TYNDP 2024

Sea-Basin ONDP Report

TEN-E Offshore Priority Corridor: South and East Offshore Grids

January 2024

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ENTSO-E Mission Statement

Who we are

ENTSO-E, the European Network of Transmission System Operators for Electricity, is the **association for the cooperation of the European transmission system operators (TSOs)**. The **40 member TSOs**, representing 36 countries, are responsible for the **secure and coordinated operation** of Europe's electricity system, the largest interconnected electrical grid in the world. In addition to its core, historical role in technical cooperation, ENTSO-E is also the common voice of TSOs.

ENTSO-E **brings together the unique expertise of TSOs for the benefit of European citizens** by keeping the lights on, enabling the energy transition, and promoting the completion and optimal functioning of the internal electricity market, including via the fulfilment of the mandates given to ENTSO-E based on EU legislation.

Our mission

ENTSO-E and its members, as the European TSO community, fulfil a common mission: Ensuring the **security of the inter-connected power system in all time frames at pan-European level and the optimal functioning and development of the European interconnected electricity markets**, while enabling the integration of electricity generated from renewable energy sources and of emerging technologies.

Our vision

ENTSO-E plays a central role in enabling Europe to become the first **climate-neutral continent by 2050** by creating a system that is secure, sustainable and affordable, and that integrates the expected amount of renewable energy, thereby offering an essential contribution to the European Green Deal. This endeavour requires **sector integration** and close cooperation among all actors.

Europe is moving towards a sustainable, digitalised, integrated and electrified energy system with a combination of centralised and distributed resources. ENTSO-E acts to ensure that this energy system **keeps consumers at its centre** and is operated and developed with climate objectives and **social welfare** in mind.

ENTSO-E is committed to use its unique expertise and system-wide view – supported by a responsibility to maintain the system's security – to deliver a comprehensive roadmap of how a climate-neutral Europe looks.

Our values

ENTSO-E acts in **solidarity** as a community of TSOs united by a shared **responsibility**.

As the professional association of independent and neutral regulated entities acting under a clear legal mandate, ENTSO-E serves the interests of society by **optimising social welfare** in its dimensions of safety, economy, environment, and performance.

ENTSO-E is committed to working with the highest technical rigour as well as developing sustainable and **innovative responses to prepare for the future** and overcoming the challenges of keeping the power system secure in a climate-neutral Europe. In all its activities, ENTSO-E acts with transparency and in a trustworthy dialogue with legislative and regulatory decision makers and stakeholders.

Our contributions

ENTSO-E supports the cooperation among its members at European and regional levels. Over the past decades, TSOs have undertaken initiatives to increase their cooperation in network planning, operation and market integration, thereby successfully contributing to meeting EU climate and energy targets.

To carry out its **legally mandated tasks**, ENTSO-E's key responsibilities include the following:

- Development and implementation of standards, network codes, platforms and tools to ensure secure system and market operation as well as integration of renewable energy;
- Assessment of the adequacy of the system in different timeframes;
- Coordination of the planning and development of infrastructures at the European level (**Ten-Year Network Development Plans, TYNDPs**);
- Coordination of research, development and innovation activities of TSOs;
- Development of platforms to enable the transparent sharing of data with market participants.

ENTSO-E supports its members in the **implementation and monitoring** of the agreed common rules.

ENTSO-E is the common voice of European TSOs and provides expert contributions and a constructive view to energy debates to support policymakers in making informed decisions.

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This will take you to the contents page. You can click on the titles to navigate to a chapter.

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You will find a link to the glossary on each page.

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ENTSO-E ONDP interactive data visualisation platform

Questions?

Contact us as at **tyndp@entsoe.eu**

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Executive Summary

Key Messages for the Mediterranean East and Black Sea Basins

The Offshore Network Development Plan (ONDP) is a follow-up of requirements from the revised TEN-E regulation (EU-reg. 2022/869), in which ENTSO-E was identified as responsible for the planning of the offshore grid development. ENTSO-E has developed and published this first ONDP for the Mediterranean East and Black Sea Basin. In this plan, the Ministries of the involved countries have delivered expected offshore wind generation for the target years 2030, 2040 and 2050, from which ENTSO-E has developed a view on the required infrastructure needed to realise this offshore wind, including how to transport the offshore generated energy to the demand centres on shore.

According to the 2030 climate target plan, greenhouse gas emissions must be reduced by at least 55 % from 1990 levels by 2030. Consequently, the offshore wind sector aims to grow, which is why the total number of offshore connections is rapidly increasing in the European Union (EU). The EU has set ambitious objectives for renewable energy, expecting to develop at least 300 GW of offshore wind power by 2050 and at least 60 GW by 2030 to become the first carbon-neutral continent.

This report emphasises the importance of infrastructure development to accommodating the energy transition towards decarbonised electricity systems, especially Offshore Power Plants in the East Mediterranean and Black Sea basin, comprising: Italy, Greece, Croatia, Romania and Cyprus (with Member State [MS] offshore goals, and others without them: Bulgaria, Slovenia). These regions have great potential for producing offshore wind energy, which would considerably advance Europe's ambitions for renewable energy. Numerous locations for the development of offshore wind farms (OWFs) and international connections can be found throughout its diversified coastline. The price of building OWFs in the East Mediterranean and Black Sea basin varies according to local variables, water depth, and distance from the shore. OWFs and offshore grids often require sizable upfront investments for the construction of related infrastructure.

The Sea Basin includes TSOs with different challenges, different energy mixes and different sizes in terms of the whole ENTSO-E. For example, Italy has a significant role in the synchronous area of continental Europe while countries such as Croatia and Slovenia represent only a small part of the transmission grid of continental Europe.

At the moment, only Italy has installed capacities in offshore wind but the numbers are not significant regarding the total production for the Continental South East region and Sea Basin that is surrounding the region. Indeed, the targets for the 2040 and 2050 time horizons are highly ambitious compared to the current numbers of OWFs. Some countries such as Italy and Greece will lead the region in achieving its goals. It is expected that offshore wind plants will have more full load hours than comparable onshore plants and grid operation in real time in those conditions could be easier than the system with more onshore plants. In addition, environmental studies could face fewer challenges on the sea than on the land. Undoubtedly, offshore energy sector has great potential in the Sea Basin and new offshore plants can help the electricity sector to achieve the targets and goals for 2050 time horizon and to become net zero emission sector in the region and in the whole EU.

The main challenge for this Sea Basin is the establishment of maritime spatial plans (MSPs) in every country included. This is the first step, which must be followed in parallel with the implementation of MS targets in national databases and the development of plans and goals defined in the energy strategies. In addition, it is important to further investigate in more detail the applicable technologies of offshore wind. For the present, Slovenia has a valid MSP, and Italy is in the process of revising the draft version. The other countries have prepared the legal framework for the preparation and adoption of MSPs.

The next challenge that must be highlighted at this early phase is the lack of internal infrastructure for accepting higher amounts of energy produced from offshore wind power plants. This implies additional grid reinforcements and the establishment of meshed high and extra-high voltage nodes in the transmission network especially near the coast. From the current perspective, it is difficult to justify, because apart from the MS goals, in most countries there are still no interested investors with ongoing procedures for connection. This gap could be bridged by the establishment of the aforementioned MSPs.

This also highlights the importance of involving the public since in the early stages of the development of such projects and related infrastructure.

Therefore, this report, as the first ONDP for this Sea Basin, gives a strong message and invites all stakeholders to help in further development, because this basin offers enormous potential which can help most of the countries to accelerate the achievement of the goals set by the EU (defined in Strategy on offshore renewable energy).

East Mediterranean basin expects up to 27GW offshore RES until 2050

MSs have declared their offshore wind capacity requirements to meet their RES policy targets, with variations between data from ENTSO-E/TSOs and MSs in the East Mediterranean and Black Sea Basin. **The non-binding targets for the year 2030 expect total figures of 8.8 GW in the Sea Basin for 2030, 16.8 GW for 2040 and 25.9 GW for 2050. The targets defined by TSOs differ from MS targets of 0.1 GW less for the 2030 target year and 2.4 GW more both for the 2040 and 2050 target years.** Details are presented and described in Chapter 3.

Offshore RES capacities are expected to connect radially to the onshore grid

The ONDP 2024 is the first step to further developing a future offshore grid. Therefore, this first iteration of the ONDP report for the East Mediterranean and Black Sea Basins focuses on identifying possible connection configurations and assets needed to integrate the offshore RES associated with the MSs' non-binding targets. Since only Italy from those Basins already has installed capacity from Offshore RES, in this early stage of development it is assumed that the majority of projects will be connected radially to the onshore transmission grid. Therefore, it is expected that the existing grid will also require significant reinforcements to connect new offshore RES capacities.

Offshore grid RES could support hydrogen production

New OWFs offer great potential to become future production hubs for green hydrogen production at scale to meet increasing demand. However, there are still many challenges that must be investigated and addressed. To transport and distribute the energy to end-users, there is currently no dedicated hydrogen grid network similar to that of natural gas and electricity. There is the possibility to retrofit and upgrade existing gas pipelines for its transport, which can contribute to solving a key constraint. In addition, it is necessary to monitor the development of the Hydrogen Valleys in this region.

1 Introduction to the Mediterranean East and Black Sea Basins Report

On 3 June 2022, the revised TEN-E regulation (EU) 2022/869 went into force, mandating ENTSO-E with the new task of developing offshore network development plans (ONDPs) for each sea basin by 24 January 2024.

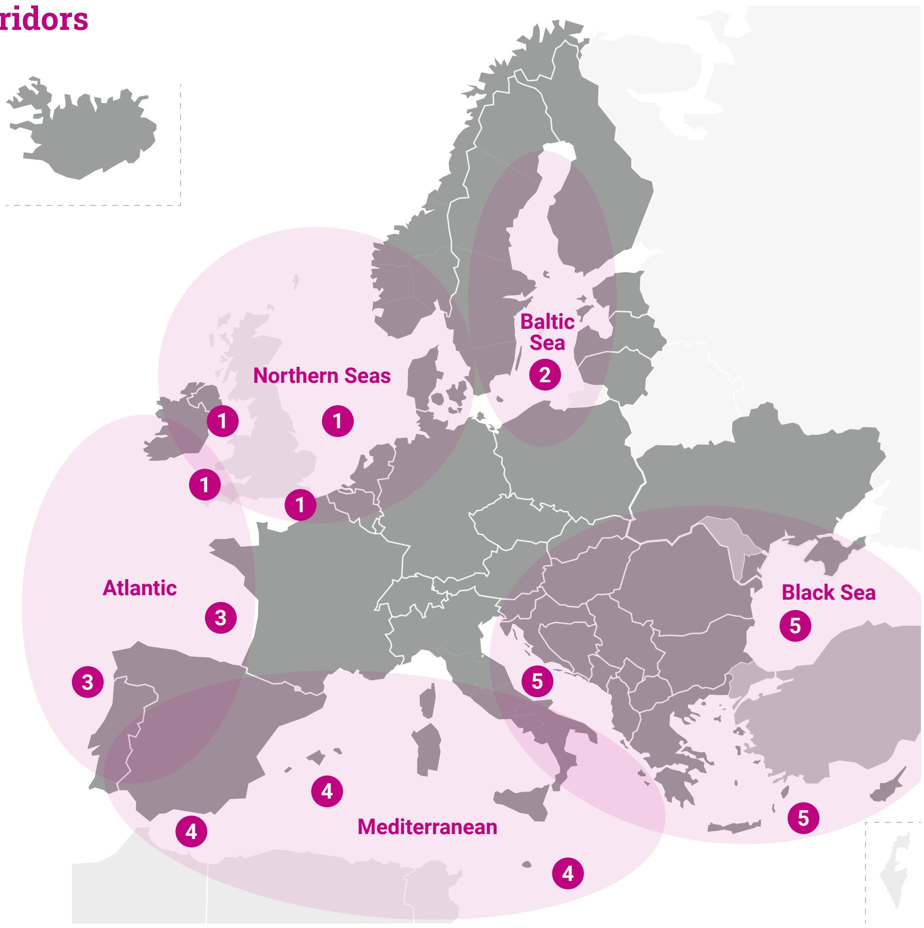
Formally, the ONDPs are a separate part of ENTSO-E's Ten-Year-Network Development Plan (TYNDP). The offshore plans must be built on the joint Member States' (MSs) non-binding agreements on joint offshore renewable energy source (RES) goals for each sea basin. On 19 January 2023, EU countries, with the support of the Commission, concluded regional non-binding agreements to cooperate on goals for offshore renewable generation to be deployed within each sea basin by 2050. These agreements include intermediate steps in 2030 and 2040.

Priority Offshore Grid Corridors

1. Northern Seas Offshore Grids (NSOG)
2. Baltic Energy Market Interconnection Plan (BEMIP offshore)
3. Atlantic Offshore Grids (AOG)
4. South and West Offshore Grids (SW offshore)
5. South and East Offshore Grids (SE offshore)

ENTSO-E Member

ENTSO-E Observer Member



TEN-E Priority Offshore Grid Corridors	Countries involved
1. NSOG	BE, DK, FR, DE, IE, LU, NL, SE
2. BEMIP offshore	DK, EE, FI, DE, LT, LV, PL, SE
3. AOG	FR, IE, PT, ES
4. SW offshore	FR, GR, IT, MT, PT, ES
5. SE offshore	BG, CY, HR, GR, IT, RO, SI

Figure 1 – TEN-E Priority Offshore Grid Corridors as laid down in Regulation (EU) 2022/869.

The ONDPs deliver a high-level outlook on potential offshore generation capacities and the resulting offshore network infrastructure needs for each sea basin:

- **Northern Seas Offshore Grids (NSOG)**, including North Sea, the Irish Sea, the Celtic Sea, the English Channel and neighbouring waters;
- **Baltic Energy Market Interconnection Plan offshore grids (BEMIP offshore)**, including the Baltic Sea and neighbouring waters;
- **South and West offshore grids (SW offshore)**, including the Mediterranean Sea, including the Cadiz Gulf, and neighbouring waters;
- **South and East offshore grids (SE offshore)**, including the Mediterranean Sea, Black Sea and neighbouring waters; and
- **Atlantic offshore grids (AOG)** including the North Atlantic Ocean waters.

More detailed information on the legal framework is provided in the Pan-European Offshore Network Transmission Needs report. Information on the methodology used to elaborate this plan can be found in the Methodology Report.

The current document comprises 9 chapters with detailed information at the regional level:

- **Chapter 2: Introduction to the Sea Basin Report**
  This chapter introduces the Sea Basin Report and discusses the background context, particularly the revised TEN-E regulation (EU) 2022/869.
- **Chapter 3: Member States' non-binding Targets**
  This chapter focuses on the analysis of MSs' non-binding targets for offshore wind capacity declared by MSs and TSOs.
- **Chapter 4: Offshore RES Capacities and Infrastructure Today**
  This chapter provides an overview of the current state of offshore wind power and high voltage direct current (HVDC) infrastructure in this Sea Basin.
- **Chapter 5: Environmental Needs – specific to Sea Basins**
  This chapter emphasises the importance of preserving landscape, tourism and environmental needs.
- **Chapter 6: Spatial Planning Needs – specific to Sea Basin**
  This chapter discusses spatial planning needs for offshore wind development in different sea basins and the importance of establishing MSPs.
- **Chapter 7: High-Level Results on Offshore Network Infrastructure Needs**
  This chapter provides high-level results related to offshore network infrastructure needs in the context of decarbonising the electricity system.
- **Chapter 8: Reflections for the Regions**
  This chapter describes the role of TSOs in the Offshore Wind integration process and reflects on possible mitigations of the current challenges faced.
- **Chapter 9: Conclusion**

2 Member States' non-binding Targets

The non-binding offshore RES targets of the amount of capacity offshore has been provided by the EU MSs to the European Commission (EC), who collected a list of non-binding target per MS and sea basin for each reference year.

Some MSs delivered a range; in these cases, as a standard approach, ENTSO-E used the upper boundary, unless more detailed information is available. This has been done to provide the full picture of a potential offshore network infrastructure.

MS Target [GW]	2030	2040	2050	ONDP Data [GW]	2030	2040	2050	Delta [GW]	2030	2040	2050
BG	0.00	0.00	0.00	BG				BG	0.00	0.00	0.00
CY	0.10	0.10	0.10	CY				CY	−0.10	−0.10	−0.10
HR	0.51	1.20	3.00	HR	0.51	1.20	3.00	HR	0.00	0.00	0.00
GR	2.70	10.00	17.30	GR	2.70	10.00	17.30	GR	0.00	0.00	0.00
IT	4.50	4.50	4.50	IT	4.50	7.00	7.00	IT	0.00	0.00	0.00
RO	1.00	1.00	1.00	RO	1.00	1.00	1.00	RO	0.00	2.50	2.50
SI	0.00	0.00	0.00	SI				SI	0.00	0.00	0.00
TOTAL	**8.81**	**16.80**	**25.9**	TOTAL	**8.71**	**19.20**	**28.30**	TOTAL	**−0.10**	**2.40**	**2.40**

Table 1 – Offshore RES generation capacities: left: upper range delivered by the MS; middle: ONDP data applied by ENTSO-E; right: difference between both.

The reasons for differences higher than 1 GW are the following:

Regarding Italy, the data for offshore generation on Italian side are derived from Terna Scenario Description Document 2022. **The developed policy scenario includes 8.5 GW of offshore wind generation, of which 4.5 GW located in the Adriatic Sea included in the East Sea Basin, to achieve the target of +70 GW of RES installed capacity at 2030 in Italy.** This challenging target is achievable considering the huge number of connection applications submitted to Terna (Figure 2) and the technological maturity of these generation sources. Most of the connection requests (more than 80 %) are concentrated in the southern Italian regions and in the main islands where the potential for offshore wind, both regarding geographical suitability and producibility, is higher.

For the East Mediterranean Sea Basin, the Italian MS target of a new 4.5 GW of offshore wind installed capacity is aligned with the Italian scenario at 2030. For the 2040 and 2050 time horizons, the flat value of 4.5 GW for the Italian MS target represents a minimum technical value, lower to the Italian scenario values at the same time horizon.

For this region and the whole EU area, the challenging goals for the reduction of CO_2 emissions until 2030 and even higher targets for 2050 will require a huge increase of the number of new RES capacities (e.g. in Italy +70 GW by 2030 compared to installed capacity in 2019 in the Fit-for-55 policy scenario). In the area of new sources, offshore wind power plants will play a greater role than before, due to their comparative advantages compared to onshore plants.

Most new capacities are expected from wind and sun, which are intermittent and non-programmable sources. Although new storages such as batteries are expected, the demand for the construction of new lines, cables and different transmission infrastructure is rising on the national level and EU level. The requests for new offshore plants in the Sea Basin are relatively small (except for Italy – Figure 2), but possible locations for new plants are already identified, as can be seen in Figure 3.

Planning effort is essential to anticipate the expected evolution of national generation as far in advance as possible. The size of the future grid needs to be set at the level that enables connection of the additional renewable capacity and safely manages power flows between production areas and load centres. Experts have to prepare a modular approach with conditional implementation according to the development of RES to respond quickly and efficiently to the various exogenous factors that may influence the energy and electricity system. Political circumstances are also a significant influential factor whereby the global situation can increase the need to fasten the whole energy transition process.

The East Mediterranean and Black Sea Basins and especially some respective parts observed from the states included in this report have relatively small distances from the coast and most (or all) of the new plants will need a cable length less than 150 km unlike the Baltic Sea and North Sea, where the distances from the coast are higher. However, the total CAPEX at the start for new infrastructure are high compared to onshore solutions. The benefits are also higher due to expected higher full load hours for offshore plants.

The targets from MS and TSOs for respective years are set at around 8 GW for 2030, 18 GW for 2040 and 27 GW for 2050. Compared to current installed capacities, the gap is huge. The MSPs for the respective countries are in the process of preparation in some cases and in revision in some cases. The targets set at an ambitious level can help to speed up the process of preparing the legislative for offshore plants on the national level, such as defining the national spatial planning process (MSPs) and the grid codes from the TSOs.

Distribution off-shore connection requests [GW]: March 2023

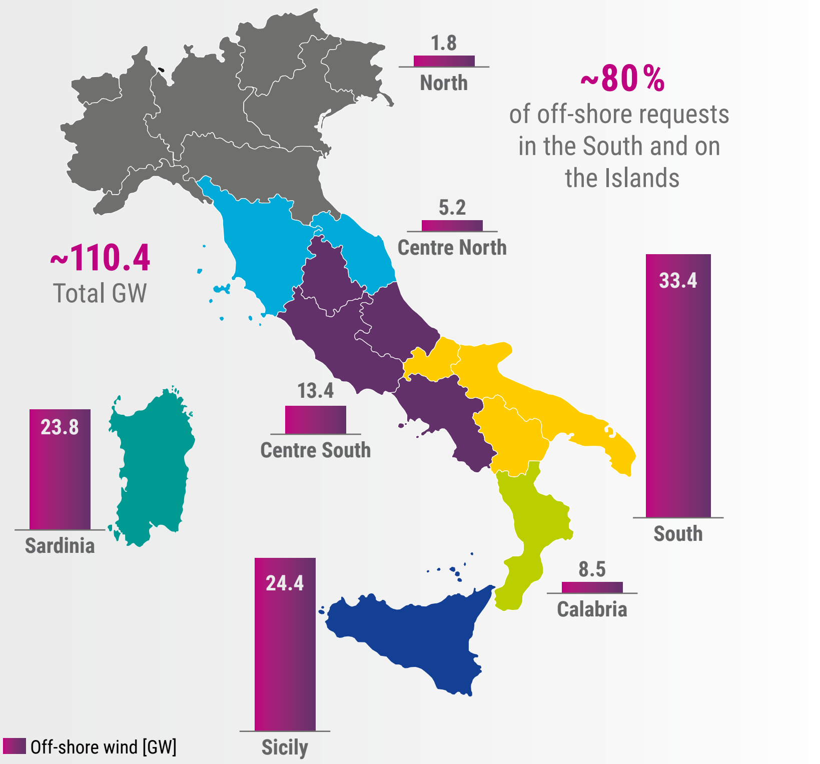


Figure 2 – Connection requests in Italy at March 2023.

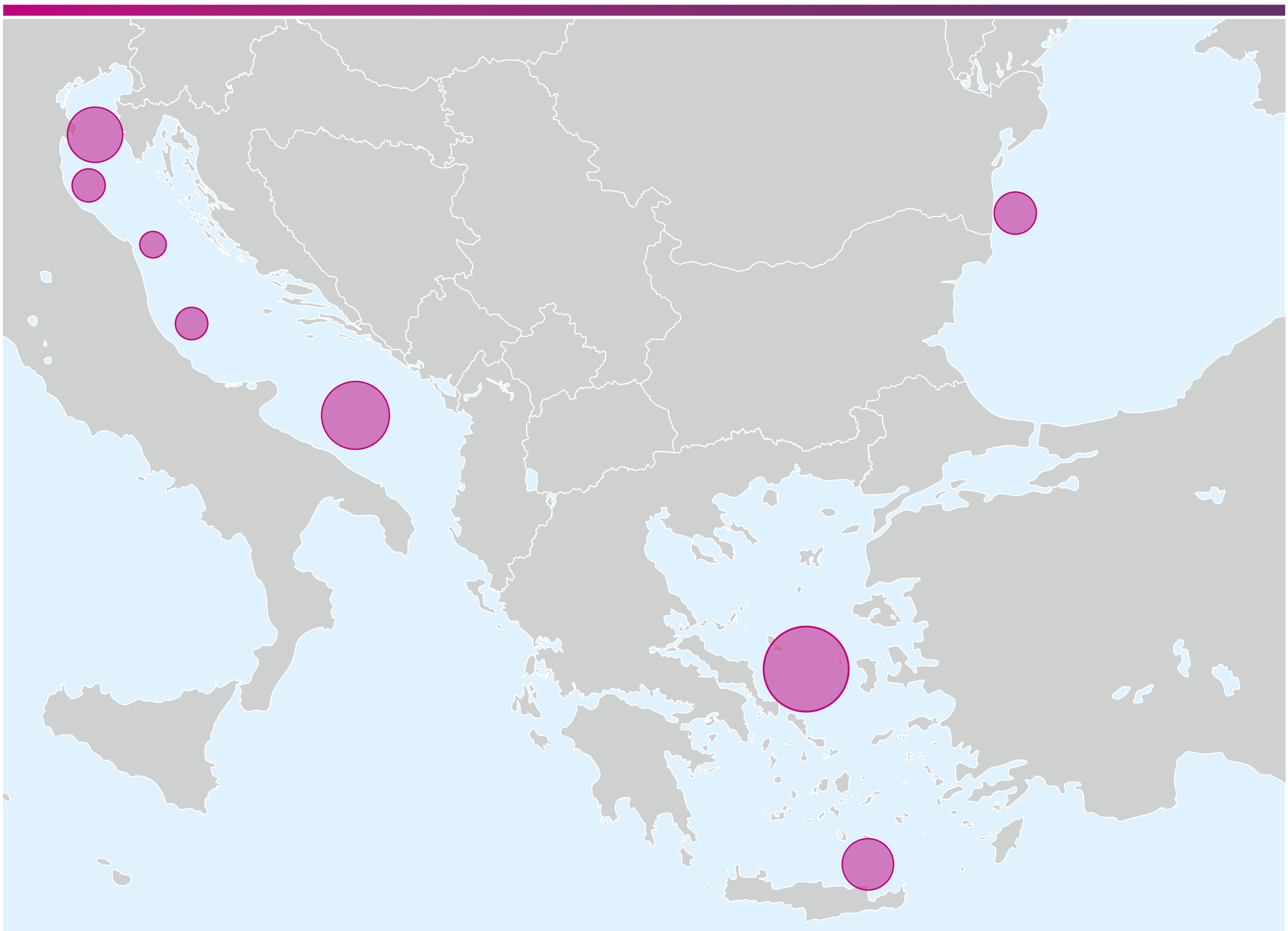


Figure 3 – Possible location of expected wind offshore power plants for 2050 in East Mediterranean and Black Sea Basin.

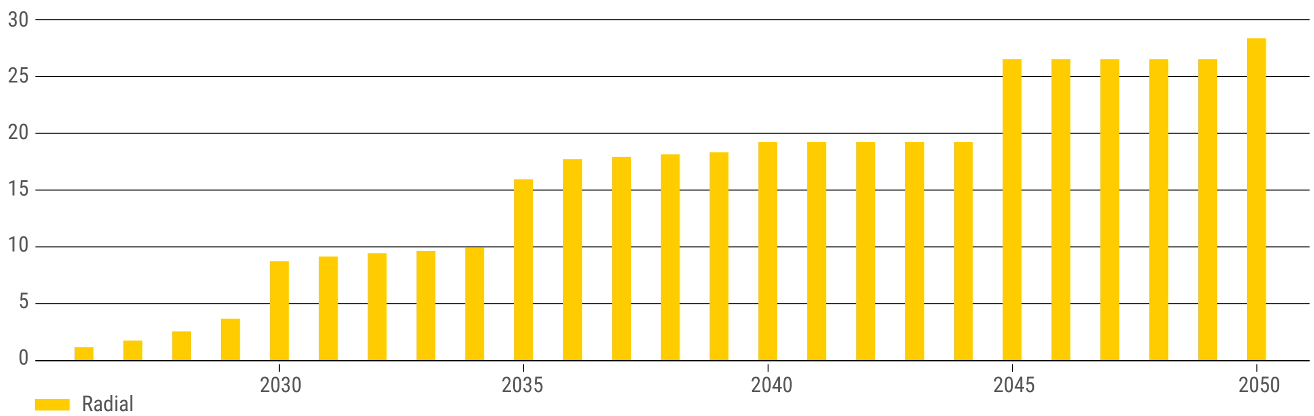


Figure 4 – Evolution of offshore targets from TSOs for East Mediterranean and Black Sea Basin [GW].

3 Offshore RES Capacities and Infrastructure Today in the South and East Offshore Grids

The current status of offshore capacities and infrastructure in the waters comprised in the South and East offshore grids is described in the paragraphs below. Details are provided for each country, regarding the capacities and infrastructure.

Croatia

Currently, Croatia does not have installed offshore RES capacities and has no connection requests for new offshore plants. The Croatian association *The Renewable Energy Sources of Croatia* has prepared a study Action Plan for Marine Renewables in Croatia where offshore development is being discussed with a brief overview of the current status of legislative, future challenges, obstacles and opportunities for this area of RES.

Greece

Currently, Greece has no installed offshore RES capacities. The existing infrastructure of the Greek transmission system and the new interconnections forecasted along with the planned internal projects included in the National Development Plan, and especially those connecting the Aegean islands to the mainland system and the strengthening of the connection of Crete, will have a significant role in connecting OWFs to the grid and transferring their production, while contributing to the achievement of the targets set for 2030 and 2050.

In November 2023, the Hellenic Hydrocarbons and Energy Resources Management Company S.A. (HEREMA S.A.), as the Planning Authority of the National Offshore Wind Farm Development Programme (NDP-OWF), announced the public consultation of the Strategic Environmental Impact Assessment (SEIA) of the draft NDP-OWF. Discussions on a national level regarding the potential areas for OWF development in addition to the allocation of the foreseen offshore capacities and their connection to the grid are on-going.

Italy

Currently, in Italy there is only one OWF application in service. The project, located in Taranto (Apulia, South of Italy) and entered into operation in May 2022, is composed of 10 turbines with a nominal power of 30 MW in total. The wind offshore power plant is anchored outside the port of Taranto, near the coast.

Even if the current status of OFW power plants in operation is limited to one case, it should be highlighted that, as anticipated in the previous chapter, Italy will face in the next years several challenges for the achievement of energy transition new climate targets, especially regarding offshore wind integration. To this aim, even though for the moment Italy has not planned yet hybrid interconnection, RES integration (including offshore one) will be granted thanks to significant developments regarding offshore and onshore grid internal/cross-border reinforcements expected in the coming years (see Chapter 7).

In this regard, it is worth noting that the Italian peninsula is an energy hub in the Mediterranean Basin, electrically connected with 7 countries (France, Switzerland, Austria, Slovenia, Montenegro, Greece, and Malta) through 26 tie lines both AC and DC technology mostly Extra High Voltage.

A substantial number of these interconnections are submarine cables laid on the seabed of the Ionian Sea and Adriatic Sea, characterised by huge depths (Figure 6).

The existing tie lines, in addition to new interconnection and internal planned projects, will be functional to the connection of OWFs application requests and the transmission of RES generation from the Southern Italy and the Main Islands to the North.

In the last three years, there has been a recent increase in connection requests for offshore wind plants in Italy. Due to limited experience in connecting and operating such plants, Terna has decided to conduct an international survey aimed at gathering information from experienced TSOs in managing offshore projects and key suppliers of wind turbines, cables, and substations, with the aim of formulating rational and coordinated connection solutions aligned with the Italian Network Code criteria and the global standards adopted for onshore renewable power systems.

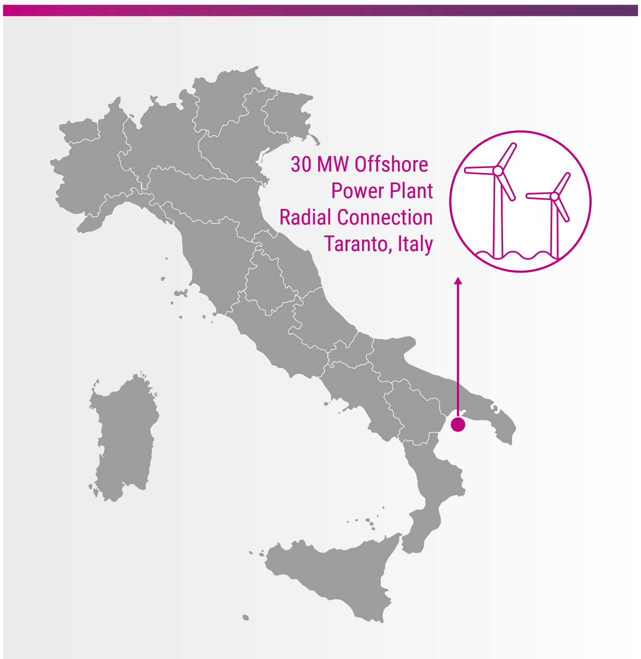


Figure 5 – Offshore Power Plant in service in Italy.

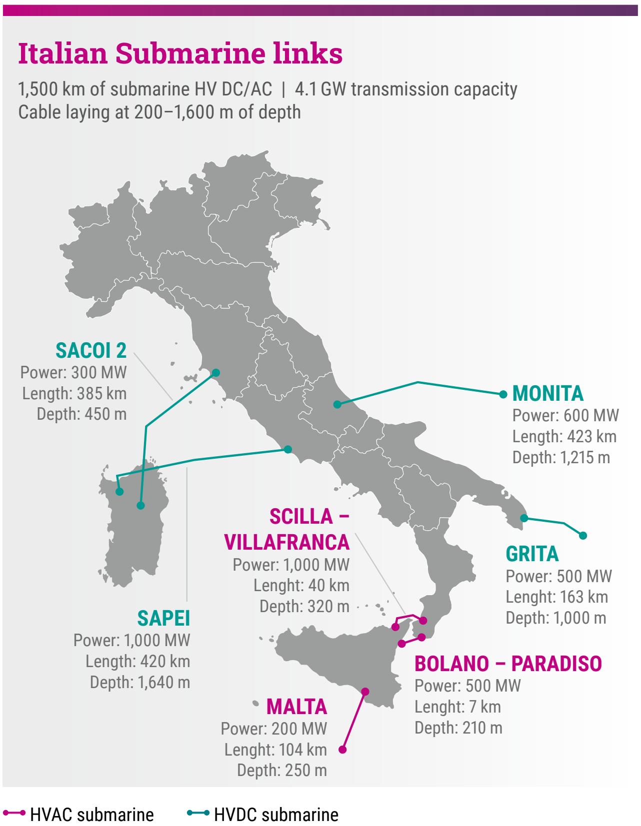


Figure 6 – Italian existing submarine cables.

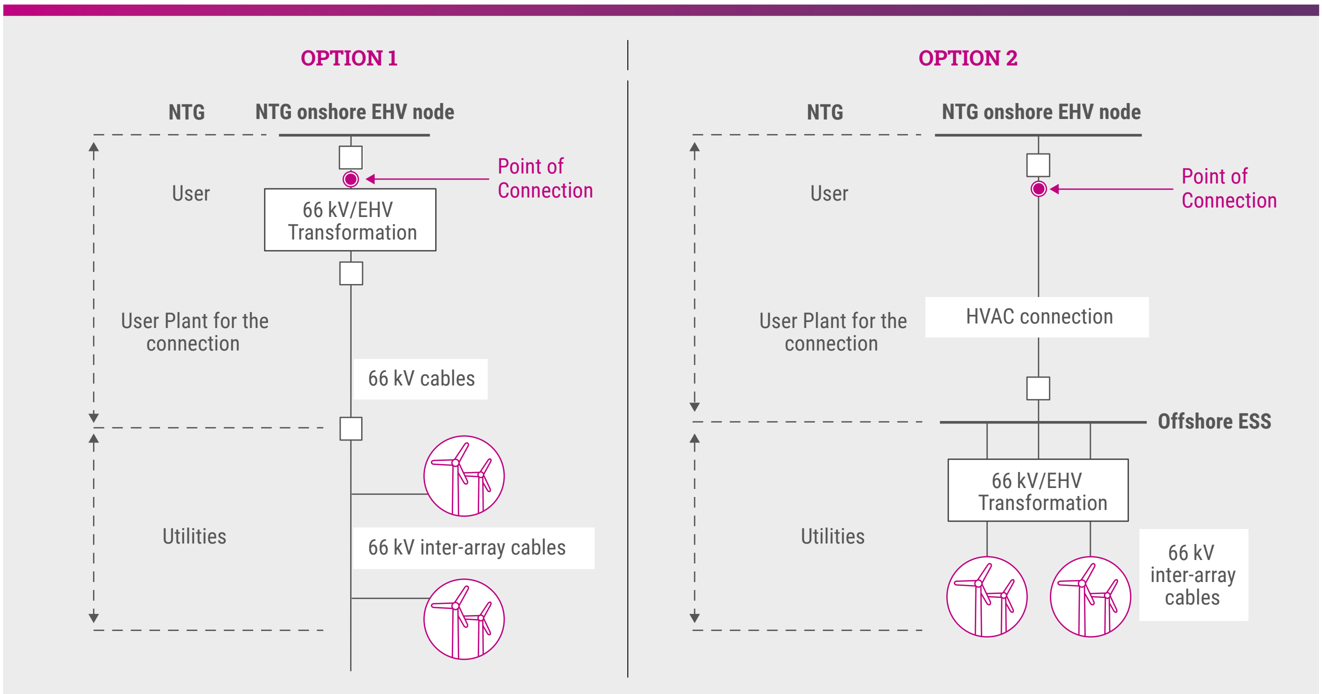


Figure 7 – Technical solutions defined for the wind offshore generation (Italian case).

The choice between single mesh connection or radial connection is strictly related to:

- of the primary source compared to the size of the new offshore wind power plants, distance from the load centres, need of new network reinforcements; and
- depth of the seabed and distance from the shore as they affect the technological solutions.

When planning the offshore wind power connection scheme, grid reinforcement becomes a crucial concern to facilitate the integration of new renewable energy generation and fully exploit the national generation pattern. Over time, grid solutions have evolved to enhance cost savings and minimise the environmental impact.

Figure 7 illustrates the two technical solutions specifically developed for incorporating offshore wind generation into the Italian power system. Both options necessitate meshed Extra High Voltage (EHV) onshore nodes (either 400 or 230 kV) of the National Transmission Grid (NTG).

Option 1 entails a direct interconnection of 66 kV between the OWF and the shoreline, with a 66 kV/EHV step-up transformer placed before the EHV NTG bay.

This solution is more suitable for:

- distances of less than 40 – 60 km from an existing or a new 400 or 230 kV node; and
- an OWF size smaller than 300 MW.

Option 2 involves an offshore sub-station for the step-up transformer 66 kV/EHV and an HVAC 400 or 230 kV interconnection link to the onshore NTG bay. This solution is most suitable for:

- distances greater than 40 – 60 km from an existing or a new 400 or 230 kV node. In this regard, it should be noted that the HVAC connection is adopted to reach up to 120 km, while the HVDC is used above this threshold; and
- an OWF size greater than 300 MW.

So far, the floating substation solution for offshore wind is considered more suitable for the bathymetry of the Mediterranean Sea, which is characterised by depths of several hundred meters just a few kilometres away from the coastline.

Romania

Although Romania is a leading country in South-East Europe in terms of onshore wind development, with almost 3 GW already installed, currently there is no offshore wind capacity installed or planned and Transelectrica didn't receive either any specific grid connection requests for offshore generation projects.

Given the estimated potential of Romania's offshore wind sector development in the Black Sea, there is interest from the investors, which are waiting, however, for the finalisation of the adequate regulatory and financial framework for supporting such projects.

There is no installed offshore capacities in Cyprus, Slovenia and Bulgaria. The offshore infrastructure, such as HVDC submarine cables, is also non existent in the above-mentioned countries.

Technology for offshore connection

HVDC technology is used to connect remote areas or to deliver power over long distances in a better and cost effectively manner rather than AC technology, especially through offshore infrastructure such as submarine cables. HVDC systems are becoming increasingly interesting for offshore development thanks to significant and well-known advantages under these conditions and many projects have been developed and commissioned over the years.

2021 saw 20 years of operation of the submarine cable connecting Italy and Greece. Strategically relevant for UE, the project is an HVDC monopolar link using LCC technology with a rated voltage of 400 kV DC and bidirectional capability of 500 MW. The project optimises energy supply at the import stage and provide greater flexibility for renewable energy production at the export stage. The total length is more than 300 km composed by 43 km of OHL (Italy side) and 160 km of submarine cable laid deeply up to 1000 m.

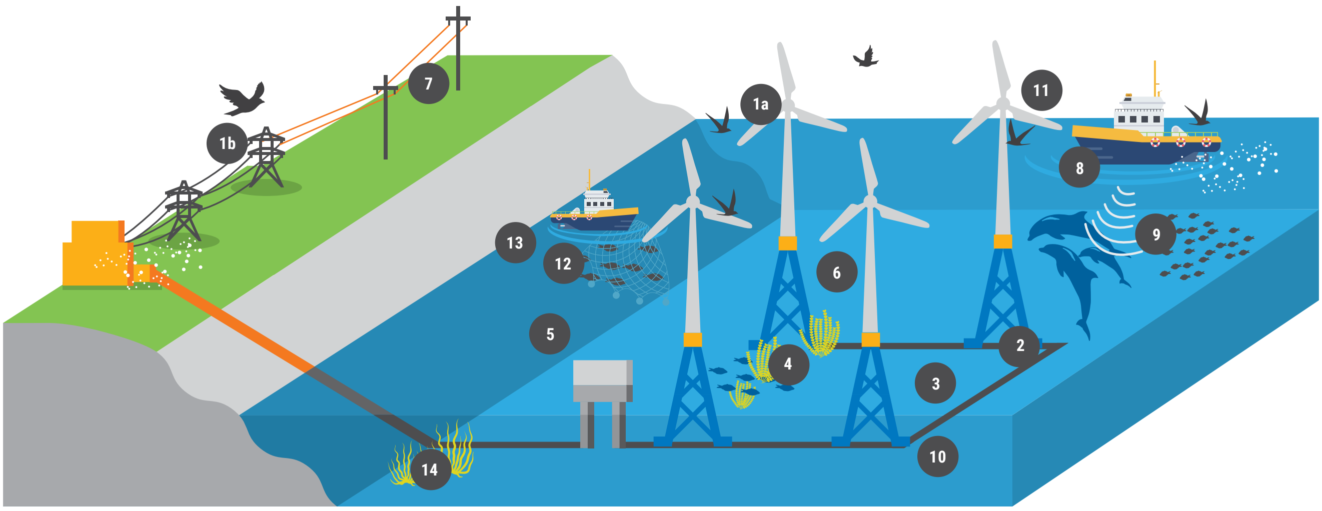
Another relevant HVDC interconnector project is the "Italy – Montenegro" link which started operating in 2019. The infrastructure has been planned as a bipolar HVDC in LCC technology with rated voltage of 500 kV DC and bidirectional total capability of 1,200 MW. Currently, one pole is in operation, with a capability of 600 MW available through a submarine cable of over 400 km and submarine electrodes located in each country.

4 Potential Environmental Impact – specific to Mediterranean East and Black Sea Basins

Introduction and general remarks

The development, construction and operation of offshore RES power plants can have a significant impact on marine biodiversity. Therefore, offshore RES projects must be carefully planned and managed so that they have a low impact on the surrounding environment. To achieve the greatest possible sustainability of offshore RES projects in relation to biodiversity, the EC issued a Guidance document on wind energy developments and European Union (EU) nature legislation in 2020. The purpose of this document is to provide guidance on the best manner to ensure the compliance of wind energy projects with the Birds Directive and the Habitats Directive.

For future wind offshore project developers, it is very important to be aware of potential risks and the necessary countermeasures to avoid or mitigate them. For this reason, The International Union for Conservation of Nature (IUCN) and The Biodiversity Consultancy (TBC) created Guidelines for project developers for mitigating biodiversity impacts associated with solar and wind energy development (2021). Figure 8 shows the potential impact from bottom-fixed offshore wind farms.



1. Bird and bat collision with, a) wind turbines and b) onshore transmission lines
2. Seabed habitat loss, degradation and transformation
3. Hydrodynamic change
4. Habitat creation
5. Trophic cascades
6. Barrier effects or displacement effects due to presence of wind farm
7. Bird mortality through electrocution on associated onshore distribution lines
8. Mortality, injury and behavioural effects associated with vessels
9. Mortality, injury and behavioural effects associated with underwater noise
10. Behavioural effects associated with electromagnetic fields of subsea cables
11. Pollution (e. g. dust, light, solid/liquid waste)
12. Indirect impacts offsite due to increased economic activity and displaced activities, such as fishing
13. Associated ecosystem service impacts
14. Introduction of invasive alien species

Figure 8 – Potential impacts on biodiversity and the associated ecosystem services due to bottom-fixed offshore wind developments (IUCN & TBC, 2021)

Ecological impact – Natura 2000

Offshore wind farms in the East Mediterranean Sea and Black Sea may be significantly impacted by the Natura 2000 network regarding their construction and management. Natura 2000 sites are subject to strict regulations and rules designed to safeguard their biological integrity as they are protected areas designated to conserve biodiversity. To guarantee compliance with the EU's nature protection rules, offshore wind projects that are planned inside or close to Natura 2000 areas must go through a rigorous review.

Developers must complete thorough environmental impact studies (EIAs) to analyse potential effects on the Natura 2000 areas before developing any OWF. These evaluations examine the project's possible impact on habitats, species and the health of the ecosystem as a whole. Natura 2000 sites are defined across the countries in the East Mediterranean and Black Sea.

East Mediterranean specifics

The whole Adriatic maritime area is characterised by the presence of sites of important environmental value and for the protection of cultural heritage (Natura 2000 network areas, Protected Marine Areas, UNESCO sites).

For example, Greek waters are home to a number of marine and coastal protected areas, including Natura 2000 marine areas, National Marine Parks (Alonissos in the Aegean sea, Zakynthos in the Ionian sea, island Gyaros and its surrounding marine area) and National Parks that encompass coastal areas and transitional waters (such as the National Park of Evros Delta, National Park Eastern Macedonia and Thrace).

Regarding natural protection, it is worth noting that 266 Natura 2000 marine sites have been established in Croatia over a total of about 16 % of the country's marine area. There are no marine protected areas (MPA) as defined by the Nature Protection Act, but there are many protected areas that include marine areas over a total of 1.5 % of the country's marine area (Figure 9).

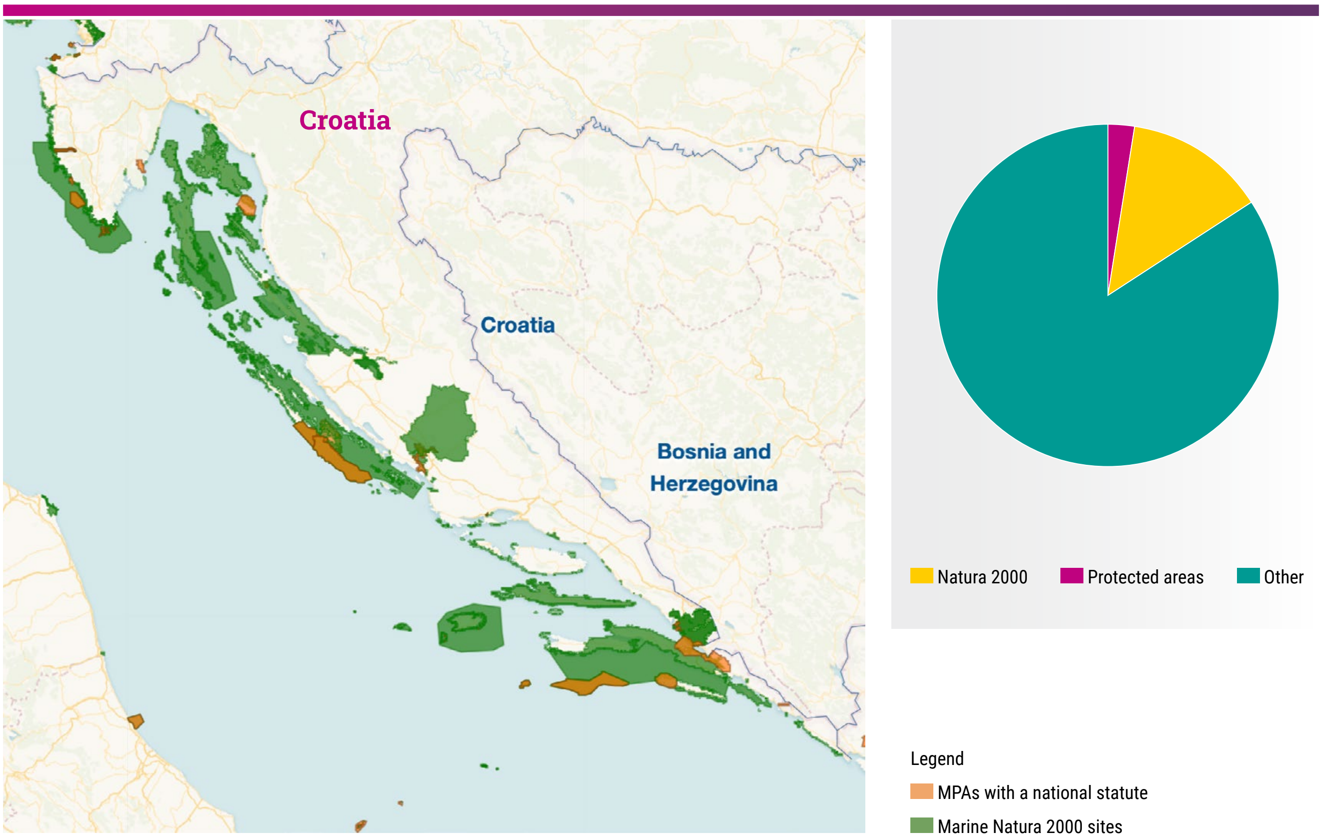


Figure 9 – Example of offshore protected areas and Natura 2000 sites in one part of the East Mediterranean (www.mapamed.org, 2023)

Black Sea specifics

The continental shelf along the Romanian coast is strongly influenced by the Danube River plume. In fact, it is known that the Danube River discharges a significant quantity of freshwater, sediments and organic nutrients into the sea and, consequently, influences water parameters (e.g. temperature and salinity) and marine ecosystems composition and structure in the western part of the Black Sea.

The composition of Black Sea fish fauna has changed from the 1950s until the present due to the deterioration of environmental conditions and inadequate fisheries management. However, the availability of food, rocky substrate and higher salinity condition in the southern part of the Romanian coast have led to greater diversity and concentration of fish population. The area hosts several vulnerable species and several endemic species. Many species of concern are anadromous migratory fish such as the three sturgeon species, which are listed as critically endangered (CR) and some demersal and pelagic species, listed as vulnerable (VU) or near threatened (NT) Threatened Species (IUCN, 2022). For some, species protection at the international level through legal instruments and agreements is also established (e.g., CITES, Bonn Convention).

The Romanian coastal and shelf waters are commonly inhabited by all three endemic marine mammals of the Black Sea: the Black Sea Harbour Porpoise, the Black Sea Bottlenose Dolphin and the Black Sea Common Dolphin.

Natura 2000 covers 9.7 km² of protected land in the Dobrogea region in Romania. The Natura 2000 network from Dobrogea includes 67 sites (35 Sites of Community Importance [SCI] and 32 Special Protection Areas [SPA]; most of the SCIs and SPAs spatially overlap). In the EU, natural habitat 62CO* Ponto-Sarmatian steppes is limited in its range and occurs only in two member states – Bulgaria and Romania.

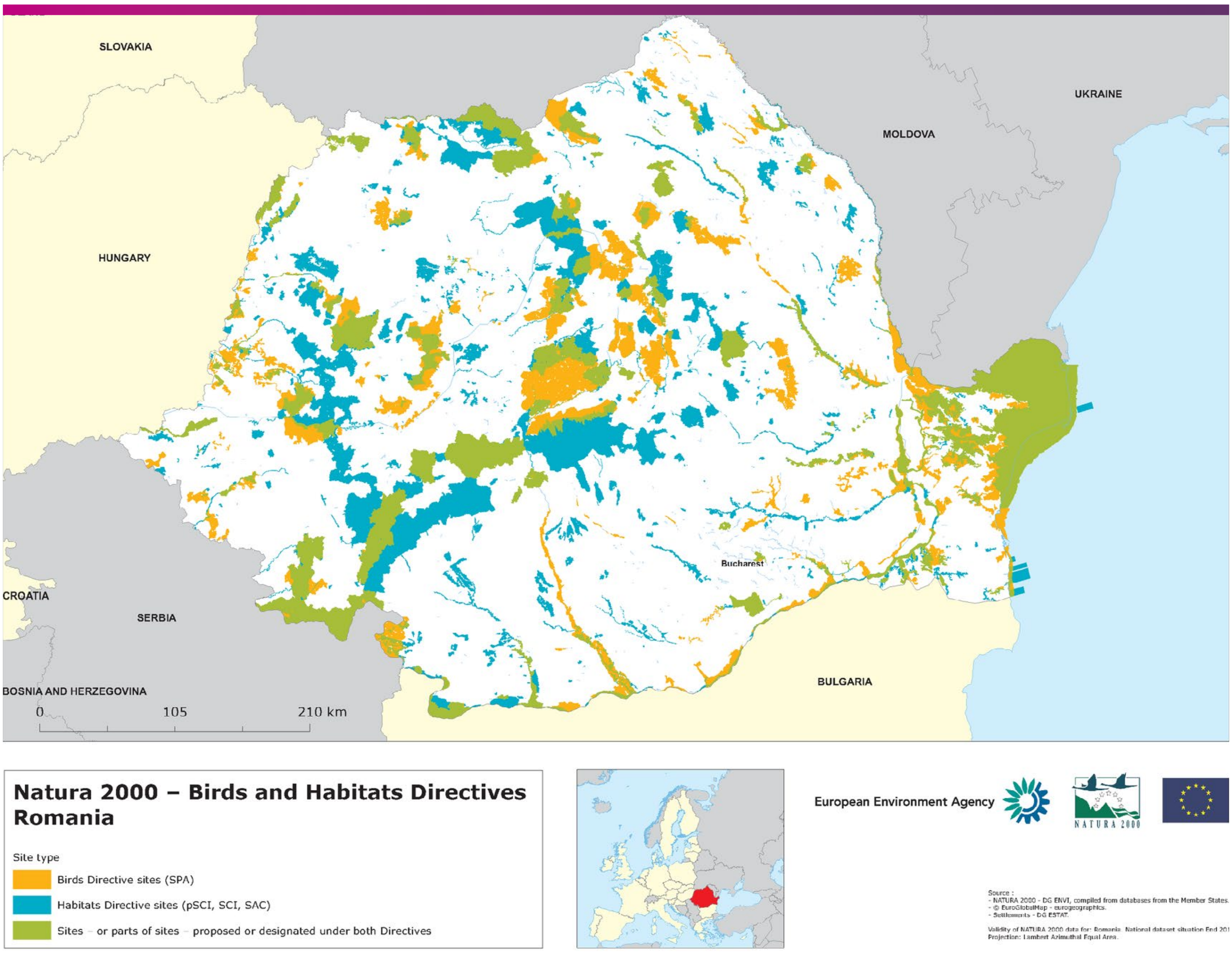


Figure 10 – Natura 2000 in Romania

In the marine area of Romania, the **Natura 2000** network comprises 9 SCIs and an SPA, while the sea part of the Danube Delta Biosphere Reserve (ROSCI0066 – Danube delta – marine zone) accounts for 45 % of the total. Only 37 % of Natura 2000 sites in the Romanian Black Sea sector have management plans, and conservation measures are largely not adapted to the requirements.

In Romania, conservation objectives have not been agreed unanimously, and strategies that should involve stakeholders as a first step towards understanding the ecological, cultural and social benefits have also not been developed, which has led to conflicts with other types of marine space uses.

The management of marine sites that are part of the Natura 2000 network requires additional interventions in the direction of improving conservation measures, protecting species, preventing degradation of ecosystems, restoring biodiversity, monitoring and funding.

Natura 2000 covers 34.9 % of the land and maritime zones in Bulgaria and covers 120 areas for wild birds protection and 234 protected areas for habitat conservation. The Black Sea protected areas included in Natura 2000 are conserved over 40 different habitat types. They also include habitat types such as estuaries, coastal lagoons and reefs. Along the Bulgarian Black Sea coast, there are over 30 protected areas which are included in Natura 2000. There are many territories, of course, that are of crucial importance for bird conservation, for other species or entire ecosystems. As a result, the protected areas overlap partially or entirely with each other.

Fish population Marine Mammals, Birds

Offshore RES can have a negative impact on habitats, species and the health of the ecosystem as a whole. According to the Guidance document on wind energy developments and EU nature legislation, the impacts of offshore wind energy projects can occur in four main phases of the development:

- pre-construction phase (e.g. meteorological tests, research studies on sediment stability and seabed preparation);
- construction (e.g. transportation of materials by vessels and construction of foundations, grid connection cables, etc.);
- operation (including maintenance); and
- end-of-life activities such as life-time extension and decommissioning (removal of a wind farm or individual turbines).

Most of the impact on fish is manifested through the action of electromagnetic fields of cables that carry electricity from the power plant to shore, the emission of anthropogenic under-water noise, and the creation of new habitat conditions by the formation of artificial reefs on the substratum seabed.

Concerns about the effects of electromagnetic fields are usually eliminated by covering the cable with protective sheaths and sinking the cable into the seabed to a depth of one metre or more. This method also excludes the influence of heat from the cable to the marine environment.

The majority of the impact on marine mammals is manifested through the loss and/or deterioration of marine habitats in the areas of the foundation and anchoring of power plants or the route of the submarine cables, noise emissions from geophysical and geotechnical investigations during location selection, the foundation of wind turbines (driving pylons) and the vessels themselves during construction.

The offshore wind impacts on the marine environment can affect habitats, fish, birds, marine mammals and other species such as plants, algae, invertebrates and bats. In this context, it is also necessary to remember the difference between fixed and floating wind turbines technology, including the nature of the seabed on which these structures will be placed.

According to Guidance document on wind energy developments and EU nature legislation, OWFs have the potential to impact birds by:

- displacing individuals from foraging areas;
- through collisions of birds in flight with the rotating turbine blades;
- barrier effects that increase the energy needed to transit between sites; and
- habitat loss and degradation through the removal or fragmentation of the supporting habitat that birds would otherwise use and be attracted to (e.g. roosting sites).

The main concern regarding these species is collision with the turbine blades. Therefore, important nesting areas and bottlenecks in the corridors of the migration routes must be considered when planning potential sites for the construction of OWFs.

Conclusion

It is important to regulate the ecological effect of wind offshore farms. To reduce possible harm to animals and coastal ecosystems while simultaneously maximising the chance to have a neutral or beneficial ecological impact, careful site selection, rigorous environmental studies and ongoing monitoring are crucial. The key to securing a sustainable future is striking a balance between energy requirements and environmental conservation.

Offshore wind development must ensure that the development activities do not affect the landscape and cultural heritage integrity. Therefore, it is necessary to allow systemic, harmonious and sustainable development aimed at protecting and enhancing the landscape and environment.

Chapter 5 describes the potential environmental impact of offshore technology. This chapter is highly interlinked with Chapter 6, where spatial planning needs are further described and where the process of preparation of MSPs is addressed as one of the significant topics in the offshore energy sector.

5 Spatial Planning Needs – specific to Mediterranean East and Black Sea Basins Part of South and East Offshore Grids

Introduction

The East Mediterranean and Black Sea Basin are covered in this report. On one side, the East Mediterranean Sea Basin includes:

- the Adriatic Sea, separates the Italian peninsula from the Balkan peninsula and extends from the Strait of Otranto to the south to the Gulf of Venice in the north;
- the Ionian Sea lying to the south of Italy and Greece, where the deepest sounding in the Mediterranean, about 16,000 feet (4,900 metres) has been recorded;
- the Aegean Sea, located between the Greek and the Anatolian peninsulas, with the island of Crete defining its southern border; and
- the Levantine Sea is separated from the Ionian Sea by a submarine ridge between the western end of Crete and Cyrenaica and extends to the south of the Anatolia peninsula.

On the other side, there are six countries with coastlines on the Black Sea (clockwise), Ukraine, Russia, Georgia, Turkey (Türkiye), Bulgaria and Romania. The Black Sea is landlocked except for its connection with the Mediterranean through the Bosphorus; this connection is slender, having a shore-to-shore width of only 725 m at the choke point, and a midchannel sill depth of only 40 m.

Countries in this area, the ones covered by this report, share some common MSP related issues and challenges, such as the possible exploitation of submarine natural gas and oil resources, the need for environmental conservation and management actions – also considering that environmental quality is a winning asset for coastal tourism and a relevant economic activity for the East Mediterranean – and the sustainable management of fishery and fish stocks.

Most countries have not adopted MSPs at the present, but this subject has been addressed in the public in recent years. In addition, most countries are in the process of adopting MSPS and their laws are defining the processes of the creation of MSPs.

Current status of MSPs in the Sea basin[1]

Bulgaria

Bulgaria transposed the EU MSP Directive in 2018 by an amendment of the Maritime Spaces, Inland Waterways and Ports of the Republic of Bulgaria Act. Since then, the Advisory Council on Maritime Spatial Planning has been working on the development of the Plan. There are no formal MSPs in Bulgaria yet, but the current final draft version of the MSP to be presented according to the provisions of the Directive 2014/89/EU (Article 15, item 3) was submitted to the EC on 31 March 2021. Furthermore, Bulgaria is involved in various European and cross-border projects, as described below.

1 https://maritime-spatial-planning.ec.europa.eu/sea-basins/east-mediterranean

Croatia

Croatia adopted the Physical Planning Act, which came into force in July 2017 and fully transposed the MSP Directive into the Croatian legislation. The Ministry of Construction and Physical Planning and the Croatian Institute for Spatial Development – which is the expert institution that develops or coordinates the development of these plans – are both the competent authorities for MSP implementation in Croatia. Croatia is developing a new generation of spatial plans to improve the integrity of marine spatial planning, consideration of interactions, effective monitoring and reporting on the state of the maritime area. The country has also been involved in several European projects.

Cyprus

Cyprus has transposed the MSP Directive through its MSP Law, approved by the House of Representatives in October 2017. The competent authority for MSP implementation is the Ministry of Transport, Communication and Works (Department of Merchant Shipping). The Law also established an MSP Committee which oversees the draft MSP. There is, therefore, no MSP Plan developed in Cyprus yet, but the country has been involved in several European projects on MSP.

Greece

Currently, there is no legally binding national MS Plan in Greece. However, MSP related issues are addressed in "Special Frameworks for Spatial Planning" (terrestrial spatial plans, TS Plans) covering specific economic sectors. Sectoral plans have been elaborated so far for aquaculture (2011, to be revised), tourism (under finalisation) and industry (2009, to be revised), which include spatial planning guidelines for the land-based, coastal, and marine segments of each sector. Furthermore, the Special Framework for Renewable Energy Sources (2008, new study under finalisation) sets the strategic guidelines for offshore wind parks.

Greece is an archipelagic area divided by a peninsula in two parts: the Aegean and the Ionian Sea. This means that there is a great variety of uses and activities all over the Greek seas and that many uses and activities exist in great density. Indicatively but not exhaustively, you can find in the Greek seas:

- Marine and coastal protected areas (as described in Chapter 5)
- Fisheries and aquaculture – there is also an ongoing procedure for the organisation of zones allocated to aquaculture (AZA), named POAY in Greek; that is, Areas of Organised Aquaculture Development. Greece is one of the most important world producers, according to the Food and Agriculture Organisation (FAO).
- Underwater cultural heritage – Greece, counting more than 10,000 archaeological sites and ancient monuments as well as a further few thousand monuments of modern times, located both on the terrestrial and the marine space, is considered a pioneer regarding the protection of cultural heritage.
- Maritime shipping – there are major Mediterranean ports in Greece. Many ports have adopted Port Master Plans that establish policies and guidelines to direct the future development of the port and manage its operations;
- Coastal industries – they mainly concern activities such as cement industries, desalination infrastructure, industrial aquaculture coastal installations etc; and
- Oil and gas – The Hellenic Parliament recently ratified four concessions allowing the extraction of hydrocarbons in the Ionian Sea and in the west of Crete. In addition, off-shore oil platforms are being developed in Kavala – Thasos.

Italy

To date, Italy has not yet officially adopted an MSP. The proposal for an MSP Plan is currently being revised and finalised by the Technical Committee, according to the observations received during the public national consultations phase on MSP Plans and their Strategic Environmental Assessment (SEA). Three maritime areas have been identified: Maritime Area "Adriatic", Maritime Area "Ionian and Central Mediterranean" and Maritime Area "Tyrrhenian and Western Mediterranean"[2].

The Eastern Mediterranean Sea basin includes the Adriatic Sea from the Italian side. The Adriatic Sea is characterised by a high density of uses, particularly in the areas closest to the coast, and therefore by potential and real conflicts between some activities. At the same time, however, different uses can coexist in the same area and develop synergies leading to the effective sharing of the maritime space and its resources (multi-use), with advantages for all the sectors involved.

The Adriatic Sea hosts historical and intense anthropic activities, some of which are relevant for socioeconomic value and for potential impacts on species, habitats and ecosystems.

Among these, some of the most relevant are the maritime transport, coastal urbanisation, fishery, aquaculture, tourism system and marine areas for hydrocarbon exploitation (O&G).

The areas dedicated to the energy sector identified in the Adriatic Sea Plan are suitable for reconciling the protection of the marine-coastal habitat, landscape and visual integrity with innovative forms of energy production from RES (e.g. wind offshore, hydrogen, wave energy); promoting the decarbonisation and, where possible, enabling the conversion of decommissioned platforms for multi-purpose projects, which include the storage of renewable energy, the creation of areas of "biological protection" and/or sites of interest for tourism and underwater fishing and aquaculture. In addition, the transformation of harbours into facilities with a positive energy balance is promoted, encouraging the reduction of CO_2 emissions and other pollutants related to the combustion of fossil fuels linked to port activities.

Ultimately, the Plan proposes to favour the experimentation and the possible development of technologies and plants for the generation of energy from renewable sources in the sea (with particular reference to the wind energy), both in the coastal sub-areas and in the offshore ones, compatibly with the current policies and requirements of environmental and landscape protection.

Romania

Romania has approved the MSP legislation for its maritime space consecutively in 2016 and 2017. The Ministry for Development, Public Works and Administration is the competent authority to prepare the MSP national legislation, to nominate the MSP authorities and for the MSP Directive implementation.

Romania has not yet adopted a MSP. After the submission and finalisation of the environmental evaluation, the new MSP draft plan was under public consultation until 28 August 2023.

The country has been involved in projects related to marine research and MSP. The development of MSP was based on the previous experiences in Integrated Coastal Zone Management (ICZM).

Slovenia

In Slovenia, the MSP Directive is implemented within the framework of the Spatial Planning Act adopted in 2017. The Ministry of Environment and Spatial Planning (Spatial Planning, Construction and Housing Directorate) is the competent authority for the implementation of the MSP. The final Pomorski prostorski plan Slovenije (Maritime Spatial Plan of Slovenia) was adopted by the Government in July 2021 and Slovenia is currently the only country in the sea basin with an adopted MSP.

2 https://www.mit.gov.it/documentazione/pianificazione-dello-spazio-marittimo

Conflicts with other sectors

Spatial analysis of the distribution of marine space uses can help to anticipate and resolve potential conflicts by providing information on overlapping uses, but without knowing the intensity, frequency or magnitude of these interactions. Moreover, proposals for maritime space planning, which anticipate these conflicts, must consider the provisions of sectoral policies and regulations, which are not amended by the Maritime Space Planning Plan.

From the spatial analysis of the use of marine space it follows that the overlap of protected natural areas, the infrastructure for the protection of the coastal area (digs), the transport infrastructure (cables, pipelines, maritime transport routes, ports), fishing areas and those for the exploitation and exploration of mineral resources can be one of the factors influencing the dynamics of conflicts between different types of uses and the objectives of conservation and protection of biodiversity and marine habitats. To avoid and minimise the impact of maritime activities, the objectives of development of offshore infrastructure must consider the existing protection measures in the legislation in the field of water and the environment, which will lead to its sustainable development.

Fishing and fisheries

The fisheries sector in the Mediterranean and the Black Sea encompasses a total of 85,300 vessels, generating an annual capture fisheries production of 1,189,200 tonnes (excluding tuna-like species), with an associated revenue of USD 2.9 billion and an estimated half a million jobs along the value chain, including 194,000 jobs directly on board fishing vessels. In the region, 59 percent of the total employment on board fishing vessels comes from small-scale fisheries.

The co-existence of offshore RES with fishery groups will be needed in many offshore areas. There is the potential for synergy between such sectors, which must start through constructive dialogues. Fishing can play a crucial role in employment in some coastal communities, which will be impacted by the construction and operation of an offshore RES. There is potential for fishing activities in offshore wind areas. During the construction activities of an offshore RES, fishing activities are usually restricted; therefore, developers should consult fishermen in the site identification phase. Developers may offer compensation schemes if local fishing activities were disrupted or offer temporal work opportunities. Once in operation, bottom trawling and other fishing activities that disturb the seabed should be avoided due to the potential damage to submarine cables by fishing gear or anchors. To reduce the risk of accidents, it is important to transparently share data on submarine cable locations and exclusion zones. However, the lack of seabed-disturbing activities often results in a growing number of fish stocks that are available for less invasive fishing activities. Such limited fishing activities can take place within and nearby ORES. Lastly, ORES may also offer alternative or parttime employment to fishermen to help with safety patrols, or other services, depending on the size and condition of their vessels.

Shipping

Another strong traditional economic sector in the Mediterranean and Black Sea is transport, specifically maritime transport. The Mediterranean Sea is among the world's busiest waterways. Countries such as Italy and Greece (together with Spain) are on the top and have the highest total number of ships in the whole Mediterranean. Almost two-thirds of the traffic was internal (Mediterranean to Mediterranean), one-quarter was semi-transit voyages of ships mainly of small size, while the remainder was transit voyages. The importance of Black Sea ports in international maritime trade is continuously increasing and this tendency will continue for the near future. The recent war has reduced the overall numbers, but it is only a temporary disturbance. Considering the size of the shipping sector in the East Mediterranean and Black Sea, conflicts with OWFs are possible and expected.

OWFs are classified as restricted zones, therefore some activities could be limited or outlawed there. This may involve limitations on marine activities such as anchoring or fishing. Ship operators must be aware of the locations of wind turbines and arrange their courses appropriately. Efficiency and logistics may be affected if shipping traffic needs to detour or acquire special clearance to pass. Maintenance and servicing ships must frequently visit OWFs. Consequently, there may be an increase in marine traffic close to the wind park, which can add to the congestion in major shipping zones.

Offshore networks may open up new business prospects for the maritime sector. Wind farm and network installation, maintenance and repair vessels are in great demand. Companies and income streams for shipping businesses that adapt their offerings to serve the offshore wind sector can expand.

The shipbuilding sector could benefit from offshore development as they both involve mainly steel and welding, forming, bending and casting processes. Shipyards have production capacities (large workshops, cranes, etc.) that can support the construction and assembly of offshore wind.

While planning the locations for new offshore plants zones of directed navigation need to be avoided to reduce the impact on existing shipping routes. After installation, to avoid OWF areas, ships may need to change their path. Ships traveling through the region may have safety issues due to the presence of offshore wind turbines. Wind turbines are potentially dangerous constructions, especially when bad weather or poor sight are present. When sailing in or close to wind farm zones, ships may need to follow navigational instructions to protect their safety.

It takes a flawless and fluid connection for offshore networks, which link several wind farms to the onshore electricity grid, to operate efficiently. This meshing procedure, however, may face difficulties due to the requirement for cable crossings along maritime routes. Passing ships may unintentionally damage undersea cables, disrupting electricity transmission and necessitating expensive repairs.

Tourism

Coastal tourism is the most important maritime activity in the East Mediterranean. Seaside and beach resorts continue to represent the main tourist attraction for the domestic markets and the second type of preferred destination for the international market. The activity is deemed one of the most promising because of its huge potential, not only in socioeconomic terms but also regarding environmental sustainability. The Black Sea is also a popular tourist destination for people in nearby countries. Focusing on their natural and cultural heritage, they have developed the typical Mediterranean urban tourism model.

OWFs can have a negative impact on tourism in terms of visual effect. According to some literature, the wind farms located 12 nautical miles or more from the coast are far enough that potential visual landscape impacts are minimised or non-existent.

Nautical tourism, windsurfing or diving are developed in the respected Sea Basin. OWFs can block potential sailing routes, or restrict the available space for other recreational activities, such as windsurfing or diving.

Military

In the coastal areas of countries in the East Mediterranean and Black Sea, there are certain areas destined for military exercises, and in the marine area the areas of the territorial sea are used for military practices, with specific rules concerning maritime and navigational activities.

In principle, the coexistence of military activities with those of other maritime activities, such as maritime transport, tourism or fishing, is not prevented. As a rule, restrictions or temporary closures of maritime districts are used during the course of the exercises. As the offshore plants have precise coordinates, the data should be exchanged with the military sector, and the offshore plants should be areas with low intensity of military exercises.

The covered Sea Basin was also historically involved in the world war battles. One element that could impose temporary restrictions is the presence of marine mines, launched on the Black Sea coast during World War II or in the more recent conflicts in the area. This is more a threat to the environment than to the possible offshore wind development but it still needs to be investigated as the entire coastal belt has not been explored on the subject.

In the current geo-political situation, with more conflicts in the area, the presence of military ships in the Sea Basin may represent possible conflicts, too.

Oil and Gas

Security of supply of all types of energy has become a major issue for EU countries in recent years. Some countries in the region have existing oil (Italy) and gas platforms (such as Italy, Croatia, Bulgaria…). In the last decade there have been plans to improve hydrocarbons production with new gas and oil platforms. Greece recently ratified four concessions allowing the extraction of hydrocarbons in the Ionian Sea and in the west of Crete. In addition, off-shore oil platforms are being developed in Kavala – Thasos. Romania has plans to start extracting hydrocarbons from the Black Sea. Croatia has built a LNG terminal in the Northern Adriatic Sea and provided concessions for research for possible oil reserves.

In the offshore context, the expected expansion of oil and gas operations in some areas could lead to serious conflicts with typically offshore sectors such as maritime transport, commercial fishing, and exploratory sectors such as marine mineral mining and dredging activities. The influenced sector in the future is electricity, specifically OWFs. However, they may be compatible in the presence of adequate planning. With technology improvement and rising CO_2 taxes, it is expected that OWFs will have commercial advantage over gas and oil production.

Conclusion

At present, countries in the East Mediterranean and Black Sea Basin have not yet adopted a MSP, except for Slovenia, where offshore development is not a significant factor. Some countries such as Italy are in the process of revision of their draft version of MSP where the allocation of maritime areas for energy sector, and in some cases specifically for offshore power plants, is provided. However, most countries in the Sea Basin have adopted regulations where the preparation of MSP is required and in the near future (3–5 years) it is expected that MSPs will be adopted by most countries. The goal of the energy sector should be to implement offshore allocation in the first version of MSPs, which is the first step for future development in the sector. The East Mediterranean and Black Sea Basin is influenced by different sectors such as fishing, shipping (traffic and industry), tourism, military and gas. The coexistence of traditional sectors in the Sea Basin has been a factor over the past few decades and offshore energy in the future should contribute to the diversity of the sectors in the Sea Basin. Some conflicts between offshore and other sectors are possible (as is described); but the overall social and economic impact from the coexistence of the offshore sector with other sectors can be positive on a long-term basis, especially after defining legal frameworks (regulation, laws and MSPs).

6 High-Level Results on Offshore Network Infrastructure Needs

TSOs’ expectations regarding the evolution of generation power plants cover an increasingly important role in the identification of infrastructure development needs. Indeed, transmission systems of TSOs in ENTSO-e are facing new challenges regarding RES generation, mainly due to the locations of renewable power plants, which are often far from consumption areas, unlike the conventional power plants and conventional power systems that are characterized by areas of consumption close to energy production.

The AC transmission system has seen an increase of HVDC solutions concretization compared to 40 years ago and larger countries such as Germany, Poland and Italy are planning to increase the number of HVDC links to meet the infrastructure needs and to directly connect production areas with consumption areas.

The process of decarbonization of the electricity system, which is necessary to achieve national and international energy and climate targets, will lead to radical and deep changes in the electricity system.

In the East Mediterranean and Black Sea, as aforementioned in the previous chapters, the possibility of developing OWFs has been recently introduced and, therefore, actual foreseen capacities could be considered the upper limit of potential offshore RES production. As the current existing grid of the countries is one of the main drivers taken into consideration for the definition of OWFs connection points and feasible technologies to use for offshore projects development, there are yet many steps to be taken on a national level by the countries concerned in this sea basin regarding the identification of concrete sites dedicated to offshore energy generation and specifics for such projects. It could be concluded that there are still many uncertainties over the future of transmission grid expansion for offshore installations in the area of interest.

The amount of radial transmission assets serving the connection of the generation capacities illustrated in Table 2 will match the generation values, meaning that overall in the corridors **8.7, 19.2 and 28.3 GW of transmission infrastructure** will be needed in 2030, 2040 and 2050 respectively to connect the offshore RES power plants foreseen in East Mediterranean and Black Sea waters at the same time horizon.

	Offshore transmission capacity [GW] to connect the offshore RES generation		
Country	**2030**	**2040**	**2050**
Italy	4.5	7.0	7.0
Croatia	0.5	1.2	3.0
Greece	2.7	10.0	17.3
Romania	1.0	1.0	1.0
Total	**8.7**	**19.2**	**28.3**

Table 2 – Offshore transmission capacities [GW] – South and East Offshore grids.

These assets will cover a maritime distance of **1,560 km**, potentially requiring up to **44 offshore AC offshore substations**.

The realisation of this infrastructure is strongly dependent on the availability of full mature floating solutions and dynamic cables, given the average water depth characterising the region. There is an impact on costs for these kinds of assets, determining an additional 50 % – 150 % increase for floating assets (in comparison to gravity-based ones) and 20 % increase for dynamic cables, in comparison to tradition bottom-laid solutions.

The latter increase factors should be considered when reading the summaries of Table 4 and Table 6, including the potential costs for transmission infrastructure connecting the offshore RES foreseen in the South and West Offshore grids corridor.

In this 1st edition of the ONDP for South and East offshore grids corridor (East Mediterranean and Black Sea) there are no significant results in terms of the infrastructure needs corridor for hybrid OWFs development; indeed, only radial connections have been considered, with assumptions concerning quantities of connection points and allocation of the foreseen capacities to these points. Therefore, more detailed and accurate costs estimations for installations and development of hybrid projects, also conceptual ones, in the very long-term horizon will follow in the next editions after further investigation by the TSOs.

Equipment Needs Route Length, Number	Radial (route length)			Expansion		Radial – considered in the expansion loop			Total			Total Sum [km] or nr.
DC Grid [km], [Nr]	2025 – 2030	2031 – 2040	2041 – 2050	2031 – 2040	2041 – 2050	2025 – 2030	2031 – 2040	2041 – 2050	2020 – 2030	2031 – 2040	2041 – 2050	2025 till 2050
Onshore DC Cables (updated)												
Offshore DC Cables (updated)												
Onshore AC Cables (updated)	350	660	546						350	660	546	1,556
Offshore AC Cables (updated)												
Offshore DC converters												
Onshore DC converters												
Offshore AC substation	13	19	12						13	19	12	44
Offshore node expansion (incl. DC breaker)												
											Total Route Length	**1,556**

Table 3 – Amount of offshore transmission equipment to connect the RES generation in South East Offshore Grid corridor, in the event of the availability of DC breakers (DC Grid configuration). The value for cables considers the route length to be covered, not the exact km of cables to cover the route.

Costs	Radials			Expansion		Radial – considered in the expansion loop			Total			Total Sum [M€]
DC Grid [M€]	2025 – 2030	2031 – 2040	2041 – 2050	2031 – 2040	2041 – 2050	2025 – 2030	2031 – 2040	2041 – 2050	2020 – 2030	2031 – 2040	2041 – 2050	2025 till 2050
Onshore DC Cables (updated)												
Offshore DC Cables (updated)												
Onshore AC Cables (updated)	330	468	638						330	468	638	
Offshore AC Cables (updated)												1,437
Offshore DC converters												
Onshore DC converters												
Offshore node expansion (incl. DC Breaker) E20												
Offshore AC substation	3,841	4,938	4,542						3,841	4,938	4,542	13,322
												14,759

Table 4 – Costs for transmission infrastructure connecting RES in South East Offshore Grid corridor, in the event of the availability of DC breakers (DC Grid modelling configuration).

Equipment Needs Route Length, Number	Radial (route length)			Expansion		Radial – considered in the expansion loop			Total			Total Sum [km] or nr.
DC LINK [km], [Nr]	2025 – 2030	2031 – 2040	2041 – 2050	2031 – 2040	2041 – 2050	2025 – 2030	2031 – 2040	2041 – 2050	2020 – 2030	2031 – 2040	2041 – 2050	2025 till 2050
Onshore DC Cables (updated)												
Offshore DC Cables (updated)												
Onshore AC Cables (updated)	350	660	546						350	660	546	1,556
Offshore AC Cables (updated)												
Offshore DC converters												
Onshore DC converters												
Offshore AC substation	13	19	12						13	19	12	44
Offshore node expansion (with converter), E18												
											Total Route Length	**1,556**

Table 5 – Amount of offshore transmission equipment to connect the RES generation in South East Offshore Grid corridor, in the event of the unavailability of DC breakers (DC Link configuration). The value for cables considers the route length to be covered, not the exact km of cables to cover the route.

Costs	Radials			Expansion		Radial – considered in the expansion loop			Total			Total Sum [M€]
DC LINK [M€]	2025 – 2030	2031 – 2040	2041 – 2050	2031 – 2040	2041 – 2050	2025 – 2030	2031 – 2040	2041 – 2050	2020 – 2030	2031 – 2040	2041 – 2050	2025 till 2050
Onshore DC Cables (updated)												
Offshore DC Cables (updated)												
Onshore AC Cables (updated)	330	468	638						330	468	638	
Offshore AC Cables (updated)												1,437
Offshore DC converters E18												
Onshore DC converters												
Offshore node expansion (with converter), E18												
Offshore AC substation	3,841	4,938	4,542						3,841	4,938	4,542	13,322
												14,759

Table 6 – Costs for transmission infrastructure connecting RES in the South East Offshore Grid corridor, in the event of the unavailability of DC breakers (DC Link modelling configuration).

Electricity Transmission Infrastructure Needs – Italian case

Electricity Transmission Infrastructure Needs on the national level on the long term horizon are briefly described below for the case of Italy.

Among many aspects referring to the planning process, in recent years the expected evolution of the generation power plants has played an increasingly important role in assessments aimed at identifying infrastructure development needs. The EU long term strategy aiming to reach energy source diversification and carbon neutrality by 2050 will lead to a radical and deep change in the electricity system. On the one hand, it will mean the decommissioning of conventional thermal power plants while at the same time leading to the loss of programmable capacity capable of providing valuable regulation services to the electricity system. On the other hand, achieving the decarbonisation targets set at the national and international level will require a significant increase in generation capacity from renewable sources, in particular from intermittent and non-programmable wind and PV sources (es. +70 GW by 2030 compared to installed capacity in 2019 in the Fit-for-55 policy scenario in Italy).

This planning effort is essential to anticipate the expected evolution of national generation as far in advance as possible, so that the grid of the future can accommodate the additional renewable capacity, safely managing power flows between production areas and load centres. However, due to possible sudden changes in the energy and geopolitical context, this extraordinary infrastructure effort will need to be adaptable and flexible, including a modular approach with conditional implementation according to the development of RES, to respond quickly, effectively and efficiently to the various exogenous factors that may influence the energy and electricity system.

In this sense, in the **2023 National Development Plan**, Terna defined a basket of projects under consideration for the achievement of the energy and climate objectives set, in compliance with the obligations of the TSO and in line with Terna's objectives and mission. The innovative approach adopted for planning the new grid infrastructures is characterised by a holistic view of the electricity system as a whole, considering not only the grid infrastructure but also the main related technologies (e.g. RES, electrolysers, storage, inverter-based systems) to enable the coordinated planning of the grid, renewables and storage.

In addition, to face the challenges related to long-term planning studies in this complex scenario, Terna has developed a novel methodology to identify additional cost-effective transmission capacity to achieve between internal bidding zones and at the borders of the Italian power system in different planning scenarios. The analysis underlines the need to develop significant cross-border additional transmission capacity, both on the Italian Eastern and Northern borders. The detailed results of the assessment carried out in the framework of the Italian Network Development Plan 2023 are returned in the **Identification of Target Capacity Report 2023**.

7 Reflections for the Region

This first edition of ONDP emphasises the main reactions and steps followed by the region to new policy targets set, especially looking to the integration of offshore wind power generations.

From this perspective, it can be observed that the region is taking its first steps towards offshore expansion mainly at the local level through the installation of a significant capacity of OWFs with radial connections in the long and very-long time horizons.

The main reasons behind this, most of which are due to the recent development of this new technology in many countries, are the following:

- The existing capacity of wind offshore plants is close to zero (only one existing project in Italy of not significant size);
- Different characteristics of the seabed require different types of technology, whose maturity could still be limited;
- Non yet adopted MSPs that could support the identification of appropriate areas for offshore wind farms expansion; and
- A common planning strategy for the development of hybrid projects at regional level is at the starting point through the ONDP Pan-EU Summary "European Offshore Network Transmission Infrastructure Needs".

Reflections per country are described below. The brief overview per country summarises the overview from each respective TSO, and addresses future challenges and the current status of the sector.

Bulgaria

Bulgaria borders the Black Sea to the east. On the Bulgarian territory, the bottom of the Black Sea changes with a very large slope. At 2–3 km from the coast the sea is very deep, and this makes it difficult and very expensive to build wind farms there. According to the World Bank, most of the potential for wind offshore is related to floating wind farms.

Until now, no official applications have been received in Bulgarian TSO (ESO EAD) for the construction of OWFs. Another problem is that Bulgaria has not yet had a change in the national grid code, which describes the requirements for connecting such parks.

Croatia

For this first edition of ONDP, Croatia provided expected capacities for the 2040 and 2050 as radially connected offshore plants to the onshore grid (based on MS inputs). Currently, the Croatian TSO has not received any connection request for offshore plants. In terms of Croatian transmission network, size and specifics targets that are set for each of the time horizons (2030, 2040 and 2050) can be described as highly ambitious. It is expected that, for the connection of new 1.2 or 3.0 GW, new internal reinforcements of the offshore grid are needed. The north part of the Adriatic Sea is more suitable for offshore plants, because of the lower depth of the Sea, and the Croatian TSO expects that the first development of offshore in Croatia will happen in that area. After the commissioning of the first offshore plant in Croatia (time horizon 2030 or after), expandable offshore node the possibility for an expandable node will be considered and Croatia could be involved in the expansion loop for 2040 and 2050 horizons.

Cyprus and Slovenia

Cyprus and Slovenia, respectively the TSOs from Cyprus and Slovenia, have not provided any offshore capacities for the first iteration of the ONDP plan. In the event any offshore development happens (such as the MS of Cyprus provided for TEN-E Regulation then, according to different sources, the wind offshore potential for Slovenia and Cyprus is close to zero or non-existent. The sea depth around the island of Cyprus is a barrier that needs to be tackled. However, in the event any wind offshore development happens, it is expected that the overall numbers will not be influential for the region and ENTSO-e area.

Greece

In this 1st ONDP edition, the upper limits of offshore capacities provided by the MS and adopted in this study for each time horizon were considered as radial connections to the Greek transmission system, with high volumes installed in the East Mediterranean Sea basin, while considering the data available at the time. The resulting outcomes based on the above, should rather be considered as a future possibility than a robust presentation of offshore development needs in Greece. The uncertainty of the specifics for the future development of OWF in Greece – as there are still many steps to be taken towards the maturity of such installations at a country level, along with the continuing evolution of onshore RES – are the most prominent factors that will shape the future editions of this report.

Italy

Given the current status of offshore RES development, in this first edition of the ONDP, Italy presents only radial offshore wind projects, which do not include the presence of expandable offshore nodes.

Future offshore/submarine transmission infrastructure planned by Terna plays a crucial role in the energy transition and significantly contributes to reducing internal congestions, thus enabling RES integration from South to North and through Italian borders towards EU and not EU countries. From this perspective, the Italian transmission grid is characterised by high congested loading centres in the Northern Italy and bottlenecks between mainland and main islands (Sardinia and Sicily) and Southern Italy, where a huge amount of RES is foreseen. To cope with the safe integration of energy produced by RES, these new planned infrastructures presented in the NDP 2023 will take advantage of DC technology, able to deliver power in a bidirectional manner, from South to North and vice versa, while guaranteeing security and quality services to the AC grid.

Romania

There is currently no installed offshore wind capacity, and Transelectrica has not received any specific request to connect to the grid for offshore generation projects. A radial connection to the Romanian transmission system was considered for the offshore wind capacities in this first ONDP, based on the MS targets. In terms of Romanian transmission network size and specifics targets, the connection of 1 GW OWF until 2030 requires new internal reinforcements of the offshore and onshore grid.

8 Conclusions

The EU is accelerating the deployment of renewables to contribute and reach the goal of reducing net greenhouse gas emissions for at least 55 % until 2030. All SE offshore grids (East Mediterranean and Black Sea regions) MSs are contributing to the continental effort in decarbonising the energy mix through the increase of RES connected to the transmission system. In addition to onshore RES, offshore renewable energy solutions are recognised as an important potential provider of steady power output and contribute to reaching the EU's climate and energy goals. Nowadays, in the East Mediterranean and Black Sea region only Italy has installed capacities in offshore wind even if of not relevant capacity.

An offshore transmission infrastructure is a necessary asset to link the RES capacities to the continental energy system. To connect the offshore RES capacities to the mainland, a considerable amount of transmission assets will need to be laid down in the SE offshore grids corridor's waters. Indeed, **8.7, 19.2 and 28.3 GW of transmission assets will be needed in 2030, 2040 and 2050 respectively, covering almost 1,600 km of routes**. The overall **investments up to 2050 could total around 15 billion euros**, just considering the transmission infrastructure connecting the units. The necessary internal reinforcements ensuring the adequate dispatch of the energy produced are not considered in the estimated total investment.

All countries part of the SE offshore grid corridor have strategic interests in the development of tourism specific to the maritime areas, a high number of fishing communities interested by the development of offshore energy systems and relevant areas dedicated to nature conservation, so it is very important to ensure a high level of local communities involvement since in the early phase of its development process.

This first edition of the ONDP did not identify any concepts for hybrid transmission at the cross-border level among countries part of the TEN-E SE offshore grids priority corridor. The main reasons behind this, most of which are due to the recent development of this new type of offshore connection solution in many countries, are summarised below:

- The need of development of national MSPs. At the present, the majority of countries have national legislation that defines the preparation of MSPs, but only Slovenia has developed and adopted an MSP and Italy is in the process of the revision of a draft version; in addition, coordination between MSs on spatial planning is a pre-requisite for the development of hybrid solutions;
- The further development of offshore legal framework for hybrid infrastructure in the countries which are part of this TEN-E offshore priority corridor;
- The necessity of further investigations focused on the specific benefits that could arise from this kind of complex infrastructure compared to radial solutions in this TEN-E corridor; and
- The inclusion of offshore non-binding agreements between MSs into the national scenarios and targets (databases, Energy strategies, NDPs, NECPs etc.);
- Analysis of needed reinforcements of internal onshore transmission networks, in light of the non-binding agreements between MSs, for onshore and offshore grid and generation optimisation.

It is important to state that the above mentioned elements are deemed present challenges that are currently under investigation and resolution. Once they are solved, and with the rapid deployment of offshore radial solutions in this maritime region, opportunities for hybrid interconnections deployment is expected to open also in the SE offshore grids TEN-E corridor.

Glossary

Term	Definition
ACER	The European Union Agency for the Cooperation of Energy Regulators
AOG	Atlantic Offshore Grid (priority offshore grid corridor – EU 2022/869)
BEMIP	Baltic Energy Market Interconnection Plan
BEMIP offshore	Baltic Energy Market Interconnection Plan offshore grids (priority offshore grid corridor – EU 2022/869)
EC	European Commission
EEZ	Exclusive Economic Zone: area of the sea in which a sovereign state has special rights regarding the exploration and use of marine resources, including energy production from water and wind. It stretches from the outer limit of the territorial sea (12 nautical miles from the baseline) out to 200 nautical miles (nmi) from the coast of the state in question. The EEZ does not include either the territorial sea or the continental shelf beyond the 200 nautical mile limit.
EU	European Union
ENTSO-E	European Network of Transmission System Operators for electricity: the European association for the cooperation of TSOs for electricity
IEA	International Energy Agency
IRENA	The International Renewable Energy Agency
MS	Member State of the European Union
MSP	Maritime Spatial Planning
NECP	National Energy and Climate Plan
NSCOGI	North Seas Countries' Offshore Grid Initiative (High level group; 2009 – 2015)
NSEC	The North Seas Energy Cooperation (NSEC) (High level group since 2016, follow-up to NSCOGI)

Term	Definition
NSOG	Northern Seas Offshore Grids (priority offshore grid corridor – EU 2022/869)
NT	National Trends – ENTSO-E scenario in the TYNDP22, building on countries' NECPs.
ONDP	Offshore Network Development Plan (new plan according to Art. 14.2 of EU 2022/869), part of ENTSO-E's TYNDP)
P2X	Power-to-X or conversion of renewable electricity into other forms of energy substances (such as gas, plastic, heat, chemicals etc)
PV	Photovoltaics
RES	Renewable Energy Sources
SB	Sea-basin
SB-CB	Sea-basin cost benefit
SB-CS	Sea-basin cost sharing
SB-ONDP	Sea-basin Offshore Network Development Plan
SE offshore	South and East Offshore Grids (priority offshore grid corridor – EU 2022/869)
SW offshore	South and West Offshore Grids (priority offshore grid corridor – EU 2022/869)
TEN-E	Trans-European Networks – Energy, refers to Regulation (EU) 2022/869 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 30 May 2022 on guidelines for trans-European energy infrastructure, amending Regulations (EC) No 715/2009, (EU) 2019/942 and (EU) 2019/943 and Directives 2009/73/EC and (EU) 2019/944, and repealing Regulation (EU) No 347/2013
TSO	Transmission System Operator
TYNDP	Ten-Year Network Development Plan; generated and published by ENTSO-E every two years for electricity infrastructure and by ENTSOG for gas infrastructure

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