-for-offshore-wind-as-capacity-surpasses-83gw-worldwide-nid31394.html (Accessed: July 8, 2025).

tion of 298 gigawatt hours (GWh), it is planned to meet the electricity needs of 73 million households. As of May 2025, it is anticipated that new allocations totaling 100 GW will be added between 2025 and 2026 to the 48 GW of power plants currently under construction.

In addition, the sector's contribution to the labor market/employment has reached a significant level. According to the report, by the end of 2024, offshore wind energy development worldwide will have created a total of 17,500 jobs, providing full-time employment for 8,700 people directly and 8,800 people indirectly. To achieve all this, it is estimated that investments in the sector worldwide have reached $327.8 billion.[47]

When investments are examined on a production basis, it is seen that the largest investment in offshore wind energy technologies worldwide has been made in China. Chinese companies are intensively investing in the production of components such as blades and nacelles, turning the country's coastal regions into technology production centers in this field. With 20 production centers and more than 10 offshore ports, as well as production centers currently under construction, China is expected to reach a production capacity of 20 GW, enabling it to meet its national demand for the next 5-10 years. The fact that the longest and largest wind turbines are also manufactured in China makes the country a leader in this technology.

In contrast, Europe maintains its leading position in wind turbine production. European countries, which were the first to host onshore and offshore wind farms, export to many parts of the world with their mature industries. While China's production is mainly for the demand in its domestic market, European companies are leading the way in accumulating experience by both exporting to many countries and shifting part of their production.[48]

Globally, it was observed that the new capacity added to installed power in 2024 was mainly centered in Asia, particularly China (7.67 percent), and Europe (5.76 percent). However, while the total installed capacity of offshore wind farms in 18 countries is 62,623 MW, China hosts the highest

47 "Global Offshore Wind Report 2025", GWEC, (June 2025), https://www.gwec.net/gwec-news/offshore-wind-installed-capacity-reaches-83-gw-as-new-report-finds-2024-a-record-year-for-construction-and-auctions, (Accessed on: July 4, 2025).

48 "Renewables 2024 – Analysis and Forecast to 2030", IEA, (October 2024), https://www.iea.org/reports/renewables-2024, (Accessed: July 28, 2025); "Global Offshore Wind Report 2025".

installed capacity, accounting for approximately half of the total installed capacity (Table 2).

China made its first investment in 2007 and increased its installed capacity, which remained at 2 MW for three years, to 100 MW in 2010.[49] As a result of adding nearly 1 GW of additional installed capacity each year as of 2016, China had 49.2 percent of the global installed capacity as of 2024.[50] This installed capacity is equivalent to 7.5 percent of China's wind energy installed capacity and 2.1 percent of its total renewable installed capacity.[51]

The United Kingdom is the second country with the most offshore wind installed capacity after China. With the help of the North Sea's productive winds and the end of numerous hydrocarbon activities in the region, the country also hosts the highest offshore wind energy installed capacity in Europe. The installed capacity of 14,745 MW is equivalent to 47.1 percent of the total installed wind capacity and 25.1 percent of the total renewable installed capacity.[52]

Germany ranks third in terms of offshore wind energy installed capacity. According to 2024 year-end data, the country's offshore wind energy installed capacity of 9,215 MW accounted for 30.32 percent of its total wind installed capacity and 5.15 percent of its renewable energy installed capacity.[53]

Denmark, the country that built the first offshore wind power plant, ranks sixth with an installed capacity of 2,812 MW, while Sweden, another pioneer in this field, is not among the top ten countries as of the end of 2024. Although Asian countries, led by China, have significant installed capacity, six of the ten countries with the highest installed capacity are in Europe (Table 2).

49 In 2010, the first commercial offshore wind farm, Donghai Bridge Wind Farm with a capacity of 102 MW, was commissioned. See "Global Offshore Wind Report 2025".

50 "Renewable Capacity Statistics 2025", IRENA, (March 2025), https://www.irena.org/Publications/2025/Mar/Renewable-capacity-statistics-2025, (Accessed: August 11, 2025)

51 "What are The Latest Trends in Renewable Energy?"; "Power Production Capacity in China 2017-2022, by Source", Statista, April 18, 2023, https://www.statista.com/statistics/302191/china-power-generation-installed-capacity-by-source, (Accessed: August 11, 2025).

52 "Renewable Capacity Statistics 2025".

53 "What are the Latest Trends in Renewable Energy?"; Bruno Burger, "Public Net Electricity Generation in Germany in 2022", January 2, 2023.

The United States, the world's largest economy, lags behind many countries in offshore wind energy. The country, which commissioned its first turbine in this field in 2013, launched its first commercial offshore wind farm in April 2024.[54]

However, countries' attitudes toward offshore wind energy today vary for various reasons. One of the most notable changes has undoubtedly been in the United States. Following the inauguration of Donald Trump, who was elected president for a second term, the US's approach to offshore wind energy—as with many other issues—has changed. Trump, by prioritizing the production of fossil fuels and placing great importance on nuclear energy, frequently stated during his campaign that he would halt and repeal a significant portion of the clean energy transition efforts initiated during the Biden administration.[55]

On his first day in office, President Trump signed an executive order withdrawing the country from the Paris Climate Agreement, as he had done in his previous term, and also suspending offshore wind energy projects. The same order also decided to temporarily freeze all federal permits for both onshore and offshore wind energy projects due to the need for a comprehensive assessment of navigation safety, transportation, national security and commercial interests, and the impact on marine mammals. Although the executive order includes the phrase "temporarily," it does not specify when this period will end.[56] Following the decision, the Department of the Interior suspended the permitting process for onshore and offshore wind and solar energy projects for 60 days. After the 60 days ended, a decision was

54 "First U.S. Grid-Connected Offshore Wind Turbine Installed off the Coast of Maine", U.S. Department of Energy, October 1, 2013, https://www.energy.gov/eere/wind/articles/first-us-grid-connected-offshore-wind-turbine-installed-coast-maine (Accessed June 24, 2025); "35 Miles East of Long Island, the U.S. has Its First Large Offshore Wind Farm," NPR, March 14, 2024, https://www.npr.org/2024/03/14/1238593852/first-large-offshore-wind-farm-opens-long-island-south-fork (Accessed June 24, 2025).

55 Onur Kolçak and Büşra Zeynep Özdemir, "The Paradigm Shift in U.S. Policies Under President Trump's Second Term: Energy, Climate, Sustainability, and Trade Agenda," *SETA Analysis*, No. 93, (March 2025); Onur Kolçak, "The Point of No Return: How the 2024 U.S. Presidential Election will Reshape Global Sustainability and Energy Policy", *SETA Analysis,* Issue: 92, (October 2024).

56 "Temporary Withdrawal of All Areas on the Outer Continental Shelf from Offshore Wind Leasing and Review of the Federal Government's Leasing and Permitting Practices for Wind Projects", The White House, January 25, 2025, https://www.whitehouse.gov/presidential-actions/2025/01/temporary-withdrawal-of-all-areas-on-the-outer-continental-shelf-from-offshore-wind-leasing-and-review-of-the-federal-governments-leasing-and-permitting-practices-for-wind-projects, (Accessed: July 8, 2025).

announced that the permit process would continue for solar and geothermal energy and storage projects, but wind energy was not included.[57]

Trump later lifted the suspension order in May for the Empire Wind project being built by Norway's Equinor in New York state, but by that date, it had caused some countries to take a step back in the field of offshore wind energy.[58][59] Following this decision, some companies operating in many countries suspended certain projects, while some governments also showed a tendency to halt offshore wind energy tenders. The Lithuanian government is one of the first examples of this. In a statement on January 29, the Lithuanian Ministry of Energy announced that it had suspended the tender process for the country's first offshore wind energy project, which was launched on November 18, 2024. It is said that the process would be reviewed to ensure that end consumers would be affected as little as possible by the electricity prices that are likely to result from the implementation of the project.[60] The government later announced in April that the tender had been reviewed, that it would continue after various changes were made, and invited companies operating in this field to participate in the tender.[61]

Taiwan, one of Asia's emerging offshore wind energy countries, is also among the countries that have suspended the tender process. In April and May, tender processes for two power plants with a total installed capacity of 900 MW were canceled. The Taiwanese government announced that the tenders were canceled because none of the winning companies fulfilled their contractual obligations on time.[62]

57 Matthew Einsenson, "100 Days of Trump 2.0: Renewable Energy Siting and Permitting", Columbia Law School, May 5, 2025, https://blogs.law.columbia.edu/climatechange/2025/05/05/100-days-of-trump-2-0-renewable-energy-siting-and-permitting, (Accessed: July 8, 2025).

58 "Trump Administration to Allow Work to Continue on $5 Billion New York Wind Farm," *The Guardian*, May 20, 2025.

59 Stine Jacobsen and Louise Rasmussen, "Orsted Cancels Major UK Wind Project as Economics Worsen," Reuters, May 7, 2025.

60 "The Tender for the Offshore Wind Farm is Being Suspended in Order to Improve Its Conditions for Consumers," Ministry of Energy of the Republic of Lithuania, January 29, 2025, https://enmin.lrv.lt/en/news/the-tender-for-the-offshore-wind-farm-is-being-suspended-in-order-to-improve-its-conditions-for-consumers, (Accessed: July 8, 2025).

61 Nadine Schioldan, "The Lithuanian Government Has Officially Agreed to Make Modifications to Its Tender for the 700 MW Offshore Wind Project , Inviting New Bids to Advance the Country's Renewable Energy Goals," 4C Offshore, April 15, 2025, https://www.4coffshore.com/news/the-lithuanian-government-has-officially-agreed-to-make-modifications-to-its-tender-for-the-700mw-offshore-wind-project2c-inviting-new-bids-to-advance-the-country92s-renewable-energy-goals.-nid31023.html, (Accessed July 8, 2025).

62 Bojan Lepic, "Taiwan Cancels Two Offshore Wind Projects", Splash247, May 30, 2025, https://splash247.com/taiwan-cancels-two-offshore-wind-projects, (Accessed: July 8, 2025).

At the beginning of July, another European government also joined the countries that decided to suspend offshore wind energy tenders. The Belgian government announced that it had ended the auction process for the Princess Elizabeth Field, which had been intensively planned for about four years, scheduled for November. Energy Minister Mathieu Bihet stated that the tender's timeline and legal framework were uncertain and unrealistic and not expected to continue. The decision has been criticized by companies operating in the country. The renewable energy cooperative SeaCoop CSVO stated that this decision by the government creates uncertainty, threatens investment security, could lead to increased costs, and will be an obstacle to achieving the 2030 emissions reduction target.[63]

The successive decisions taken by governments have created an uncertain environment for the private sector, causing companies to withdraw from tenders or decide to halt processes. Numerous companies operating or preparing to operate in the offshore wind energy sector in the US have decided to halt their projects or withdraw from them following Trump's decision. In March, German energy company RWE announced that it had decided to halt its offshore wind energy operations in the US due to the political environment created by the Trump administration. Although the US is the country where RWE has the largest installed renewable capacity outside Germany, the company has decided not to continue its offshore wind energy projects in New York, Louisiana, and California.[64]

In April, Norway-based Equinor decided to halt its Empire Wind project off the coast of New York. In a statement, the company said that the project, which would have employed approximately 1,500 people and met the electricity needs of 500,000 households, would be subject to a mandatory halt following Trump's decision, and that all rights, including legal proceedings, would be evaluated.[65] Although the lifting of the suspension decision

63 Edvard Peters, "Belgium Shocks Industry after Halting Offshore Wind Tender", 4C Offshore, https://www.4coffshore.com/news/belgium-shocks-industry-after-halting-offshore-wind-tender-nid31408.html, (Accessed: July 8, 2025).

64 Michelle Lewis, "Global Energy Giant RWE Halts Offshore Wind Because of Trump," Electrek, April 25, 2025, https://electrek.co/2025/04/25/global-energy-giant-rwe-halts-us-offshore-wind-because-of-trump, (Accessed July 8, 2025).

65 "Equinor Suspends Offshore Construction Activities for the Empire Wind Project," Equinor, April 17, 2025, https://www.equinor.com/news/20250417-suspends-offshore-construction-activities-empire-wind, (Accessed July 8, 2025).

in May guarantees the completion of Empire Wind, it has not eliminated uncertainty for other projects and companies. In July, Ocean Winds, a joint venture between Spain's EDP Renewables and France's ENGIE, and America's Avangrid announced that they were suspending their projects in Massachusetts and Rhode Island, which were planned to have a total installed capacity of 2 GW, due to President Trump's opposition to wind energy. In a statement by the CEO of Ocean Winds, it was stated that although the winning bidders were determined in September 2024, contract negotiations have been postponed four times and permission is awaited through a new presidential memorandum for the projects to be completed successfully.[66]

In the United Kingdom, the country with the second-highest installed capacity, Danish company Orsted, one of the world's leading companies in the wind energy sector, shelved a major project in May. The company, which was preparing to build one of the world's largest offshore wind farms with a license granted by the UK Department for Energy Security in 2023, had reached an agreement to implement the fourth phase of the Hornsea site. In a statement, the company cited the deteriorating global economy, which has created uncertainty in the supply chain and an unsafe environment for investments. The implementation of the project would be reconsidered in the future.[67]

Equinor also announced its decision to withdraw from a project in Australia at the beginning of July 2025. The company, which withdrew from a 1.5 GW project, has reportedly reduced its investments in renewable energy sources, including the Bass Offshore Wind Energy (BOWE) plant, in which it has held a majority stake since December 2022.[68]

Countries are also forming partnerships to utilize offshore wind energy in order to minimize the impact of high costs and share *know-how*. One of the first examples of this is in Europe. In 2016, nine European countries

66 Nichola Groom, "Focus: Trump Hostility to US Offshore Wind Reverberates Through Supply Chain," Reuters, February 14, 2025; Daniel Ackerman, "Offshore Wind Industry Whiplashed by Changing Trump Administration Policies," Market Place, May 28, 2025, https://www.marketplace.org/story/2025/05/28/offshore-wind-industry-whiplashed-by-changing-trump-administration-policies, (Accessed July 8, 2025).

67 "Ørsted to Discontinue the Hornsea 4 Offshore Wind Project in Its Current Form," Ørsted, May 7, 2025, https://orsted.com/en/company-announcement-list/2025/05/orsted-to-discontinue-the-hornsea-4-offshore-wind--143901911, (Accessed July 7, 2025); Justin Rowlatt, "Blow to Clean Energy Drive as Major Windfarm Ditched," BBC, May 7, 2025.

68Edward Peters, "Equinor Withdraws from Australian Offshore Wind Project in Major Blow," 4C Offshore, July 4, 2025, https://www.4coffshore.com/news/equinor-withdraws-from-australian-offshore-wind-project-in-major-blow-nid31429.html, (Accessed July 4, 2025).

and the European Commission came together to establish the North Seas Energy Cooperation. With the Commission, Germany, Belgium, the UK, Denmark, France, the Netherlands, Ireland, Luxembourg, and Norway as members, the partnership aims to increase the countries' utilization of renewable energy potential in the North Seas.

The cooperation also covering offshore wind energy is planned to support and facilitate grid development in the North Sea, including the Irish and Celtic Seas, and the development of the region's significant renewable energy potential, in line with the European Green Deal. Since then, various studies have been conducted to realize the potential in the region, and in 2022, nine countries came together and signed a declaration. Accordingly, it is planned to reach at least 76 GW of offshore wind energy installed capacity in the region by 2030, at least 193 GW by 2040, and at least 260 GW by 2050. This project, seen as part of the EU's goal to achieve at least 300 GW of offshore wind energy capacity by 2050 for its Net Zero Emissions target, is expected to reach 85 percent of the target.[69] Finally, in October 2024, the parties came together and reached an agreement on the areas to be put out to tender. It is also planned to produce green hydrogen in the future from these areas with a facility having minimum installed capacity of 250 MW.[70]

In 2017, Denmark, the Netherlands, and Germany launched a collaboration to realize the offshore wind energy potential of the North Sea. The North Sea Wind Power Hub Program was established with an agreement signed between system operators from the three countries. According to the studies conducted, the 30 GW potential is planned to be realized in the first phase with centers with 10 GW and in the second phase with centers with 15 GW of installed capacity. Feasibility studies for the project began in 2020, and construction was planned to start in 2025[71], but as of August 2025, this plan has not yet been implemented.

69 "The North Seas Energy Cooperation," European Commission, (October 2024), https://energy.ec.europa.eu/topics/infrastructure/high-level-groups/north-seas-energy-cooperation_en, (Accessed July 8, 2025).

70 "NSEC Tender Planning-October 2024", North Seas Energy Cooperation, (October 2024), https://energy.ec.europa.eu/topics/infrastructure/high-level-groups/north-seas-energy-cooperation_en, (Accessed: July 8, 2025).

71 "Accelerating Deployment of Large-scale Offshore Wind Power", IEA, November 17, 2020, https://www.iea.org/articles/accelerating-deployment-of-large-scale-offshore-wind-power, (Accessed: July 8, 2025); "Approach of the Consortium", North Sea Wind Power Hub Programme, https://northseawindpowerhub.eu/approach-of-the-consortium, (Accessed: July 8, 2025).

OFFSHORE WIND ENERGY STUDIES IN TÜRKİYE

Wind energy has been one of the areas of particular importance among Türkiye's renewable energy sources in recent years. Over the past twenty years, installed capacity based on renewable energies has made significant progress thanks to the increase in onshore wind energy capacity alongside solar energy. Onshore wind energy installed capacity, which was only 19 MW in 2002, reached 13,792 MW by the end of 2024. With this capacity, Türkiye has become the 6th country in Europe with the highest onshore wind installed capacity.[72] During this process, Türkiye's total renewable installed capacity has also increased from 12,291 MW to 72,288 MW, placing it 5th among European countries.[73] According to data from the Turkish Electricity Transmission Corporation (TEİAŞ), as of June 2025, the installed capacity based on onshore wind energy, which is 13,391 MW, constitutes 18.5

72 "Renewable Capacity Statistics 2025".

73 Compiled from TEİAŞ "Power Plant Capacity Reports" and IRENA "Renewable Energy Statistics 2023" data.

percent of the total installed capacity based on renewable energy sources, which is 72,288 MW.

Over the past twenty years, efforts in the field of wind energy have not been limited to the construction of power plants; investments have also been made in the wind energy industry. The Renewable Energy Support Mechanism (YEKDEM) Law, enacted in 2005, provided electricity purchase guarantees to power plants generating electricity from renewable sources, while also making additional payments to power plants that used domestic equipment during construction, which was one of the most important steps taken in this regard. As of 2017, the establishment of large-scale power plants using renewable sources has been ensured through Renewable Energy Resource Areas (YEKA) tenders, while the requirement to establish factories that will produce in the fields of wind and solar energy has enabled Türkiye to make significant progress in the renewable energy industry. As a result, Türkiye is now able to produce and export many components, primarily wind turbine towers, rotor blades, and generators.[74] However, similar to the global situation, all wind energy projects in Türkiye have been carried out on land, and no offshore wind power plants have been built yet.

In 2018, the Ministry of Energy and Natural Resources held a YEKA tender for the construction of offshore wind energy plants with a total capacity of 1.2 GW. At that time, the project, planned to be Türkiye's first and the world's largest offshore wind energy plant, identified the open waters of Saros (Edirne-Enez, Keşan), Gelibolu-Şarköy (Çanakkale-Tekirdağ), and Kıyıköy (Kırklareli-Vize) as candidate areas. Like other YEKA tenders, it was expected that at least 60 percent of the components used in the power plants would be locally sourced and that 80 percent of the technical personnel would be Turkish. In addition, the project required the use of wind turbines with a minimum capacity of 6 MW each and commissioning within 60 months, with the application deadline set for October of the same year.[75] However, the lack of on-site measurement data for the areas where the turbines were to be installed prevented participation in the tender.[76]

74 Firdevs Yüksel, "Türkiye's Wind Energy Installed Capacity Reached 13,391 Megawatts in May," Anadolu Agency Energy Terminal, June 15, 2025.

75 "Türk karasularında 2-3 milyar dolarlık rüzgar santrali", *Dünya*, June 22, 2018.

76 "Paydaş Etkileşim Planı (PEP) – Avrupa Birliği Katılım Öncesi Mali Yardım Aracı (IPA) 2019 Enerji Sektör Programı -FAZ4 Projesi (P179235)," Republic of Türkiye Ministry of Energy and Natural Resources, (February 2023), https://enerji.gov.tr/Media/Dizin/BHIM/tr/Duyurular//IPA_2019_SEP_PDF_TR_202303081115.pdf (Accessed August 29, 2023).

A year after the tender, the World Bank, one of the institutions working to increase the use of renewable energy sources worldwide, published a report on the development of offshore wind energy in developing countries. Türkiye was included in the report as one of eight countries, along with Brazil, India, and South Africa. According to the report, the most suitable areas for offshore wind energy in Türkiye are located on the northwestern coast of the Aegean Sea. In this area, wind speeds can reach up to 9 m/s, and the potential is stated to be 6 GW for fixed turbines and 19 GW for floating turbines. While there are areas along the Marmara and Black Sea coasts where wind speeds vary between 7-8 m/s, it is stated that there are some promising areas in both the south and north of our country. In total, there is a potential of 12 GW for areas with depths up to 50 meters along all coasts and 57 GW for areas with depths up to 1,000 meters. On the other hand, port areas in the Aegean and Black Seas and the heavy ship traffic in the Marmara Sea must be taken into account. More importantly, it is anticipated that the fact that territorial waters in the Aegean are limited to 6 nautical miles, the exclusive economic zone (EEZ) boundaries have not been determined, and the presence of large and small islands may pose obstacles to the utilization of this potential.[77]

Türkiye's accession to the Paris Climate Agreement on November 10, 2021, and its Net Zero Emissions target for 2053 is one of the most concrete steps taken to accelerate efforts in the field of renewable energy. Since reducing greenhouse gas emissions in the energy sector, which constitutes the largest component of greenhouse gas emissions, is directly related to increasing the share of renewable sources in installed capacity, the aim is to increase investments in this area. The Türkiye National Energy Plan, shared with the public by the Ministry of Energy and Natural Resources in January 2023, is also important in that it includes targets to be achieved by 2035 on the path to carbon neutrality. The plan forecasts that the installed wind energy capacity, which was 11.4 GW in 2022, will be increased to 29.6 GW by the end of 2035, with onshore wind energy reaching an installed capacity of 24.6 GW and offshore wind energy reaching 5 GW.[78]

77 "Going Global – Expanding Offshore Wind to Emerging Markets", World Bank Group, (October 2019), https://documents1.worldbank.org/curated/en/716891572457609829/pdf/Going-Global-Expanding-Offshore-Wind-To-Emerging-Markets.pdf (Accessed: September 1, 2023).

78 "Türkiye Ulusal Enerji Planı," Ministry of Energy and Natural Resources of the Republic of Türkiye, (2022), https://enerji.gov.tr/Media/Dizin/EIGM/tr/Raporlar/TUEP/Türkiye_Ulusal_Enerji_Planı.pdf, (Accessed: September 4, 2025).

Following the plan, the YEKDEM tariffs updated on May 1 began to address wind energy power plants in two separate categories, onshore and offshore, in terms of the contribution shares and periods paid according to the energy source.[79] The YEKDEM support mechanism application price is 106 TL/kWh (kilowatt hour) for onshore wind and 144 TL/kWh for offshore wind. Similar to other power plants, support is planned for 10 years for electricity production and 5 years for domestic equipment (Table 3).

TABLE 3. SUPPORT MECHANISM FOR TYPES OF RENEWABLE ENERGY SOURCE-BASED PRODUCTION FACILITIES ( ) (MAY 1, 2023)

Renewable Energy Source-Based Production Facility Type		YEKDEM Application Price (TL Kuruş/ kWh)	YEKDEM Price Application Period (Years)	YEKDEM Base Price (USD Cents/ kWh)	YEKDEM Ceiling Price (USD Cent/ kWh)	Domestic Contribution Price (TL Kuruş/ kWh)	Domestic Contribution Price Application Period (Years)
Hydroelectric Power Plant	Reservoir-Based	144.00	10	6.75	8.25	28.80	5
	River Type	135.00	10	6.30	7.70	28.80	5
Wind Energy-Based Production Facility	Onshore	106.00	10	4.95	6.05	28.80	5
	Offshore	144.00	10	6.75	8.25	38.45	5
Geothermal Energy-Based Production Facility		202.00	15	9.45	11.55	28.80	5
Biomass-Based Production Facility	Landfill Gas/ Waste Tires*	106.00	10	4.95	6.05	28.80	5
	Biomethanization	173.00	10	8.10	9.90	28.80	5
	Thermal Disposal	134.90	10	5.75	8.00	21.58	5
Solar Energy-Based Production Facility		106.00	10	4.95	6.05	28.80	5
Wind/Solar Integrated Electricity Storage Facility		125.00	10	5.85	7.15	38.45	10
Pumped Storage Hydroelectric Power Plant		202.00	15	9.45	11.55	38.45	10
Wave or Tidal Energy-Based Production Facility		135.00	10	6.30	7.70	38.45	10

Source: *Official Gazette*, May 1, 2023, Issue No. 32177.
* Resources obtained from by-products resulting from the processing of landfill gas and waste tires.

79 Abdullah Paçal, "Türkiye denizüstü rüzgar enerjisinde yeni bir döneme giriyor," Petrotürk, July 9, 2025, https://www.petroturk.com/yenilenebilir-enerji-haberleri/turkiye-deniz-ustu-ruzgar-enerjisinde-yeni-bir-doneme-giriyor, (Accessed on July 21, 2025).

Also in May 2023, joint work began between the Ministry of Energy and Natural Resources and the World Bank in the field of offshore wind energy. The Ministry has begun receiving consultancy services to increase the investment potential of offshore wind energy under the EU's pre-accession obligations program for the energy sector within the World Bank. Under the agreement signed between the EU and the World Bank, it was decided to provide a grant of €12,826,000 to Türkiye to develop and expand its renewable energy sources and integrate the fight against climate change into the energy sector. The project to support offshore wind energy, with the support of the World Bank, aims to reduce risk and develop institutional capacity in selected areas in Türkiye. Preliminary feasibility studies are planned to be carried out to inform investors about a possible auction-based tender. In this context, geological and geotechnical studies, as well as meteorological and oceanographic[80] measurements and techno-economic assessments, are expected to be completed by March 2027.[81]

Following the National Energy Action Plan, in February 2024, the Ministry of Energy and Natural Resources decided to conduct studies on Türkiye's offshore wind energy potential and obtain concrete data through on-site assessments. As a project supported within the EU accession process, the aim is to conduct geological and geotechnical measurements, meteorological and oceanographic analyses and measurements, economic and financial pre-feasibility studies, and environmental and social constraint analyses to determine the offshore wind energy potential in designated areas of the Marmara Sea. The findings obtained will be used to clearly identify areas suitable for the construction of offshore wind energy plants and to encourage participants to invest with confidence prior to a new tender.[82] As a result of the decisions taken and the studies conducted, suitable areas for offshore wind energy plants were identified, and on August 4, the Ministry shared

80 An interdisciplinary measurement that reveals the scope, content, and characteristics of seas and oceans from geological, chemical, physical, and biological perspectives. For more information, see "What is Oceanography?", Osinografi.com, https://osinografi.com/osinografi/osinografi-nedir, (Accessed: July 28, 2025).

81 "Restructuring Paper on a Proposed Project Restructuring of Türkiye-EU IPA Energy Sector Program Phase Project–Offshore Wind Support," The World Bank, May 25, 2023, https://documents1.worldbank.org/curated/en/099071624015012140/pdf/P179235112204d0fc1b3871ae4994cef393.pdf, (Accessed: July 11, 2025).

82 "Paydaş Etkileşim Planı (PEP) – Avrupa Birliği Katılım Öncesi Mali Yardım Aracı (IPA) 2019 Enerji Sektör Programı -FAZ4 Projesi (P179235),".

the candidate YEKA areas with the public. The identified areas are located in Bandırma, Bozcaada, Gelibolu, and Karabiga.[83]

In February 2025, the World Bank published a report specifically on Türkiye's offshore wind energy potential. The report, titled "Türkiye Offshore Wind Energy Roadmap," provides a comprehensive assessment on this subject. According to the report, Türkiye's offshore wind speeds have been measured as moderate to low under current technological conditions. The highest wind speeds, measured at 8.0-9.5 m/s, are found along the Aegean coast and in the Marmara Sea. While winds in the Black Sea region have a high consistency rate, they lag behind in terms of speed, averaging 7-7.5 m/s. Finally, Mediterranean coast is not economically suitable for power plant construction.

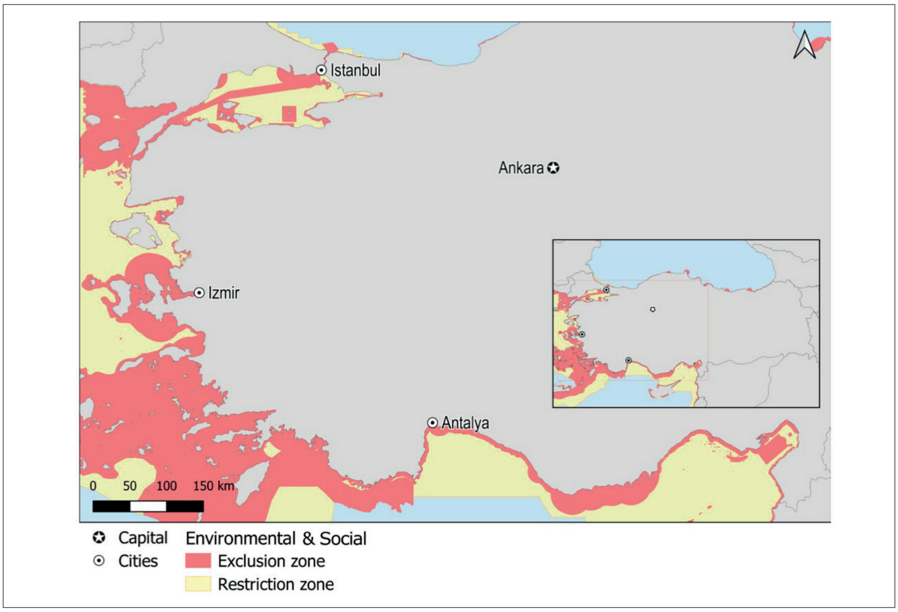
Areas with depths of up to 50 meters are available for the installation of wind turbines anchored to the seabed along the Aegean, Marmara Sea, and Black Sea coasts. However, when assessing the suitability of these areas, considering maritime traffic, port areas, navigation safety, the presence of islets and rocks, as well as areas with very high environmental and social sensitivity, it is seen that prohibited areas cover a large area[84] and that promising locations are decreasing (Map 1).[85]

83 "Offshore Candidate YEKA Announcement," Republic of Türkiye Ministry of Energy and Natural Resources, August 4, 2023, https://enerji.gov.tr/duyuru-detay?id=20382, (Accessed: July 10, 2025).

84 Prohibited areas are primarily military zones and areas with social and technical constraints, such as shipping routes registered by the International Maritime Organization, as well as protected areas and areas of international recognition in terms of biological diversity, such as feeding and nesting areas for sea turtles and habitats for Mediterranean monk seals. For more information, see "Türkiye's Offshore Wind Energy Roadmap."

85 "Offshore Wind Roadmap for Turkiye", World Bank, (February 2025), https://documents.worldbank.org/en/publication/documents-reports/documentdetail/099022625113027269, (Accessed: July 10, 2025).

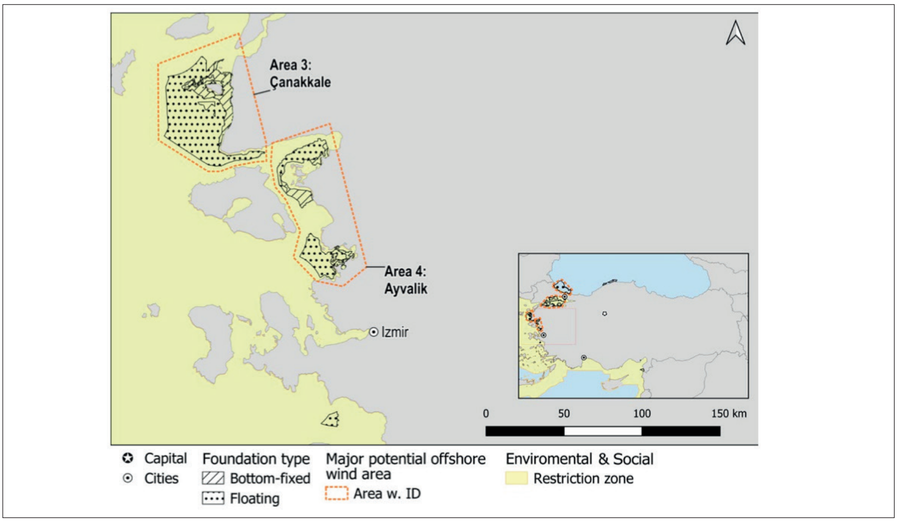
MAP 1. ENVIRONMENTAL, SOCIAL, AND TECHNICAL EXCLUSION AND RESTRICTION ZONES IN TÜRKİYE



Source: "Türkiye Offshore Wind Energy Roadmap".

According to the report, when restricted areas and regions with social and environmental constraints are excluded from the equation, the suitable areas for seabed-fixed wind turbines become quite limited. There are no areas with a depth of less than 50 meters, a wind speed of more than 7 m/s, no constraints, and all three of these characteristics for power plants consisting of seabed-fixed wind turbines. When prohibited areas, that are unsuitable from a social and environmental perspective, with low wind speeds, and with excessive depths are excluded, suitable areas for fixed and floating power plants anchored to the seabed in the Aegean and Marmara Seas are limited (Maps 2 and 3).

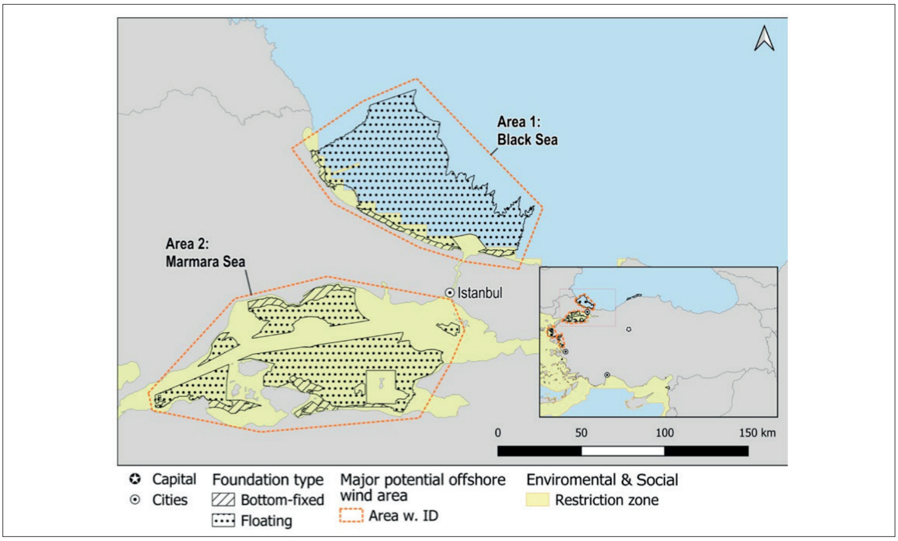
MAP 2. POTENTIAL AREAS FOR FLOATING AND FIXED-FOUNDATION OFFSHORE WIND ENERGY PROJECTS IN THE AEGEAN SEA



Source: "Türkiye Offshore Wind Energy Roadmap".

After all these assessments, there has been a decline in the potential amounts given in the previous report. Therefore, it is anticipated that these areas will require detailed evaluation before being designed.

MAP 3. POTENTIAL AREAS FOR FLOATING AND FIXED-FOUNDATION OFFSHORE WIND ENERGY PROJECTS IN THE MARMARA SEA AND BLACK SEA



Source: "Türkiye Offshore Wind Energy Roadmap".

When the technical potential of the areas shown in Maps 2 and 3 is calculated based on the most commonly used technology today, the results show 6.8 GW for fixed-bottom offshore wind turbines and 59.7 GW for floating offshore wind turbines (Table 4).

TABLE 4. CHARACTERISTICS OF IMPORTANT OFFSHORE WIND ENERGY AREAS IN TÜRKİYE

	Fixed DRES* Potential		Floating DRES Potential		Wind Speed
	Square Kilometers	GW	Square Kilometer	GW	m/s
Black Sea	290	1.3	5,530	24.9	7.0-7.5
Marmara Sea	610	2.7	4,330	19.5	7.0-8.5
Çanakkale	380	1.7	1,660	7.5	8.5-10.0
Ayvalık	230	1.0	610	2.7	7.0-9.5
Small Areas	-	-	1,140	5.1	7.0-8.5
TOTAL	1,510	6.8	13,270	59.7	

Source: "Türkiye Offshore Wind Energy Roadmap".
* Offshore wind energy

These values are lower than those stated in the previous report by the World Bank. It should also be noted that, even considering the technical potential and taking all the aforementioned constraints into account, there is a high probability that potential projects will not be fully realized.[86] On the other hand, it should be emphasized that the potential could increase if technological improvements lead to the production of more efficient turbines capable of generating electricity at lower wind speeds.

Within the scope of studies conducted in collaboration with the World Bank, on-site wind measurement studies began in the Sea of Marmara in March 2025. Although the potential is higher in the Aegean Sea, the Marmara Sea has been prioritized due to the region being considered more risky, given constraints such as the narrowness of the territorial waters, the absence of an Exclusive Economic Zone (EEZ), and occasional disputes with Greece. The measurements, planned to be completed by March 2027, aim to increase the region's investment attraction potential.[87]

86 The calculation is based on a wind turbine generator density of 4.5 MW/square kilometer.

87 "Tü rkey - EU IPA Energy Sector Program Phase IV Project - Offshore Wind Support," The World Bank Group, June 27, 2025, https://documents1.worldbank.org/curated/en/099062725101056563/pdf/P179235-5b2c8c33-9a35-417b-8344-bbcb187337e7.pdf, (Accessed: July 10, 2025); Duygu Alhan, "Türkiye Rolls Up Its Sleeves to Turn Offshore Wind Energy Potential in the Marmara Sea into Investment," Anadolu Agency Energy Terminal, November 8, 2024.

With the update to the YEKDEM tariffs on July 1, 2025, there has been another change in the prices of electricity generated from renewable sources. The price set for electricity to be generated from offshore wind energy, along with other sources, has also been changed. Accordingly, the YEKDEM application price, which was 144 TL/kWh on May 1, 2023, has been increased to 305.40 TL/kWh. The support given for the use of domestic components has also been updated to 81.52 TL/kWh, up from 38.45 TL/kWh, as the highest price given.

TABLE 5. SUPPORT MECHANISM FOR PRODUCTION FACILITY TYPES BASED ON RENEWABLE ENERGY SOURCES (JULY 1, 2025)

Renewable Energy Source-Based Production Facility Type		YEKDEM Application Price (TL kuruş/kWh)	YEKDEM Domestic Contribution Price (TL kuruş/kWh)
Hydroelectric Production Facility	Reservoir-type	305.40	61.09
	River-Type	286.30	61.09
Wind Energy-Based Production Facility	Onshore	224.80	61.09
	Offshore	305.40	81.52
Geothermal Energy-Based Production Facility		428.44	61.09
Bio-based Production Facility	Landfill Gas/Waste Tires	224.80	61.09
	Biomethanation	366.90	61.09
	Thermal Disposal	286.12	45.76
Solar Energy-Based Production Facility		224.80	61.09
Wind/Solar Integrated Electricity Storage Facility		265.11	81.52
Pumped Storage Hydroelectric Power Plant		428.44	81.52
Wave or Tidal Energy-Based Power Plant		286.30	81.52

Source: EPİAŞ

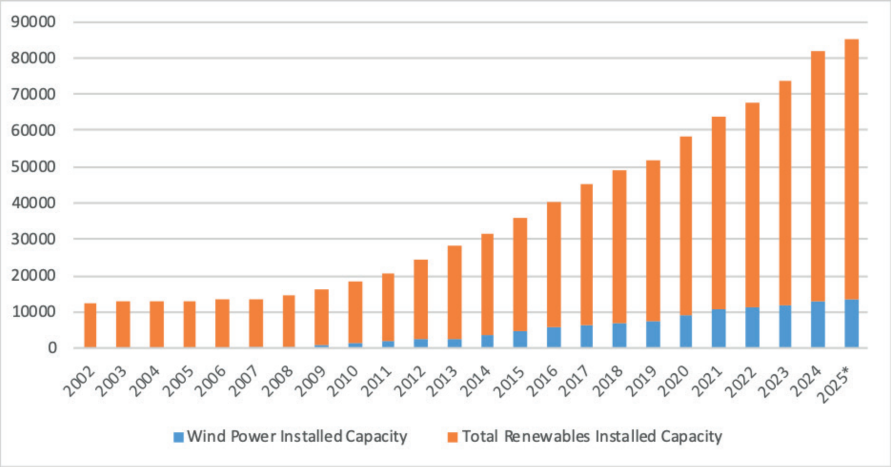
Although Türkiye does not yet have an offshore wind farm, it has the capacity to build ships that will lay the transmission lines necessary to connect the power plants to the grid. South Korea-based LS Marine Solution signed an agreement with Yalova-based Tersan Shipyard on June 30 to build Asia's largest ship in this field.[88] The agreement clearly demonstrates Türkiye's export potential for the future, as the ship will be specially developed to serve only in this field.

88 Erward Peters, "Asia's Largest Cable-Laying Vessel to Be Built at Turkish Shipyard," 4C Offshore, June 30, 2025, https://www.4coffshore.com/news/27asia27s-largest27-cable-laying-vessel-to-be-built-at-turkish-shipyard-nid31396.html, (Accessed July 8, 2025).

Opportunities and Risks

Türkiye has made significant progress in the field of renewable energy sources over the two and a half decades. As one of the first sources to meet the growing demand for energy, renewable energy sources have increased in both installed capacity and industrial production. The first investment in wind energy was made in 1986 with a turbine installed in the Çeşme district of İzmir, and the country's first wind power plant was also commissioned in Çeşme in 1998 with an installed capacity of 1.5 MW. In 2002, the installed capacity based on wind energy was 19 MW, accounting for 0.15 percent of the total renewable energy installed capacity of 12,291 MW. Subsequently, the installed capacity of wind energy rose to 2,261 MW in 2012, the installed wind energy capacity rose to 2,261 MW, accounting for 10.2 percent of the total renewable installed capacity of 22,180 MW. In 2022, the installed capacity of 11,396 MW will account for 20.4 percent of the total renewable installed capacity of 56,006 MW. According to the latest data from the Energy Market Regulatory Authority (EMRA), in April 2025, wind energy-based installed capacity in Türkiye reached 13,250 MW, accounting for 18.5 percent of the total renewable energy-based installed capacity of 71,583 MW.

GRAPH 2. DEVELOPMENT OF WIND ENERGY-BASED AND TOTAL RENEWABLES INSTALLED CAPACITY IN TÜRKİYE (2002-2025, MW)



Source: EPDK
*Up to April 2025

The increase in installed capacity has been accompanied by industrial development thanks to the policies implemented. With industrial investments mainly in the Aegean Region, Türkiye has become one of the major centers in Europe to produce wind turbine equipment. The wind energy industry in Türkiye has become capable of easing the domestic market in terms of both employment and equipment supply. In addition to contributing to the reduction of imports in this field, exporting manufacturers can also make a positive contribution to the foreign trade balance.

With this knowledge base and installed capacity, Türkiye can also show significant development in the field of offshore wind energy. The industry, which has gained significant experience in onshore wind energy, can be adapted to the field of offshore wind energy. In such a case, Türkiye can reinforce its importance as one of the production centers in the region. However, there are some points to consider for this:

- First, it is crucial to clearly define the legal and institutional framework. Frequently changing regulations in energy markets—especially the electricity market—can be perceived as risky and discouraging for investors. Transparent and predictable legal regulations and clear legal frameworks will reduce uncertainty and encourage investors.
- It is a fact that offshore wind energy plants still require high financing compared to many other renewable energy technologies. Therefore, it is extremely important for countries such as Türkiye, which do not yet have a plant in this field, to have their plant projects supported by the state. *Feed-in tariffs,* which have played a critical role in creating high renewable installed capacity in countries such as Germany and Spain, have also been effective in increasing renewable installed capacity in Türkiye through their implementation under the YEKDEM and YEKA regulations. In the YEKA processes to be organized for offshore wind power plants, the feed-in tariff amount can be set higher for the first few power plant projects to be implemented, thereby reducing the risk for investors.
- In addition to purchase guarantees, other incentive mechanisms can also be evaluated on a national scale in Türkiye. Tax credits or tax deductions – like feed-in tariffs – are one of the most frequently used

support methods. Reducing the tax liability of legal entities implementing offshore wind energy projects is an incentive for investment by reducing the tax debt owed to the state.

- By having the state carry out processes such as preliminary feasibility studies, environmental impact assessments, wind measurements, and ground assessments—as in the case of the Netherlands—in areas identified as having high potential for power plant construction, both the implementation process of the investment can be shortened and confidence for the investor can be increased.
- Similar to the Environmental Agency established in Türkiye within the Ministry of Environment, Urbanization, and Climate Change to prevent environmental pollution and facilitate the circular economy process, a Renewable Energy Agency could be established to increase the share of renewable energy sources in both industry and installed capacity, as in the case of Denmark. By streamlining processes related to offshore wind energy plants through a *one-stop-shop* approach within the agency, the investment process could be shortened and the investment environment made more secure.
- Türkiye's knowledge base on onshore wind energy is an advantage for offshore wind energy technologies. Manufacturers of turbine components such as towers, generators, and rotors, which are concentrated in the Aegean Region, can adapt to the offshore wind energy industry more quickly and safely with state support. Encouraged producers can invest more easily with less risk thanks to the investment security provided.
- The Ministry is considering reorganizing the permit process, which has been on its agenda for some time and is completed in a shorter time compared to the average in European countries. With the implementation of the "super permit" regulation, the permit process is planned to be shortened even further. This would provide an environment that poses less risk in terms of return expectations for investors and generates faster profits.
- Finally, one of the most crucial issues for all countries, including Türkiye, today is making the electricity infrastructure more resilient. To-

day, adverse weather conditions such as irregular rainfall, storms, and extreme heat caused by climate change, as well as natural disasters such as earthquakes and cyberattacks, pose a direct threat to energy supply and, consequently, national security.[89] All countries should focus on increasing the security of their entire infrastructure, including electricity generation, transmission and distribution lines, transformers, and networks, as well as increasing their installed capacity by investing in renewable sources such as offshore wind energy. For countries such as Türkiye, which are exposed to crisis regions and geopolitical risks due to their location, the sustainable supply of electricity is as critical an issue as the sustainability of production.

89 According to research, cyberattacks on the electricity sector have doubled between 2020 and 2022 alone. See "Cybersecurity in the Power Sector," Eurelectric, February 21, 2025, https://www.eurelectric.org/in-detail/cybersecurity-in-the-power-sector, (Accessed: July 29, 2025).

CONCLUSION

Offshore wind energy stands out as one of the areas with the highest technical potential among renewable energy sources. Thanks to the vast areas offered by oceans and seas worldwide and more consistent wind conditions, this technology is of strategic importance in terms of both high efficiency and sustainable electricity production. Globally, installed capacity is rapidly increasing, led by countries such as China, Denmark, and the UK, while the economic benefits of this technology in terms of energy security and employment are also growing.

However, the development of this field depends not only on technological progress but also on the stability of the investment environment, the clarity of the legal framework, the length and simplicity of the permitting process, the development of local industrial capacity, and environmental sensitivities. Recently, the suspension of tender processes, postponement of investment decisions, and financial risks in some countries point to the fragility of this sector. This situation shows that not only technical potential but also governance structure is decisive.

In Türkiye, the offshore wind energy potential has not yet been translated into concrete projects. Despite significant progress in onshore wind energy, there are no operational offshore power plants yet. Nevertheless, steps such as measurement studies led by the Ministry of Energy and Natural Resources, projects developed with the World Bank, and the updating of YEKDEM support for offshore power plants clearly demonstrate a strong strategic will in this area.

The World Bank's 2025 roadmap states that Türkiye has medium-level potential along the Aegean and Marmara coasts, but also emphasizes that usable areas are limited due to factors such as maritime traffic, environmental sensitivities, and international maritime law. Therefore, it is crucial to complete preliminary feasibility studies meticulously, conduct a multidimensional analysis of socio-economic impacts, and establish mechanisms that will increase investor confidence.

Offshore wind energy represents a significant opportunity for Türkiye not only in terms of electricity generation but also in terms of technology transfer, the development of local industry, reducing external dependency, and green transformation goals. Projects to be carried out in inland seas such as the Marmara Sea can be technically feasible and allow investors to proceed with lower risk for the first step. Simplifying the legal framework, developing *one-stop-shop* mechanisms similar to those in Europe, and increasing incentives for domestic production can contribute to Türkiye gaining a competitive position in this field.

In conclusion, Türkiye should treat offshore wind energy as a strategic sector and focus on increasing its installed capacity in this area by gaining experience through pilot projects in the initial stage. Supporting this sector, which lies at the intersection of energy supply security, climate commitments, and industrialization goals, with a comprehensive and determined public policy could take Türkiye's regional energy leadership a step further.

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REPORT

HARNESSING THE SEAS: THE RISE OF OFFSHORE WIND POWER

BÜŞRA ZEYNEP ÖZDEMİR

The accelerating global energy transition requires countries to develop new strategic orientations in line with their climate change mitigation and low-carbon development objectives. At the core of this transformation lie renewable energy solutions that rely on domestic resources while minimizing environmental impacts. In this context, offshore wind energy stands out with its considerable technical potential and growing investment appeal.

This report provides a multidimensional analysis of offshore wind energy, examining the evolution of technologies, global practices, and the structural and technical dynamics encountered throughout investment processes. It further evaluates Türkiye's current position, potential resource areas, regulatory framework, and strategic roadmap, offering concrete policy recommendations for decision-makers.

Aligned with Türkiye's 2053 Net Zero Emissions target, offshore wind energy is not merely an alternative source of electricity generation; it also constitutes a critical instrument for industrial policy, regional development, and technology transfer. By presenting a comprehensive assessment of how this potential can be realized in a rational, planned, and sustainable manner, this report aims to make a strategic contribution to Türkiye's energy transition.

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