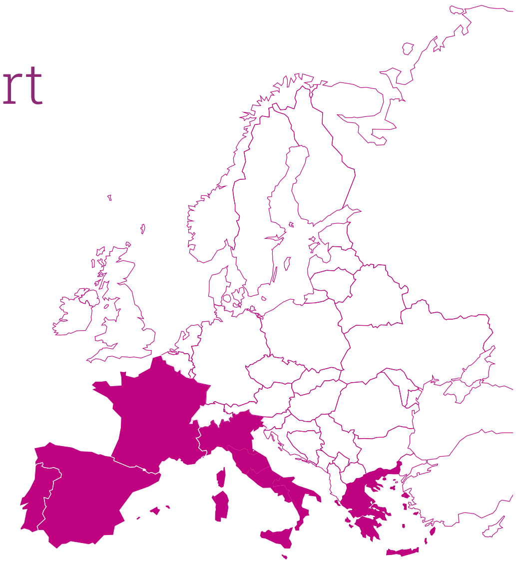
TYNDP 2024

Sea-Basin ONDP Report

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



January 2024

15 YEARS OF entsoe

ELECTRIFYING EUROPE

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.

TYNDP 2024

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

January 2024

How to use this interactive document

To help you find the information you need quickly and easily we have made this an interactive document.

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

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

Arrows
Click on the arrows to move backwards or forwards a page.

Hyperlinks
Hyperlinks are highlighted in bold text and underlined throughout the report. You can click on them to access further information.

ENTSO-E ONDP interactive data visualisation platform

Questions?

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

Contents

Executive Summary: Key Messages for the Sea Basin 6

1 Introduction to the Sea Basin Report 8

2 Member States' non-binding Targets for the South and West Offshore Grids 10

3 Offshore RES Capacities and Infrastructure Today 13

4 Potential Environmental Impacts – specific to West Mediterranean Sea Basin 20

5 Spatial Planning Needs for the West Mediterranean, South and West Offshore Grids 25

6 High-Level Results on Offshore Network Infrastructure Needs 35

7 Reflections for the South and West Offshore Grids Corridors and Conclusions 37

Glossary 40

Acknowledgements 42

Executive Summary: Key Messages for the Sea Basin

The European energy framework is currently undergoing an unprecedented transformation to support the fulfilment of the European Energy Targets. A comprehensive overhaul of electricity generation in Europe is in progress. Nuclear and fossil fuel-based power generation have already been partially supplanted by alternative primary energy sources and various types of power plants that can be deployed in different locations. The substantial increase in electricity production from variable Renewable Energy Sources (RES) commenced several decades ago but must accelerate further to meet carbon neutrality objectives.

In the coming decades, offshore wind power generation will play a pivotal role due to its high availability rates, greater public acceptance compared to onshore wind and substantial utilisation potential across Europe. These developments directly impact the transmission infrastructure, which must evolve in parallel with these changes. Therefore, it is crucial to recognise that offshore development is one of several critical aspects to consider when shaping the future of energy systems.

To this aim, on 3rd June, 2022, the EU's revised TEN-E regulation (2022/869) entered into force, requiring ENTSO-E to develop Offshore Network Development Plans (ONDPs) for each sea basin by 24th January, 2024. The ONDP translates the non-binding targets delivered by the Member States (MSs) in January 2023 into offshore transmission equipment needs and related costs.

The Sea Basin Report (ONDPs) are part of ENTSO-E's Ten-Year-Network Development Plan (TYNDP) and must align with joint MSs' non-binding agreements on offshore renewable energy goals.

The ONDP for the South and West Offshore Grids (SWOG), covering the West Mediterranean and the Gulf of Cadiz, has been developed in alignment with the join non-binding agreements delivered by the MSs in January 2023, also considering, in coordination with the MSs, the updated targets for some of them. Offshore wind power is maturing and expanding, with larger turbines and growing capacities. Transmission System Operators (TSOs) will face many challenges for their integration to the grid, including the use of floating technology AC and DC in deep seabeds, such as the Mediterranean Sea.

In addition to the technological aspect, environmental and spatial planning needs are also crucial for offshore wind development. The main efforts are related to minimising impacts on landscapes, cultural heritage and protected areas.

The report emphasises the importance of infrastructure development to accommodate the transition to decarbonised electricity systems, particularly to Offshore Power Plants in the West Mediterranean Basin comprising Spain, France, Portugal, Italy, Greece and Malta.

As better described in the next chapters, at the current stage the Offshore development for the Mediterranean West Sea basin can be summarised as follows:

- As of today, the offshore transmission infrastructure consists mostly in traditional High Voltage submarine links (cross boarder interconnectors and internal reinforcements). The total amount of offshore RES connected to the continental systems totals 110 MW;
- In the coming decades, offshore transmission infrastructure will be developed to support on and offshore RES integration, both with direct connections to the offshore generation units, offshore HVDC reinforcements and cross-border transmission infrastructure;
- In this first edition of the ONDP for the SWOG corridor, the total amount of offshore generation is foreseen to be connected through radial configurations. To connect the offshore RES capacities to the mainland, a considerable amount of transmission assets will need to be laid down in the corridor's waters. 5.6, 17.1 and 21.1 GW of transmission assets will be needed in 2030, 2040 and 2050 respectively. The overall investments up to 2050 could total 14.3 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;
- The deployment of offshore RES in the West Mediterranean basin strongly depends on the development of floating technologies and dynamic cables due to the important depths (beyond 100 m) reached by all national waters just a few nautical miles off the coasts; and
- The unique marine environment characterising the West Mediterranean basin will require a particular effort in spatial planning to ensure the coexistence of the energy infrastructure, nature conservation and economic interests.

1 Introduction to the Sea Basin Report

On 3 June 2022, the revised TEN-E regulation (EU) 2022/869 went into force, mandating ENTSO-E with the new task to develop ONDPs for each sea basin by 24 January 2024. Formally, the ENTSO-E's ONDs are a separate part of ENTSO-E's TYNDP.

The offshore plans should be in line with the MSs' non-binding agreements and offshore RES goals for each sea basin. On 19 January, EU countries, with the support of the European Commission (EC) 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. The ONDPs deliver a high-level outlook on offshore generation capacities potential and resulting offshore network infrastructure needs for each sea basin. The sea basins and involved countries are laid down in the regulation and shown in Figure 1.

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.

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

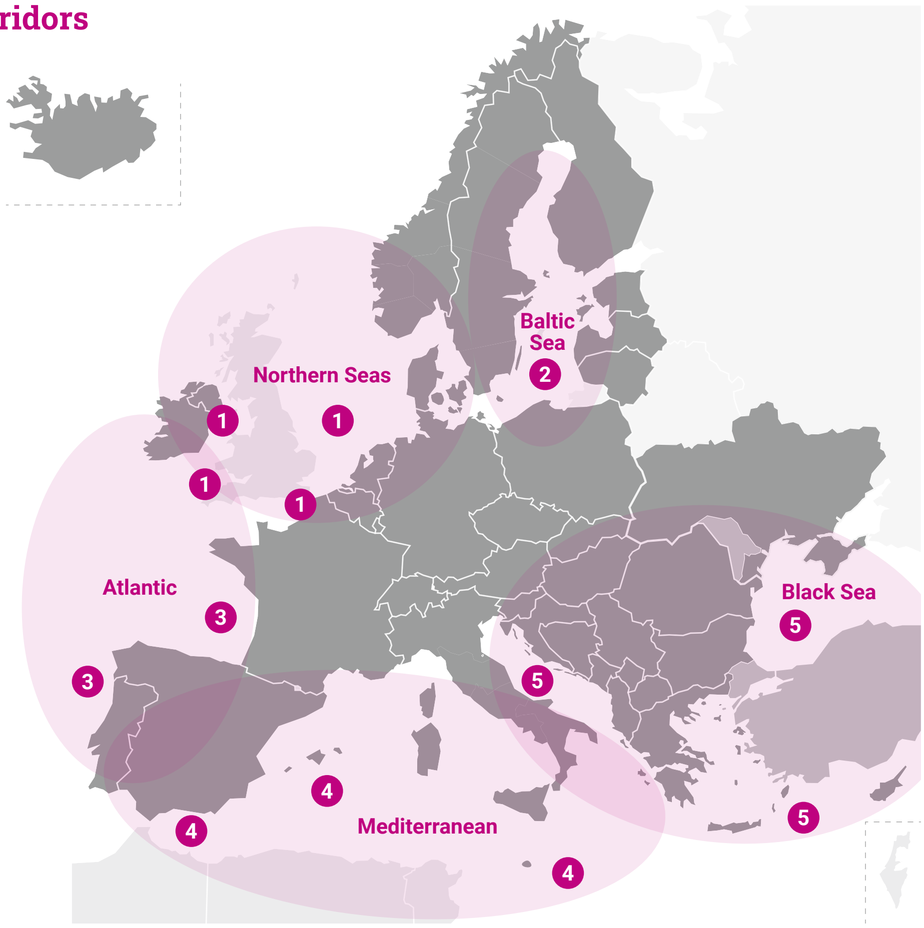


Figure 1 – TEN-E Priority Offshore Grid Corridors as laid down in Regulation (EU) 2022/869.

The present document comprises 8 chapters with detailed information at the regional level:

- **Chapter 1: 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 2: Member States' non-binding Targets:** This chapter focuses on the analysis of MSs' non-binding targets for offshore wind capacity. It discusses variations (and reasons) between data declared by ENTSO-E/TSOs and MSs for each country in the West Mediterranean Basin.
- **Chapter 3: Offshore RES Capacities and Infrastructure Today:** This chapter provides an overview of the current state of offshore wind power, highlighting its growth potential and technical advancements. It discusses challenges faced by TSOs, particularly in regions with deep seabed such as the Mediterranean Sea.
- **Chapter 4: Environmental Needs – specific to Sea Basins:** This chapter emphasises the importance of developing offshore wind projects while preserving landscape, cultural heritage and environmental integrity. It discusses the need to consider protected areas, including Marine Protected Areas and Natura 2000 sites, and outlines the potential impacts of offshore wind power plants on marine habitats and species.
- **Chapter 5: Spatial Planning Needs – specific to Sea Basin:** This chapter discusses spatial planning needs for offshore wind development in different sea basins.
- **Chapter 6: 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. It emphasises the importance of anticipating the evolution of national generation capacity to accommodate additional renewable capacity safely.
- **Chapter 7: Reflections for the South and West offshore grids corridors and conclusions:** This chapter describes the role of TSOs in the Offshore Wind integration process and reflects on possible mitigations of the current challenges faced.

2 Member States' non-binding Targets for the South and West Offshore Grids

The ONDP analysis has been carried out in line with the non binding agreements delivered by the region's MSs in January 2023, and adding, in coordination with the relevant ministries, the most updated information at national level in terms of offshore generation gathered in the framework of the next forecasting energy scenario under development for the next TYNDP 2024, derived from TSO's inputs.

Figure 2 shows how the data declared from ENTSOE/TSOs and Member State are quite different for most countries of the West Mediterranean Basin.

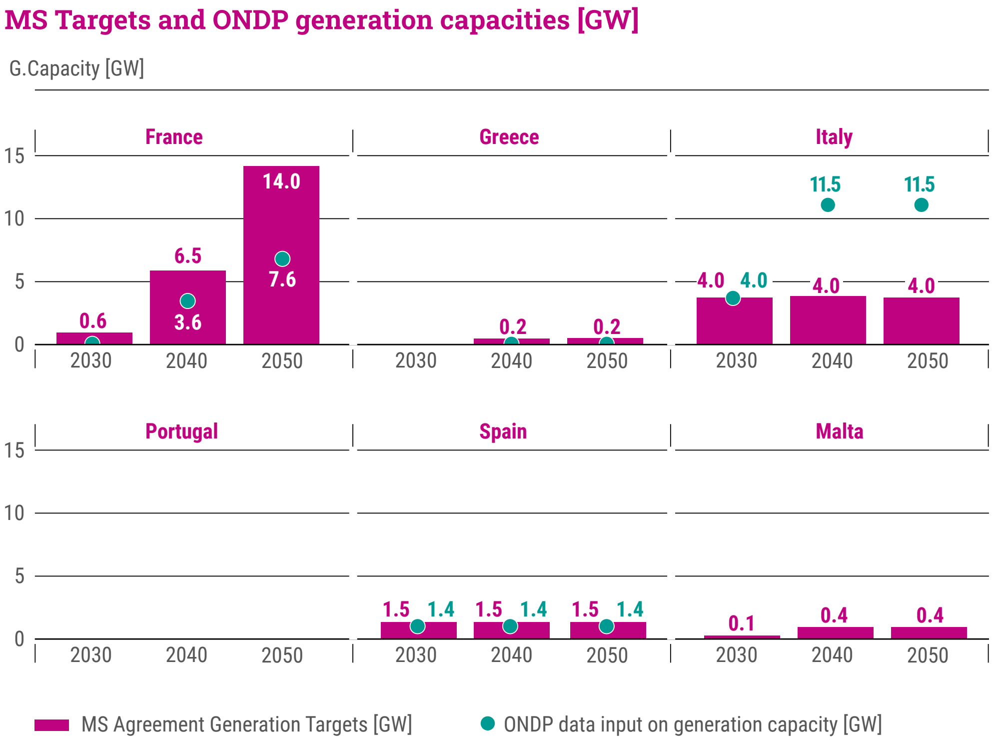


Figure 2 – Wind Offshore Targets in the South West Sea Basin.

Regarding Spain, the Figure includes the non-binding offshore RES targets provided by the Spanish government for the Mediterranean West Sea basin, which includes a total amount of 1,560 MW for the 2030, 2040 and 2050 horizons. Those targets have been provided at national level; that is, also considering non-peninsular territories. The slight differences between those numbers and the final ones considered in ENTSOE's models (1,400 MW) are due to the forecast for the installation of offshore in the Canary Islands being discounted from the total figure.

Regarding Portugal, TSO generation data are aligned with PT government's non binding agreements.

Regarding Greece, MS' Targets are aligned with entsoe/TSO generation data.

Regarding France, it is adjacent to three sea-basins and had delivered ranges to all of them. However, summing the maxima up would exceed the intended national policies. At the point of data collection in January 2023, the allocation to the sea basins was not yet clear, confirmed by a range from 10.4 GW to 47.5 GW in 2050 given by the MS. During further work on the ONDP in 2023, the MS and TSO agreed on the value shown in the table. This target of 40 GW considered by the ONDP was re-affirmed by president Macron during the North Sea Summit of 24 April 2023 as the French contribution to the 300 GW target of the EC by 2050.

At a later stage (June 2023), France updated its official targets[1]. The differences by time horizon may be summarised as follows:

	2030	2040	2050
Non binding target (Jan 23)	0.6	1.6 to 6.5	1.6 to 14
ONDP data collection (March 23)	0.1	3.6	7.6
Official updated targets (June 23)	0.6	3 to 4.5	4 to 7.5

National targets including the three sea-basins now range from 18.5 to 30.5 GW in 2040 and from 40 to 59 GW in 2050.

Regarding Italy, the data for offshore generation on Italian side are derived from Terna Scenario Description Document 2022.

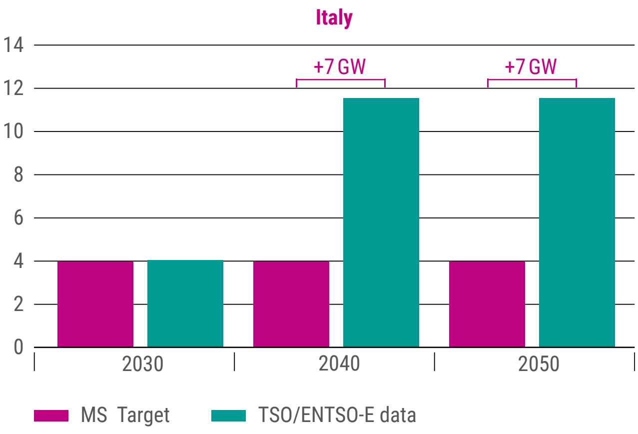


Figure 3 – Wind Offshore Targets in Italy.

The developed policy scenario includes 8.5 GW of offshore wind generation 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 4) and the technological maturity of these generation sources. Most of the connection requests (more than 80 %) are concentrated in the southern Italian regions, where the potential for offshore wind, both regarding geographical suitability and producibility, is higher.

For the West Mediterranean Sea Basin, the Italian MS target of a new 4 GW of offshore wind installed capacity is confirmed in 2030. For the 2040 and 2050 time horizons, the flat value of 4 GW for the Italian MS targets represents a minimum technical value.

1 Letter sent 6 June to the Sea Basin Coordination Prefects, signed by the Minister of Energy Transition, the Minister of Ecological Transition, the Secretary of State in charge of the Sea and Secretary of State in charge of Ecology

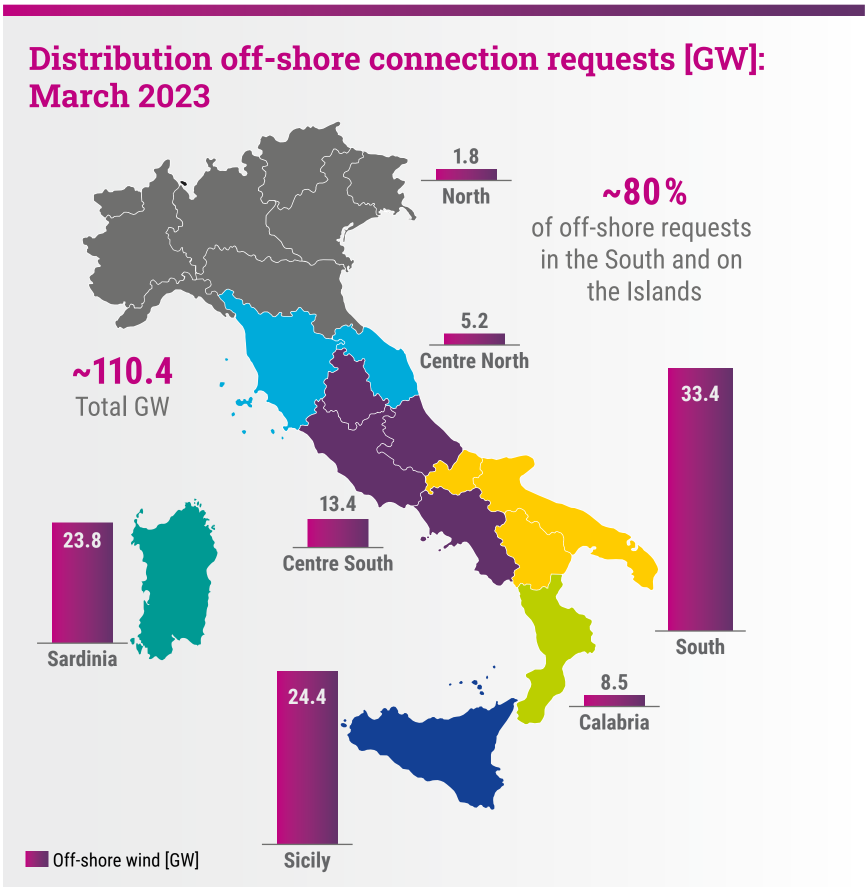


Figure 4 – Connection requests in Italy at March 2023.

Regarding Malta, at the current stage Malta is not part of ENTSO-E. In addition to the infrastructure connecting the planned capacities included in the non-binding agreements delivered in January 2023, the offshore investments are related to the HVAC submarine link between Malta and Italy (Sicily), of which:

- One is a 220 kV line already in operation with an NTC increase of ~200 MW; and
- The second will double the existing one with a capacity increase of 200 MW.

3 Offshore RES Capacities and Infrastructure Today

Offshore wind power is an increasingly mature renewable energy technology poised to assume a pivotal role in future energy systems. While it has so far only contributed to a small portion of the world's electricity needs, its significant expansion is on the horizon in the coming two decades.

Turbines are increasing in both physical size and power generation capacity, leading to substantial enhancements in performance and cost-effectiveness for offshore wind farms. The increase of offshore wind projects presents a multitude of technical and operational challenges for TSOs. One of those issues refers to the fact that the floating technology is specifically applied in deep seabed, such as the Mediterranean Sea, especially close to Italy. Based on that, the technological evolution represents one of the key points driving the Offshore development among such countries. The following paragraphs describe the current situation in the South West Sea Basin of Offshore Power Plants already in operation.

Status of Offshore Power Plant in Spain

In Spain, the first floating offshore wind turbine has recently connected to the grid (August 2023) and generating power. It is a pilot program called DemoSATH, a floating offshore wind project of 2 MW. The offshore wind turbine is located two miles off the Basque coast (Atlantic Ocean Sea Basin) and its annual production is equivalent to the annual electricity consumption of approximately 2,000 Spanish households.

The Spanish Member State objectives provided assume 1400 MW of wind farms by 2030 in the Mediterranean West Sea Basin and maintain that value stable from 2030 to 2050. In the following Figure, the distribution of the Spanish wind offshore farms in the Mediterranean Sea Basin is shown according to the polygons identified in the Marine Spatial Planning (MSP) for offshore development.

The location proposal is based on the offshore target figure established in the offshore generation roadmap, as well as in the areas of high potential for the development of offshore wind energy established in the Spanish MSP approved (POEM) in 2023.

These projects will connect radially to the onshore transmission system. The current National Development Plan plans the extension of the substations where these offshore wind farm could be connected. Further investigations regarding technology to be used (AC, DC, voltage, etc.), and potential internal reinforcements will be defined in the coming future.

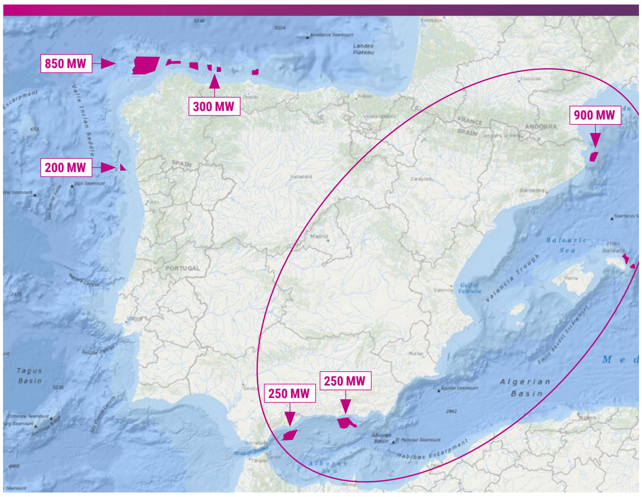


Figure 5 – Map with the areas identified for offshore generation in the Spanish maritime spatial plan.

Status of Offshore Power Plant in service in Portugal

Currently, Portugal has an installed capacity of 25 MW. This capacity relates to the Windfloat Atlantic Project consisting of 3 wind turbines (8.4 MW each), supported by 3 semi-submersible floating structures located in the coast of Viana do Castelo. The project was commissioned in 2020.

A first version of the Portuguese NECP revision was disclosed last June, where the objective of installing up to 2 GW of new capacity in an oceanic location by 2030 is defined. For this, capacity allocation models for the injection capacity in the electricity grid are being studied, with a first auction foreseen to the end of 2023. It is intended to allocate 10 GW by 2030.

An inter-ministerial working group for offshore wind was created by the Portuguese government as part of the process and a report was issued, presenting several areas in the maritime space that could accommodate 10 GW of offshore wind capacity (none of the areas is located in the Mediterranean Sea). That report was submitted to a public consultation. In July, the **Final Report** on offshore wind areas was published.

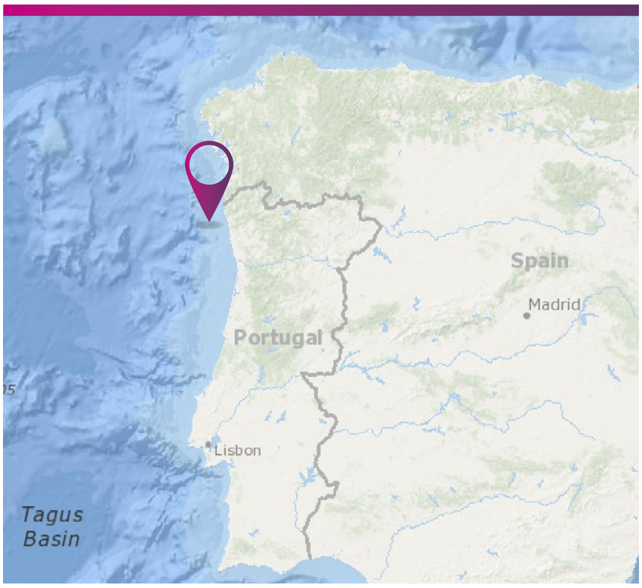


Figure 6 – Windfloat Atlantic Project location (source: 4C Offshore).

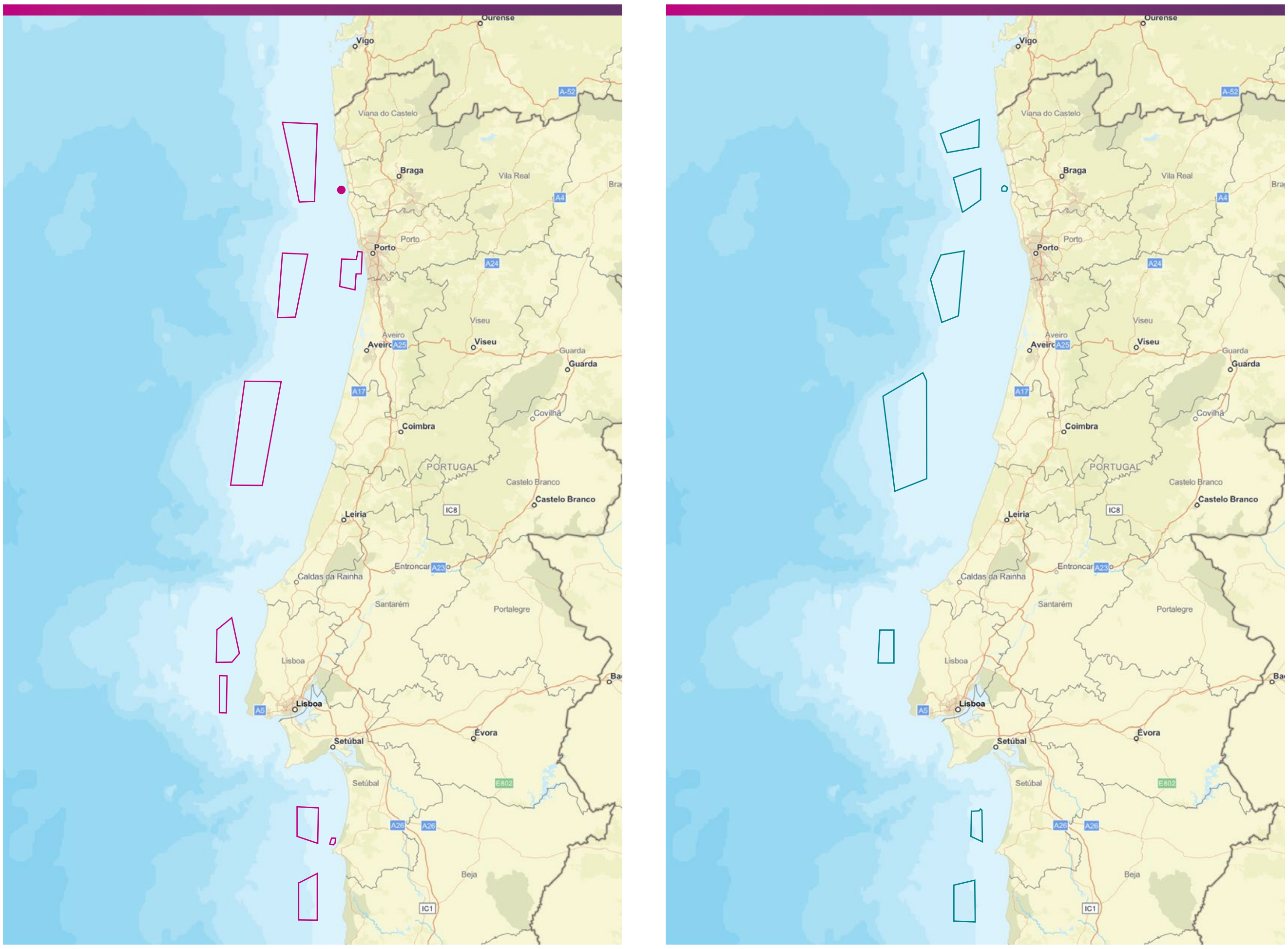


Figure 7 – Map with the areas submitted to public consultation (left) map with the new areas proposed by the working group (right).

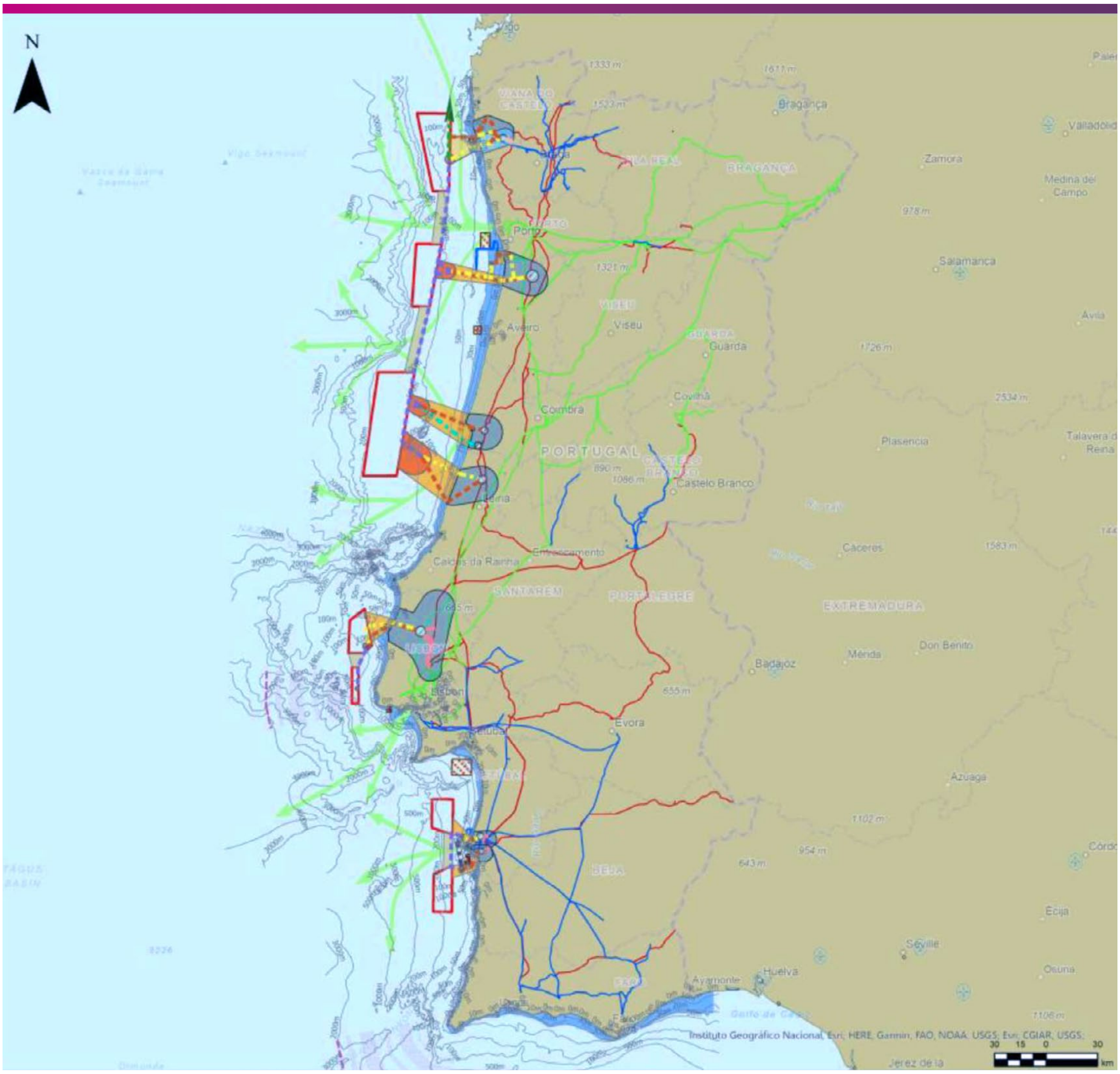


Figure 8 – Map with the proposed offshore network and connection to the onshore network.

The working group has developed some preliminary studies, identifying best locations for offshore wind farms and resource potentials, considering limitations due to maritime activities and environmental impacts. A preliminary study to evaluate possible solutions to connect the offshore areas to the onshore grid was also performed. Among other topics, this preliminary study looked for establishment costs, operation costs, transmission energy losses and needs regarding the decommissioning of offshore wind farms and the related infrastructure, in addition to the reliability aspects of the expected performance of the network. The working group will continue the technical work to further refine the areas selected to produce offshore wind energy, in addition to the auction models to be adopted and the development needs of the electrical grid and port infrastructures.

Status of Offshore Power Plant in service in 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 offshore wind farms 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 ongoing.

Status of Offshore Power Plant in France

Three generations of offshore grids are being developed by RTE:

The **first generation**, 3 pilot farms[2], with radial 66 kV HVAC connections, totals 85 MW offshore wind capacity to be connected before 2030. The offshore and onshore cable routes amount to 76 km;

The **second generation**, with 2 radial 225 kV HVAC hubs, totals 0.5 GW offshore wind capacity to be connected before 2031, expandable to an additional 1 GW at a later stage. The offshore and onshore cable routes amount to 113 km; and

	Project	Connection capacity (MW)	Technology	Commissioned
Pilot	Faraman	25	HVAC 66 kV	2023
Pilot	Leucate	30	HVAC 66 kV	2024
Pilot	Gruissan	30	HVAC 66 kV	2024
A06	Occitanie	250 (expandable to 750 MW)	HVAC 225 kV	2031
A06	PACA	250 (expandable to 750 MW)	HVAC 225 kV	2031

The additional capacity required to reach the governmental targets, i.e. between 3 and 4.5 GW in 2040 and between 4 and 7.5 GW in 2050, will form the **third generation** of offshore grids. For the purpose of the ONDP study, RTE considered for this generation standardised 525 kV "offshore grid ready" conceptual projects located in the development areas A, B and C, defined by the State in 2022[3]. The offshore grid to be developed at the 2040 horizon will be confirmed by a ministerial decision following the French public debate to be held late 2023 to mid-2024 and will be considered in the next edition of the ONDP.

2 One out of the three pilot farms connection is out of RTE's scope.

3 Journal officiel n° 0067 du 20/03/2022 - Décision du 17 mars 2022 consécutive au débat public portant sur le projet d'éoliennes flottantes en Méditerranée et leur raccordements

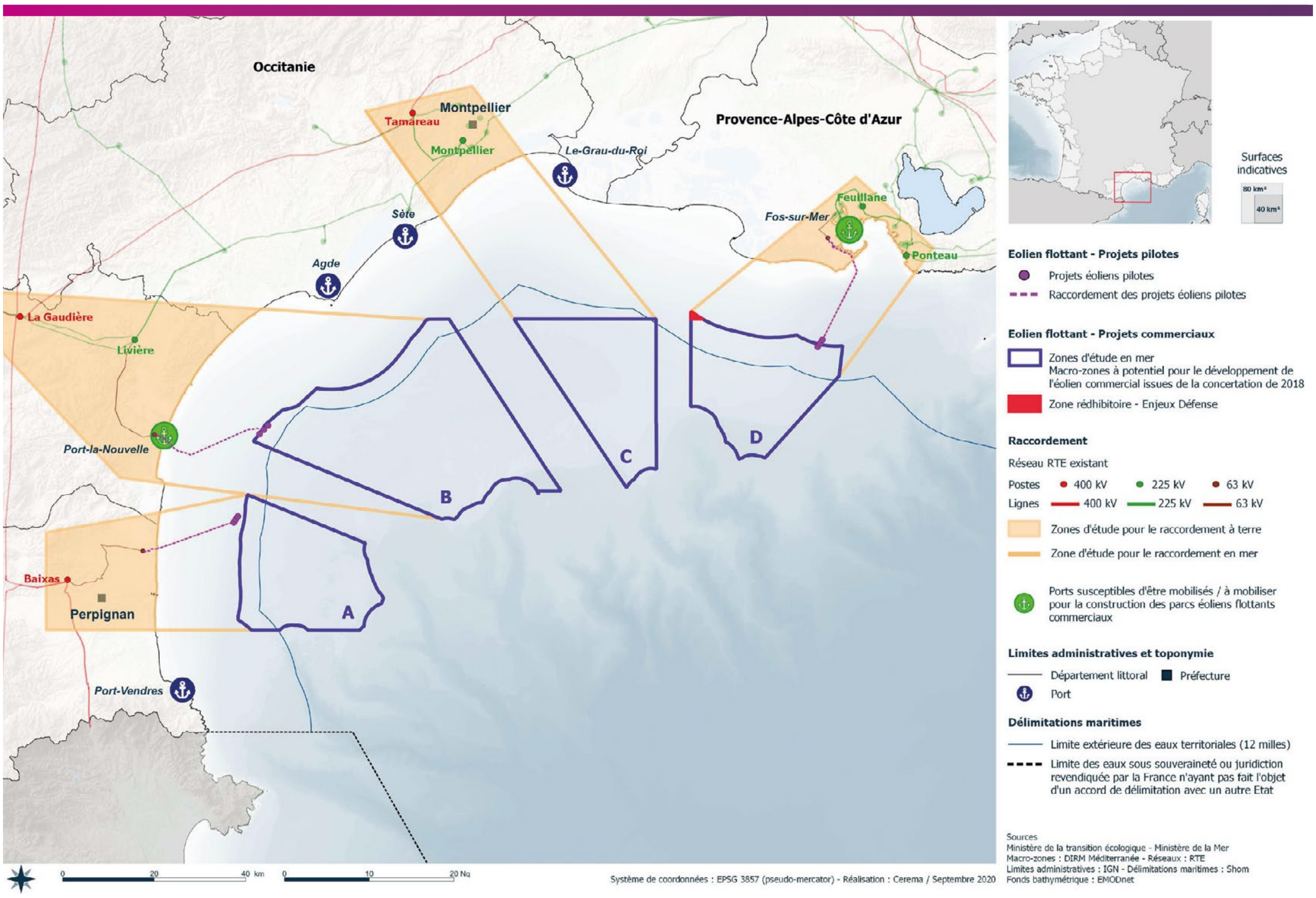


Figure 9 – Offshore development areas in the French Mediterranean sea basin.

Status of Offshore Power Plant in service in Italy

At the current stage in Italy there is only one offshore wind farm application in service. The project, located in Taranto (Apulia, South of Italy) and which came into operation in May 2022, is composed by 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 there is currently only one OWF in operation, it should be highlighted that, as mentioned in the previous chapter, Italy will face in the next few years several challenges for the achievement of the energy transition new climate targets, especially regarding offshore wind integration. To this aim, even though Italy has not currently planned hybrid interconnection, RES integration (including offshore wind) will be granted thanks to significant developments regarding offshore and onshore grid internal/cross-border reinforcements expected in the next coming years (see Chapter 7).

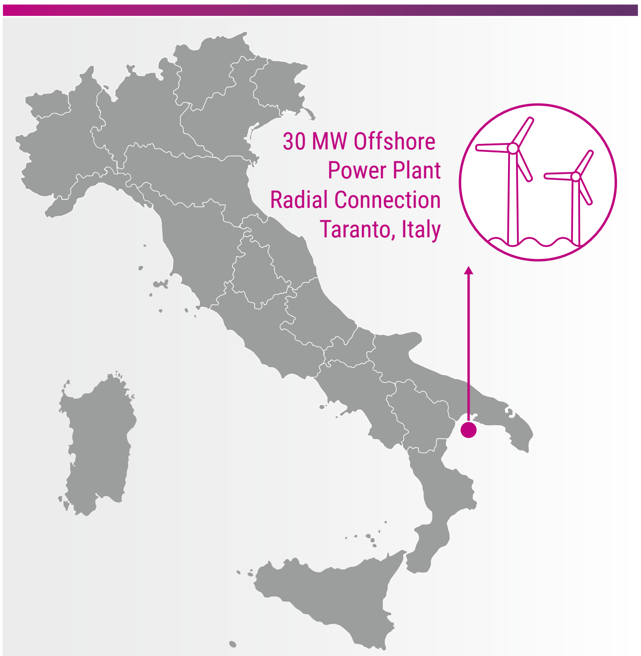


Figure 10 – Offshore Power Plant in service in Italy.

In this regard, it is worth remembering 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 (EHV).

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 11).

The existing tie lines, in addition to new interconnection and internal planned projects, will be functional to the connection of offshore wind farm application requests and the transmission of RES generation from the Southern Italy and the main islands to the North.

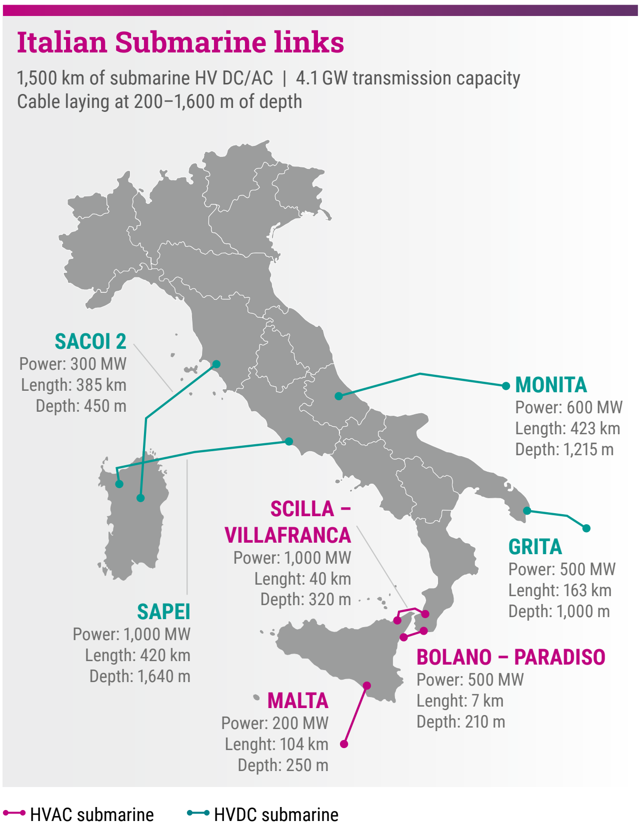


Figure 11 – Italian existing submarine cables.

Connection solution for Offshore Wind Power Plant – the Italian framework

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.

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

› 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
› the 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 environmental impact.

Figure 12 below illustrates two technical solutions specifically developed for incorporating offshore wind generation into the Italian power system. Both options necessitate meshed 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 an 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. [Further details can be found here](#).

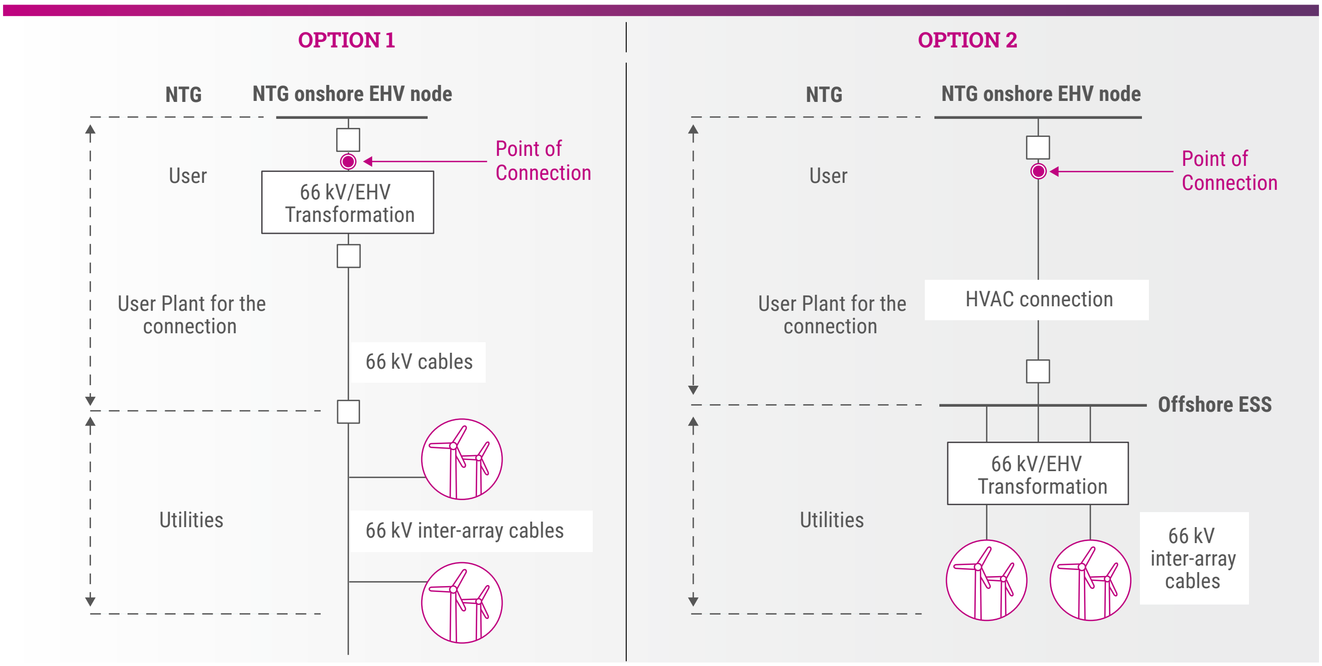


Figure 12 – Technical solutions defined for the wind offshore generation (Italian case).

4 Potential Environmental Impacts – specific to West Mediterranean Sea Basin

Offshore Wind development must be done without affecting the landscape and cultural heritage integrity. Therefore, it is necessary to allow systemic, harmonious and sustainable development aimed at protecting and enhancing the landscape, environmental and cultural historical heritage.

More in general, RES development needs to consider protected areas, both those with specific environmental protection objectives (Marine Protected Areas, Natura 2000 sites) in addition to those that directly and/or indirectly pursue environmental protection objectives.

In particular, renewable energy expansion offshore is characterised by some land-sea interaction in relation to landing point of submarine cables, and the presence of sites dedicated to the construction, assembly and maintenance of infrastructure, in addition to maritime traffic related to the construction and operational management activities.

The offshore wind power plant 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.

The most effective method of avoiding potential conflict with Natura 2000 sites and EU-protected species and habitats is through careful choice of the site where a wind farm will be built. Other mitigation measures designed to minimise impacts on marine habitats include choosing the least disruptive technical solutions for installation.

Spanish framework

The Spanish Mediterranean West Sea Basin covers three of the five subdivisions which divide the Spanish maritime space: South Atlantic subdivision, Estrecho and Alborán subdivision and Levantine-Balearic subdivision.

The **South Atlantic** subdivision is located in the southwest of the Iberian Peninsula and is limited by the coast of southern Portugal, the southwestern coast of Spain and the northern coast of Africa.

The northern continental margin is bounded by Tarifa in the Strait of Gibraltar, and towards the west by Cape Saint Vincent in Portugal.

The waters of the subdivision, together with the Strait of Gibraltar and the Alboran Sea, form a particular oceanographic set influenced by the double exchange of waters between the Mediterranean and the Atlantic.

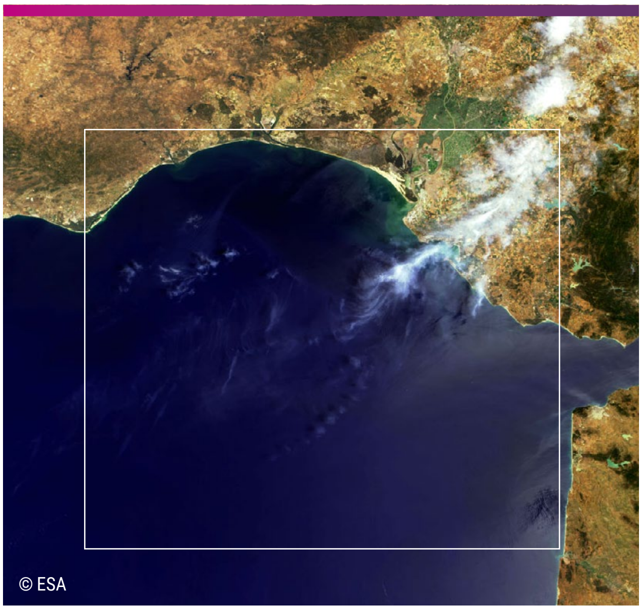


Figure 13 – South Atlantic subdivision.

Figure 14 – Estrecho and Alboran subdivision.

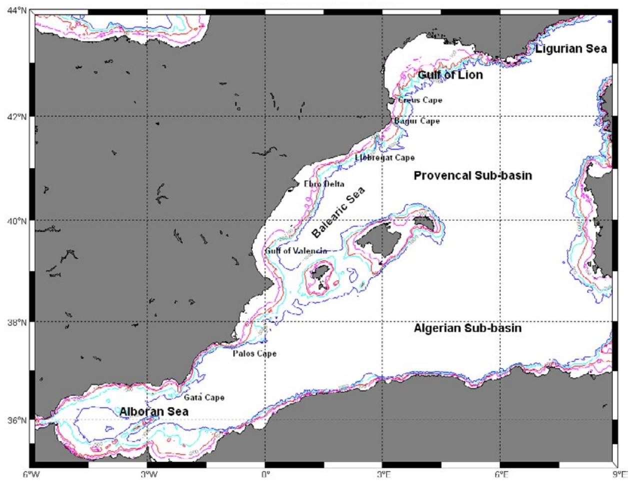


Figure 15 – Levantine-Balearic subdivision.

Compared to the waters of the Mediterranean, the waters of this subdivision are relatively warm and not very saline and feed the surface flow that enters the Mediterranean Sea, conditioning the circulation of the Alboran Sea.

From an oceanographic perspective, the surface circulation in the South Atlantic subdivision is characterised, in general terms, by variable anticyclonic periods throughout the year and related to variations in the prevailing wind regimes: East and West.

Although, as a whole, the waters of the subdivision are considered oligotrophic, the existence of outcrops in specific areas, with deep waters rich in nutrients, supports important fishing and biological activity at the regional level.

The **Estrecho and Alborán** subdivision is the prelude to the transition between the Mediterranean Sea and the Atlantic Ocean, where oceanic masses of different salinity and temperature coincides.

The shallow depth of the Strait of Gibraltar, less than 300 m, is a determining topographic feature in the functioning of the marine ecosystem of Alborán. Given the importance of its ecosystems and biodiversity, it is also considered the driving force of biodiversity in the Western Mediterranean.

The **Levantine-Balearic** subdivision includes the coast that extends between the capes of Creus (located in the Northeast of the Iberian Peninsula) and Gata (located in the Southeast of the Iberian Peninsula) and the Balearic Islands and is bathed by the waters of the Mediterranean Sea. Its marine waters bathe the coastline of the autonomous communities of Andalucia, Murcia, Valencia, Catalonia and Balearic Islands. The area covered by the marine waters of this subdivision is approximately 233,000

The length of the coast of this subdivision totals approximately 2,400 km, being distributed throughout the Algerian and Provençal sub-basins and including the Balearic sub-basin, between the islands and the peninsula. The area is limited to the North by the Gulf of Lion, characterised by strong atmospheric forcing, and to the South by the Algerian basin, dominated mainly due to density forcing. As a consequence of this contrast between the dynamics of the Northern and Southern regions, the Balearic basin acts as a transition basin, where strong adjustments occur. For this reason, the Balearic Islands and its canals play an important role in the general circulation of the Mediterranean Western.

Portuguese framework

The deployment of OWF and the supporting offshore electrical infrastructure (offshore substations, cables) will have an impact on the marine ecology and marine-based economies such as fishing. The need to define spaces for OWF and the electrical infrastructure requires an effort to make activities compatible and, in some cases, there may even be synergies between uses of maritime space. Compatibility of uses involves continuous monitoring of the effects of activities located in the same maritime space, particularly on biodiversity and water quality descriptors.

One of the biggest challenges for making uses compatible with OWF is related to commercial fishing. The compatibility of fishing activities must be duly taken care of when designing each of the wind farms and the electrical infrastructure, and it is absolutely critical to define safety protocols for access to possible fishing areas. The installation of offshore fixed-bottom\floating platforms for wind energy should provide synergies between the renewable energy sector and the aquaculture sector.

Regarding the marine ecology, the most relevant impacts are habitat disturbances, mainly during the construction phase, production of underwater noise and vibration, collision of wildlife with infrastructure and vessels. Electrical infrastructure on the seabed can also induce electromagnetic field (EMF) and heat emissions, affecting marine life. Those impacts should be minimised during the project design (routing/ sitting process) by identifying sensible ecosystems and environmental constrains or by applying mitigation measures, particularly to the construction phase, such as choosing the right timing and cable laying techniques.

The installation of wind farms and the supporting offshore electrical infrastructure could result in Cultural Heritage impacts, and to avoid that effect archaeological campaigns should be undertaken in the project design phase and further monitoring should occur during the construction activities. The places identified during this process should become places of visitation in a structured or free manner, such as the practice of scientific and recreational diving. Safety conditions for practice must be guaranteed, requiring coordination with the competent captaincies. It should also be noted that these places usually promote the biological productivity of the oceans.

Greece framework

Planning and future development of OWF in Greece considers the country's broader planning for the protection of the environment and biodiversity.

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).

In Greece, fishing is an important activity in ecological, economic, social and cultural terms and yields the largest share (23 %) of the total European small-scale fisheries (SSF).

In 2017, Greece had 14,987 active fishing vessels registered, representing 17.3 % of the fishing fleet operations in the Mediterranean and the Black Sea.

As shown in Figure 16 below, Natura 2000 sites and small-scale coastal fishing areas are indicated along the seashore of many islands and the mainland, constituting thorough environmental assessments for the connection and the site location of OWF installations.

The Greek maritime space also includes species such as Posidonia fields, a species of aquatic plant endemic to the Mediterranean Sea. These sites, although not mapped within the Natura 2000 sites, are considered in the environmental assessment of a subsea connection project.

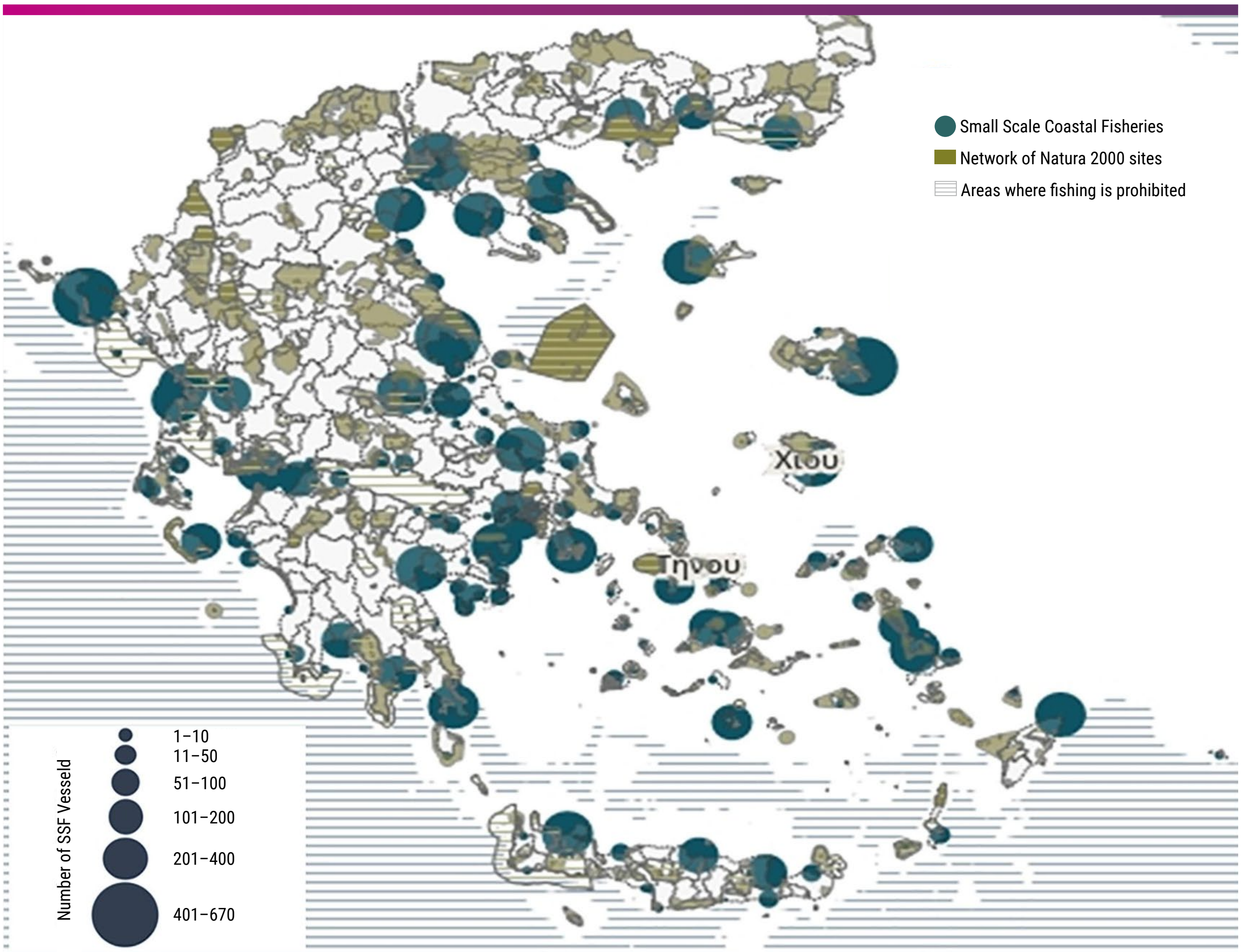


Figure 16 – Small-scale coastal fishing areas and the Network of Natura 2000 sites in Greece. Source: Kyvelou & Ierapetritis, 2021, based on data from the WWF Web Mapping Application "OIKOSKOPIO.GR", 2020.

French framework

47 % of the Mediterranean French Sea waters are environmentally protected areas, including two National Parks and two Natural Marine Parks.

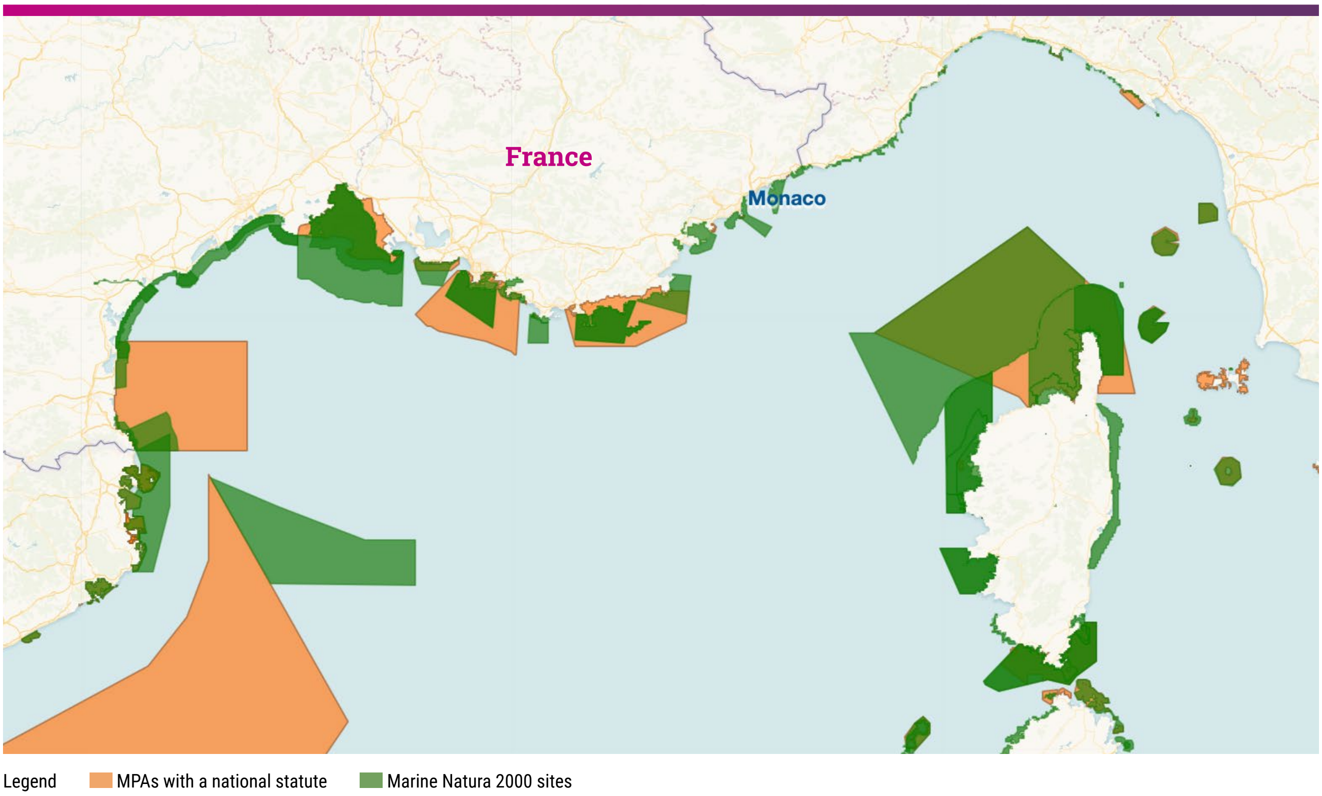


Figure 17 – Protected natural areas in the French Mediterranean sea basin.

Italian situation in the West Sea basin

Looking to Italy, the main mitigation measures to effectively prevent significant effects on the seascapes and related visual impact involve plant site selection and layout configuration. In particular, layout choice should be based on:

- Landscape and environmental consideration;
- Marine use and interaction with other uses rationalisation; and
- Technical consideration finalised to energy production optimisation.

Due to its very high ecological, landscape and cultural value, the Ionian Sea area is covered by numerous instruments of environmental and cultural protection, including many marine protected areas (MPAs). For further details, please refer to MSP.

The entire maritime area of the Western Mediterranean in general 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). From all perspectives, the study area is influenced and linked to the social, economic, geographical and environmental characteristics and dynamics of the underlying coastal zone, and vice versa. For many of the activities present, significant growth is expected in the coming years, with a potential increase in conflicts with other uses and pressures on the environment, possibly aggravating the complex consequences of climate change.

5 Spatial Planning Needs for the West Mediterranean, South and West Offshore Grids

The following sections provide an overview of the MSP frameworks in Italy, Greece, Portugal, Spain and France.

These frameworks aim to manage and regulate activities within their respective maritime areas, ensuring sustainable development, environmental protection, and compatibility between different uses and activities in their coastal and marine territories. Each country's approach to MSP reflects its unique geographical, economic, and environmental characteristics.

Spanish framework

Spain adopted its MSP, the **Planes de Ordenación del Espacio Marítimo (POEM)**, in **February 2023** by Royal Decree. It establishes a plan for each of the five Spanish marine subdivisions:

- North Atlantic;
- South Atlantic;
- Estrecho and Alboran;
- Levantine-Balearic; and
- Canary Islands.

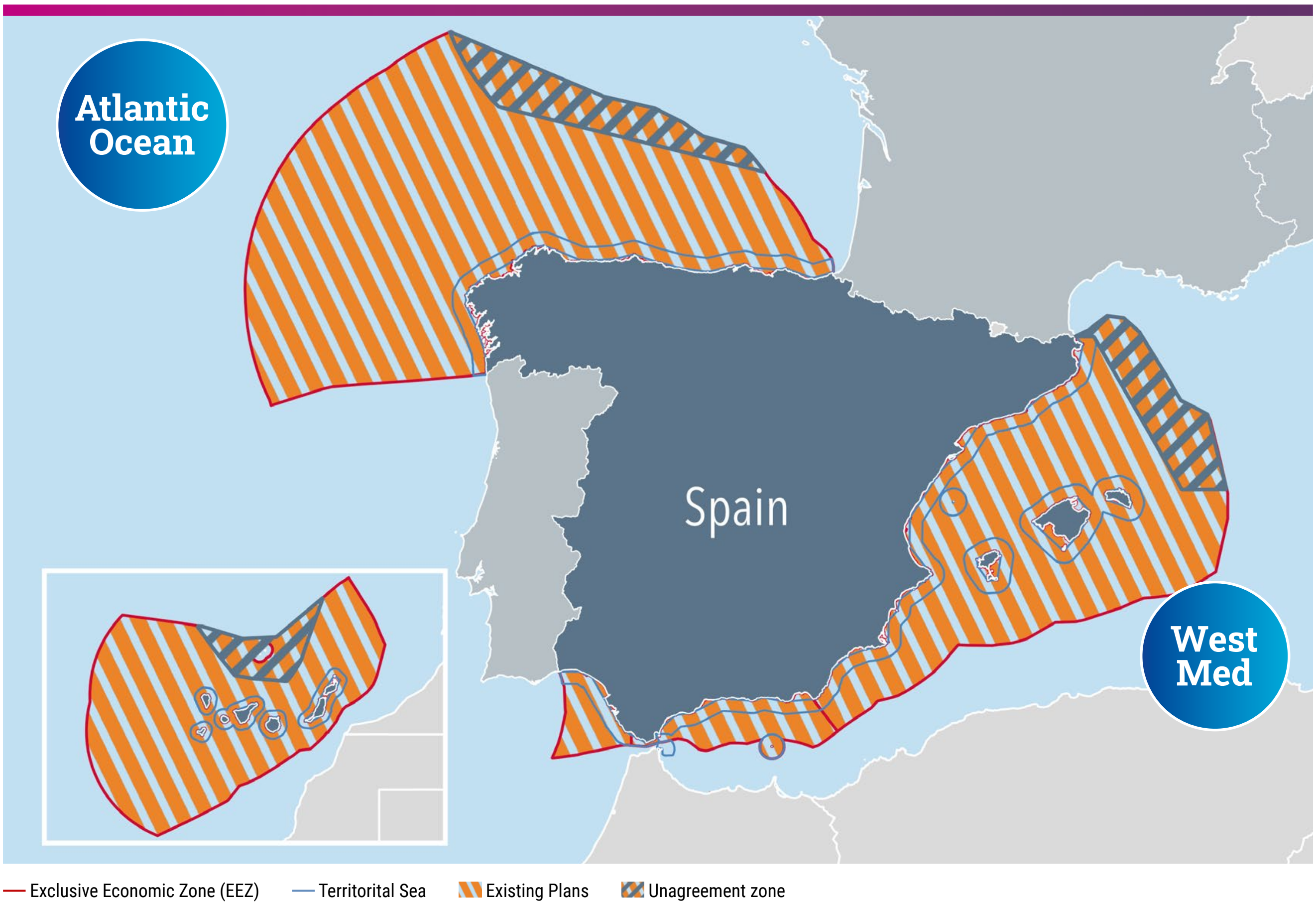


Figure 18 – Spanish maritime subdivisions.

The POEM provides relevant information establishing high potential areas for offshore wind energy development. The delimitation of these zones for the development of offshore wind energy has been carried out after a detailed analysis in which multiple variables have been considered: availability of the wind resource, impact on marine biodiversity, safety in the navigation, air safety, and national defence; and the reduction of conflicts between other present and/or future uses and activities, such as aquaculture, tourism or fishing.

The areas of high potential for offshore wind energy meet the following technical criteria:

- The wind resource is suitable for commercial exploitation as wind speeds exceeding 7.5 m/s are recorded at a height of 100 m for the four peninsular marine subdivisions, and a height of 140 m in the Canary Islands subdivision;
- The depth does not exceed 1000 m;
- If possible, they are close to an onshore area with the adequate electrical infrastructures for the evacuation of the generated energy; and
- They have been delimited as such in these plans.

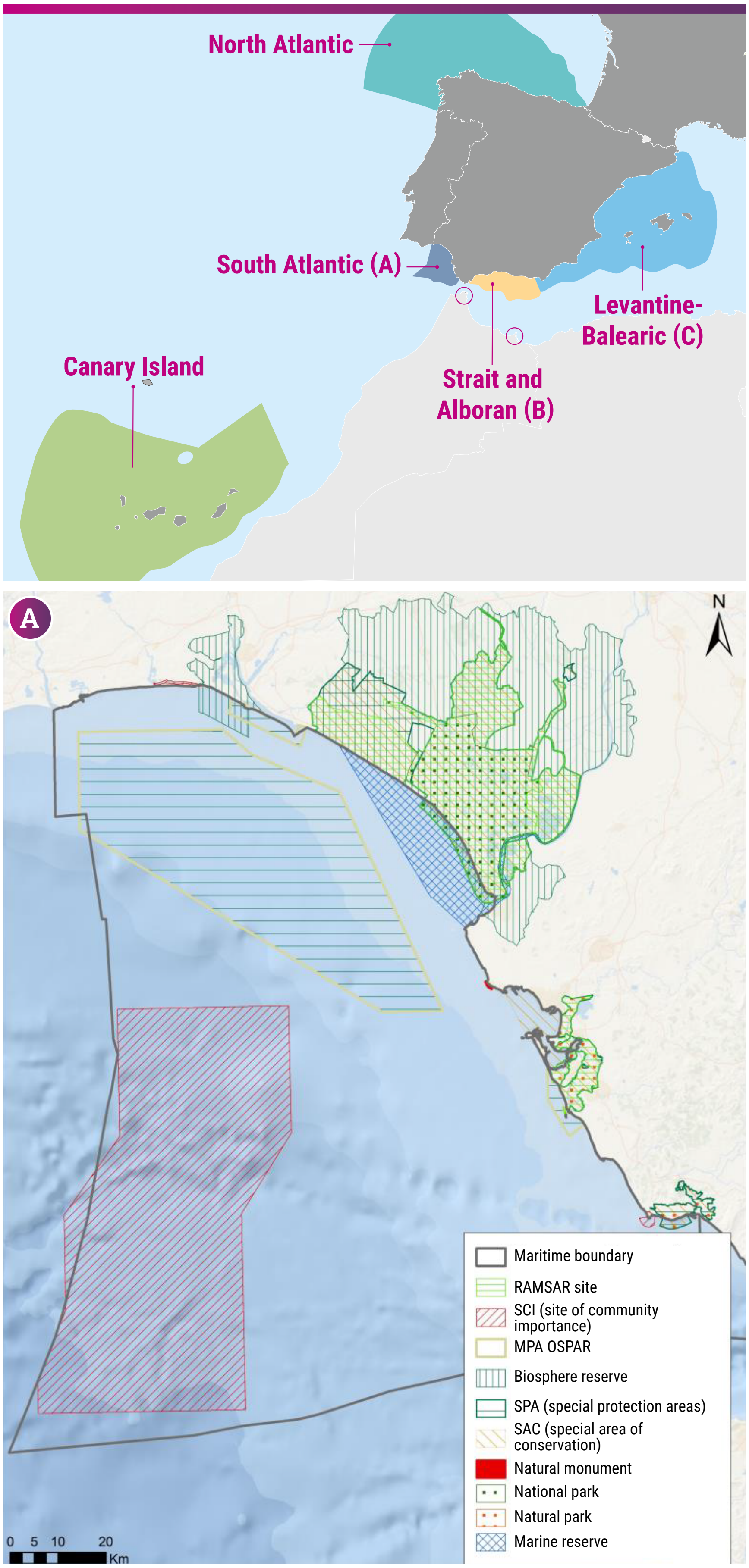
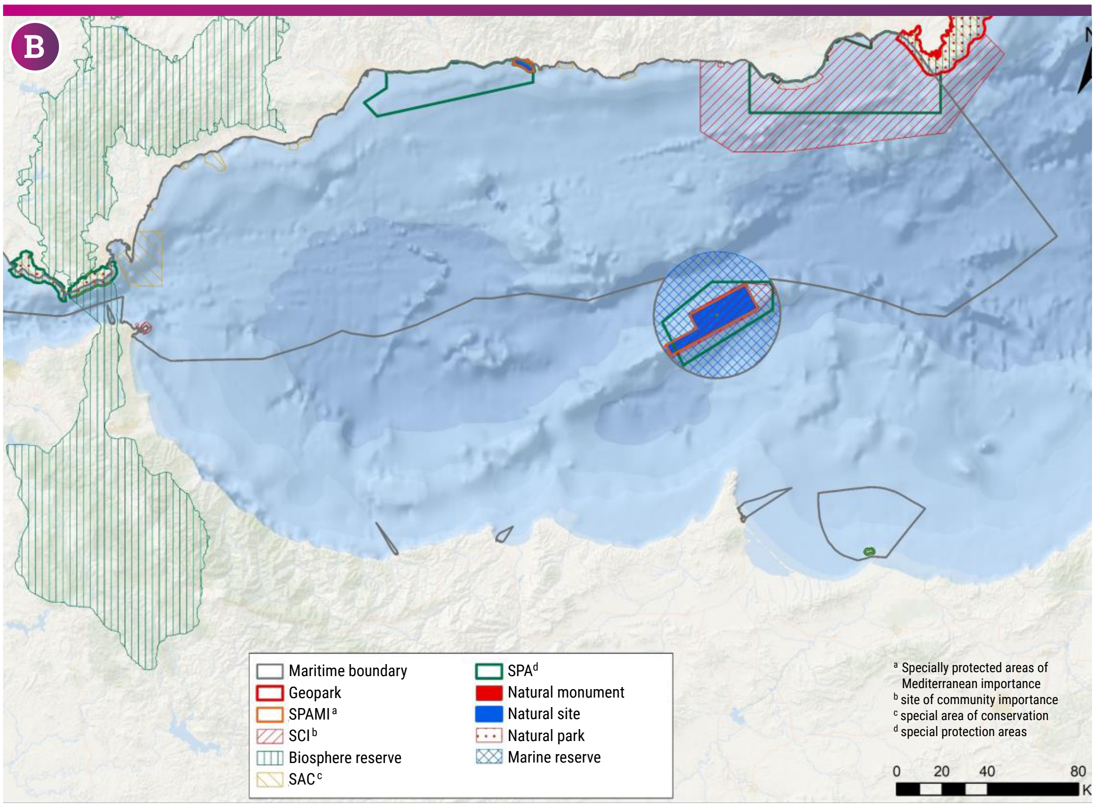
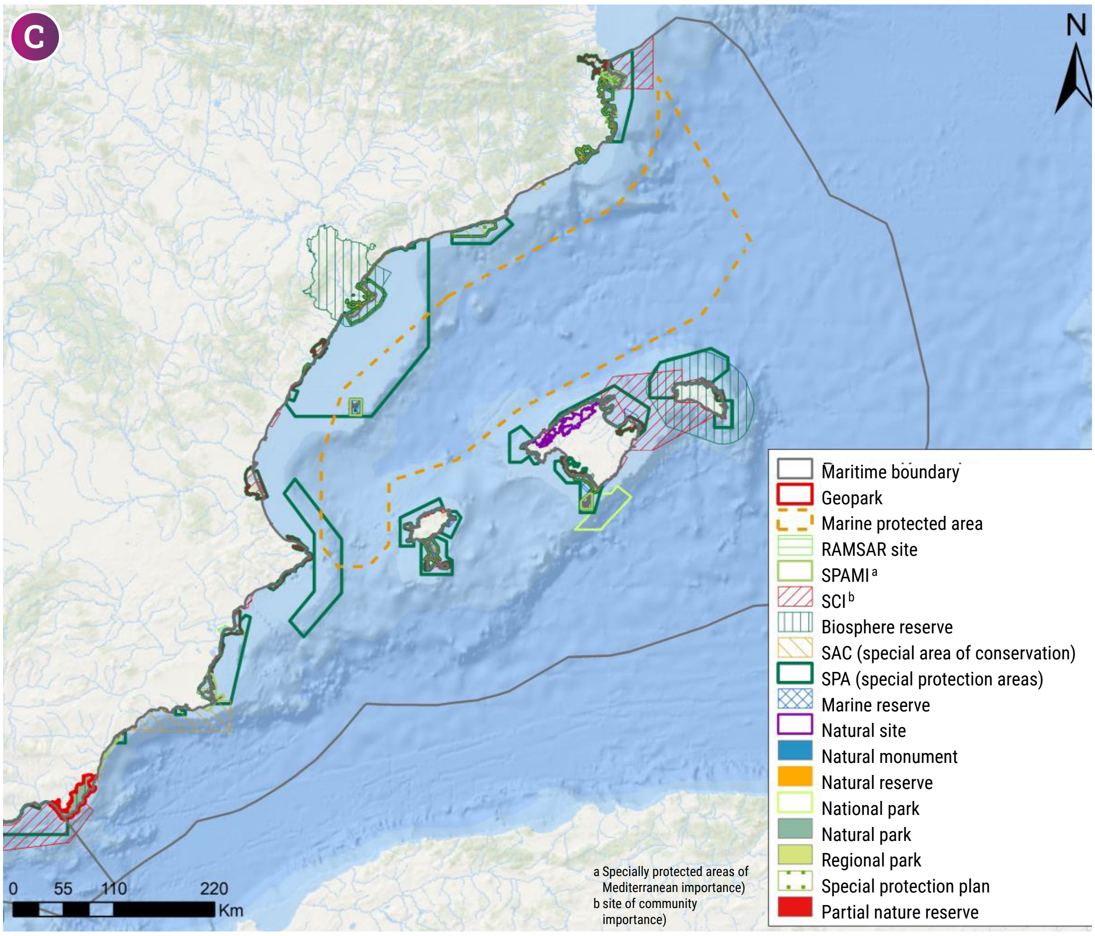


Figure 19 – Marine and maritime-terrestrial protected areas in the Spanish Mediterranean West Sea.


B
Maritime boundary
Geopark
SPAMI a
SCI b
Biosphere reserve
SAC c
SPA d
Natural monument
Natural site
Natural park
Marine reserve
a Specially protected areas of Mediterranean importance
b site of community importance
c special area of conservation
d special protection areas
0 20 40 80


C
N
Maritime boundary
Geopark
Marine protected area
RAMSAR site
SPAMI a
SCI b
Biosphere reserve
SAC (special area of conservation)
SPA (special protection areas)
Marine reserve
Natural site
Natural monument
Natural reserve
National park
Natural park
Regional park
Special protection plan
Partial nature reserve
a Specially protected areas of Mediterranean importance)
b site of community importance)
0 55 110 220
Km

In addition, with the sole purpose of facilitating the development of offshore wind energy for commercial exploitation, while guaranteeing its coexistence with other marine uses and activities, the following criteria have been established:

- Commercial OWF will occupy as little marine space as possible;
- Projects will progress where prospective analysis verifies that the impacts on communities of seabirds within designated areas are minimised. Acoustic studies will also be performed to characterise the average levels of background noise;
- Offshore wind projects must consider, for the proper evaluation of its environmental impact, a set of environmental aspects such as: birdlife and wildlife studies; the characterisation of the marine habitats affected by the project; the analysis of the cumulative effects of other nearby offshore wind projects; acoustic study before installation, during installation and during the operation of the OWF; impact study and landscape integration; and an analysis of the fishing activity in the area;
- In cases where an area of high potential for offshore wind energy overlaps with protected marine areas, the projects must carry out a detailed analysis of the alternatives that are technically and environmentally viable;
- Efforts will be made to identify, whenever possible, those fishing gears that could coexist with the commercial wind farm or with other renewables to be implemented. Such coexistence should be facilitated by the promoter;
- In areas where a relevant interaction with fishing grounds is confirmed, options will be proposed to minimise the impact;
- Efforts will be made to identify, whenever possible, those modalities of aquaculture that could coexist with the commercial wind farm or with other renewable energies that are implanted. Such coexistence should be facilitated by the promoter;
- Efforts will be made to identify the types of vessels that could navigate within the space occupied by the wind farm and, in those cases, facilitate their operation;
- The routes to land for generation will be designed to minimise the marine space occupied, using, whenever possible existing wiring traces or other pre-existing infrastructures on the seabed, avoiding affecting habitats of community interest and respecting the environmental and terrestrial plans; and
- In addition, criteria established in the strategic environmental assessment of the Spanish National Energy and Climate Plan must also be considered.

Portugal framework

Portugal adopted its MSP, the "Plano de Situacão do Ordenamento do Espaço Maritimo Nacional (PSOEM)", corresponding to the subdivision of the mainland, the subdivision of Madeira and the subdivision of the Extended Continental Shelf in December 2019 by the Council of Ministers (**Resolution No. 203-A/2019**). The MSP covers the entire national maritime space, from the baselines to the outer limit of the continental shelf, integrating inland maritime waters, the territorial sea, the exclusive economic zone (EEZ) and the continental shelf, including beyond 200 nautical miles.

The MSP is an instrument for planning the national maritime space and constitutes an essential tool for the policy of the sea. The Plan identifies the spatial and temporal distribution of existing and potential uses and activities, also identifying areas relevant to nature conservation, biodiversity, underwater cultural heritage and the networks and structures essential to national defence, internal security and civil protection. The Plan promotes compatibility between competing uses or activities, with a view to contributing to a better economic use of the marine environment and minimising the impact of human activities on the marine environment. This plan is also the instrument that allows the attribution of a Permit of Private Use of the National Maritime Space (TUPEM).

A Geographic Information tool is available; it shows the updated distribution of the uses, activities and constraints in the national maritime space.

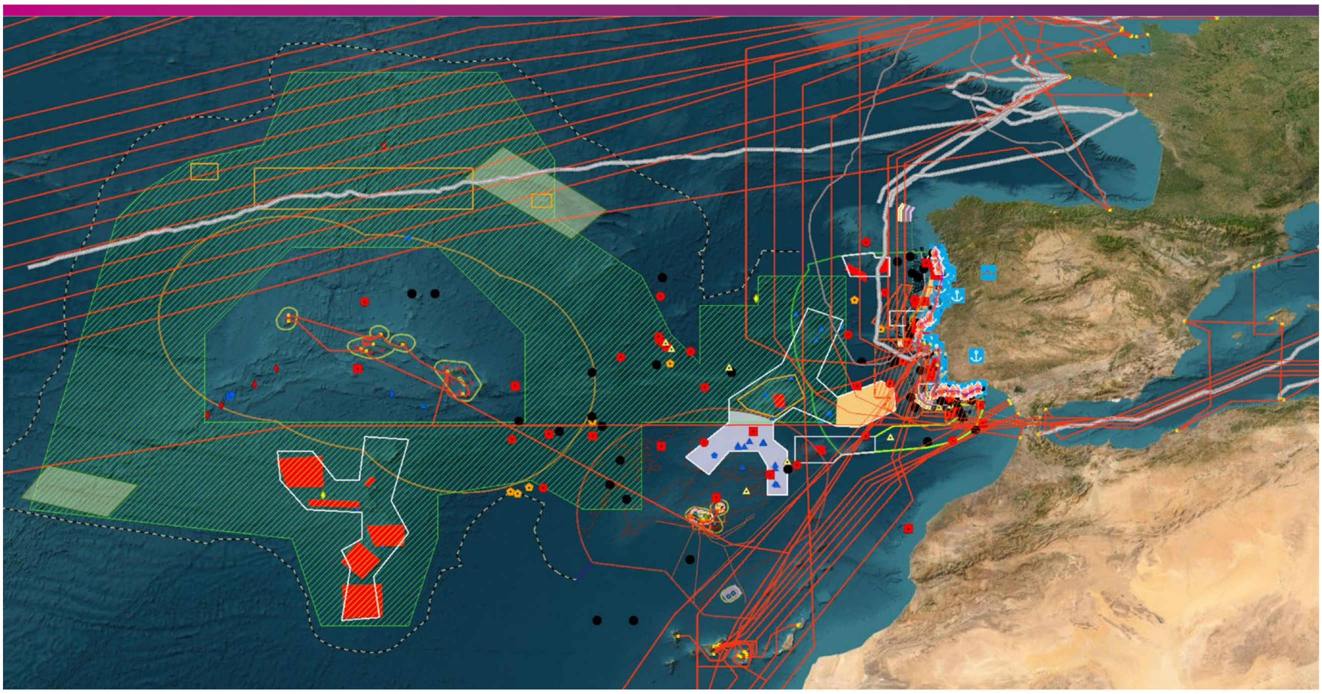


Figure 20 – Geographical Information System (GIS) for the Portuguese Maritime Spatial Plan.

Greece framework

Currently, there is no legally binding national Maritime Spatial Plan (MSP) 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**
  Further to that which has been elaborated in Chapter 5, 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). The creation of the new European Maritime, Fisheries and Aquaculture Fund (EMFAF) for the programming period 2021–2027 proves the willingness to move towards sustainable aquaculture in the EU and, particularly, in the Eastern Mediterranean sea-basin.
- **Coastal and sea tourism**
  Coastal tourism is very developed in Greece. Many activities related to boating are developed; there are 19 marinas and thousands of yachting anchorages, which can be explained by the archipelagic form of the country. Many cities are home ports for many cruise ships. Greece also has many sea bathing areas, with 519 beaches and 15 marinas having been awarded the Blue Flag Award in 2019. Those areas are privileged sites for sea sports such as surfing.
- **Underwater cultural heritage**
  Greece, containing 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. The country has had a strong and longstanding legal framework for antiquities' conservation, dating back to 1834 and incorporating provisions for both terrestrial and underwater cultural heritage (UCH).
- **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**
  These mainly concern activities such as cement industries, desalination infrastructure, industrial aquaculture, coastal installations etc.

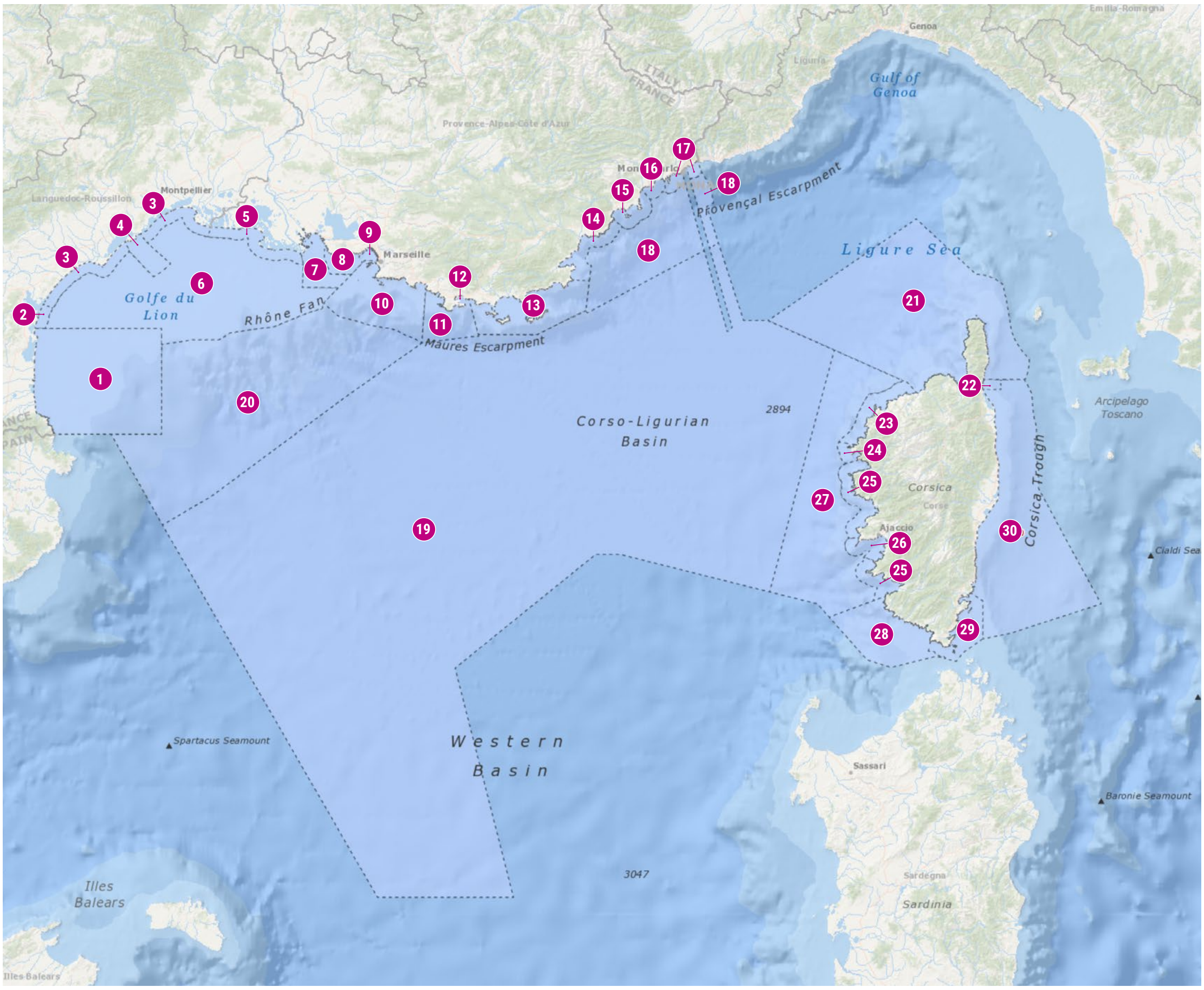
French framework

The French part of the Mediterranean Sea has a coastline of 1694 km, from the Italian border to the Spanish one, Corsica included (688 km). Industrial activities are concentrated in the Fos gulf, in Marseille (Grand Port Maritime de Marseille) and in several smaller harbours (Port La Nouvelle, Sète). Some salt marshes are also present in the Camargue area. Military activities are concentrated in Toulon harbour. Tourism and yachting represent a major economic activity in the area. At sea, the sea basin is characterised by the presence of fishing small-scale fleets and some shellfish breeding.

The **Sea Basin Strategy Document** was approved in October 2019, following a large consultation process. It will be updated in 2024. The current document addresses the requirements of two European framework directives (MSFD and MSPD), and includes a "vocation map" of maritime areas.

Thirty different "vocation areas" (see below) have thus been defined, two of them being identified as "development areas" for floating OWF only (areas 1 and 6) while preserving biodiversity and fishing activities.

Carte des vocations de la façade maritime Méditerranée



Legend

1 / Périmètre du Parc naturel marin du Golfe du Lion
2 /Port-la-Nouvelle
3 / Littoral languedocien
4 / Sète
5 / Camargue
6 / Plateau du Golfe du Lion
7 / Golfe du Fos-sur-Mer
8 / Côte Bleue
9 / Rade de marseille
10 / Périmètre du Parc national des Calanques
11 / Littoral varois Ouest
12 / Rade de Toulon
13 / Périmètre du Parc national de Port-Cros
14 / Littoral varois Est
15 / Riveria
16 / Nice et abords
17 / Littoral des Alpes-Maritimes
18 / Large Provence Alpes Côtes d'Azur
19 / Plaine bathyale
20 / Canyons
21 / Périmètre du Parc naturel marin du Cap Corse et de l'Agriate
22 / Bastia
23 / Balagne
24 / Scandola
25 / Littoral occidental de la Corse
26 / Golfe d'Ajaccio
27 / Large côte occidentale de la Corse
28 / Couces de Bonifacio Ouest
29 / Bouches de Bonifacio Est – Porto-Veccio
30 / Plaine orientale et large Est de la Corse

Figure 21 – Vocation areas in the French Mediterranean sea basin from 2019 Sea Basin Strategy Document.

Italian framework

At December 2023, Italy has not yet officially embraced an MSP. However, progress is underway with the finalisation of three MSP Plan[4] proposals by the Technical Committee. These revisions are being made in response to feedback gathered during the national public consultations on MSP Plans. Italy has identified three distinct maritime regions: the “Adriatic”, the “Ionian and Central Mediterranean” and the “Tyrrhenian and Western Mediterranean”.

The Italian waters in the Western Mediterranean Sea basin (south and West Offshore Grids corridor) include the Ionian Sea, Tyrrhenian Sea, and Central–Western Mediterranean Sea. Notably, the Ionian Sea stands out as the Mediterranean’s deepest basin, plunging to a maximum depth of 5,270 meters. This region possesses unique hydrological and geomorphological characteristics, fostering exceptional ecosystems of significant biodiversity value. Both the central Mediterranean and the Strait of Messina serve as critical migratory routes for numerous fish species, many of which hold commercial importance, along with various cetaceans. This ecologically, aesthetically, and culturally rich area benefits from numerous environmental and cultural protection measures, including an array of **marine protected areas (MPAs)**.

Within this maritime domain, there is a high density of diverse uses, especially in areas near the coast. Consequently, potential and actual conflicts between different maritime activities arise. However, it is worth noting that opportunities for coexistence and synergies among these various uses exist, leading to the effective sharing of maritime space and its resources, known as multi-use. This approach offers advantages for all sectors involved.

Several maritime and coastal activities hold strategic national significance within this area, encompassing maritime transportation, fishing, aquaculture, tourism, security, defence, and the exploration of hydrocarbons and RES. The Maritime Area Plan strongly encourages the growth of energy production from marine renewable sources. Furthermore, it promotes the exploration and implementation of offshore wind energy technologies in a manner compatible with landscape and environmental preservation. This may involve the use of floating facilities located in areas that are not visible from the mainland and deployment in zones devoid of conflicts with other activities, such as fishing or maritime traffic. In addition, the plan aims to foster the development of multi-purpose platforms, where energy production (e.g., from waves or wind) is combined with other activities, such as aquaculture, marine biotechnology and more.

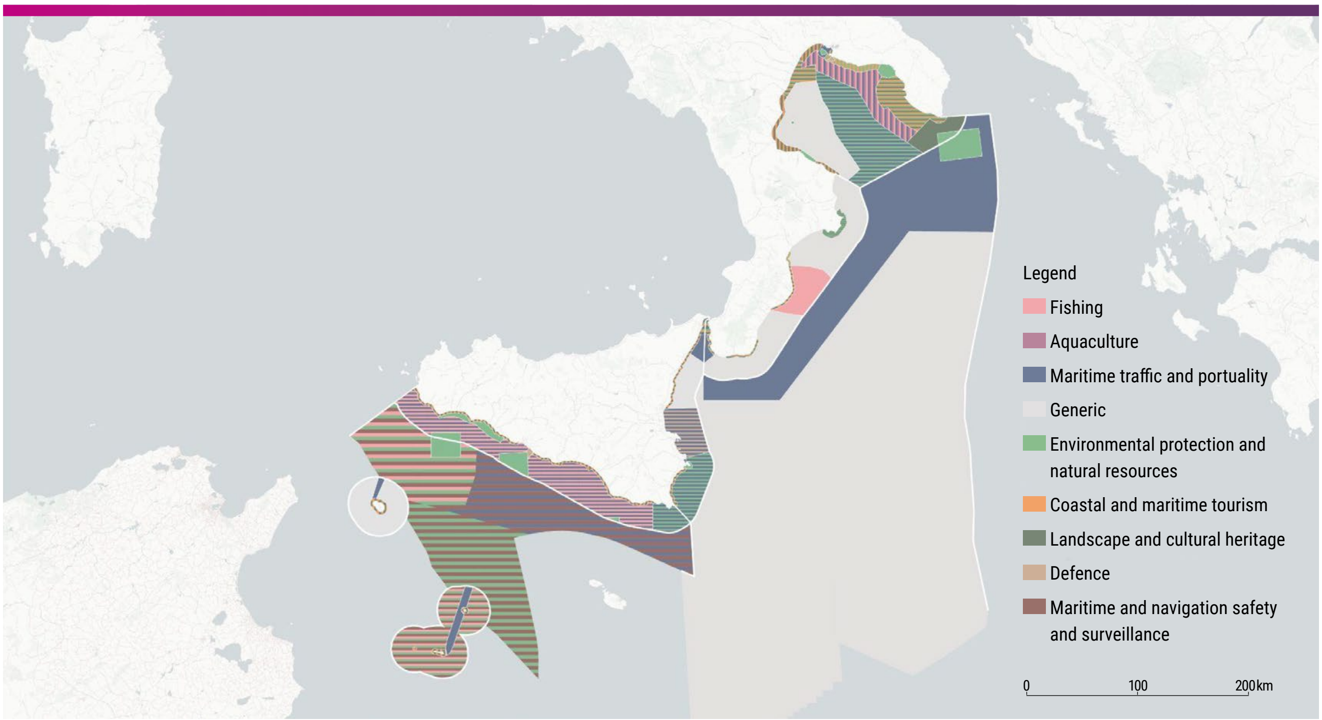


Figure 22 – **Ionian and central Mediterranean uses.**

4 For further details, please refer to MSP

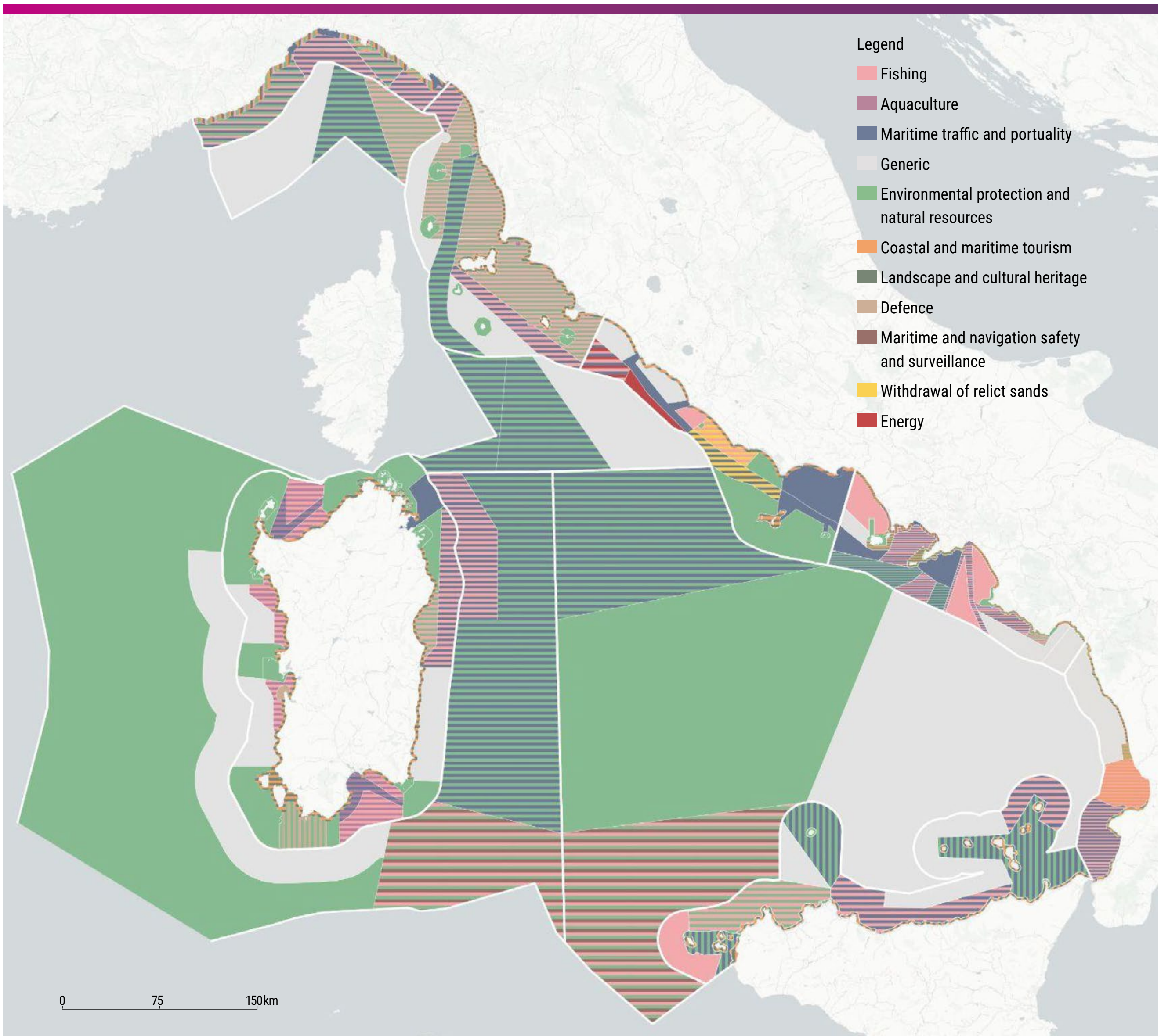


Figure 23 – **Tyrrhenian and Western Mediterranean uses.**

The "Tyrrhenian and Western Mediterranean" waters cover several sub-areas, including the Ligurian Sea, Northern Tyrrhenian Sea, Central-Southern Tyrrhenian Sea, and the Sardinian Seas (West Sardinia and East Sardinia). This larger region stretches from the Ligurian coast to encompass the entire Tyrrhenian Sea, up to the coasts of Sicily and Sardinia. The area features diverse seabed and coastline characteristics, notably marked by numerous significant canyons, some reaching depths exceeding 2000 meters, primarily in the southwest.

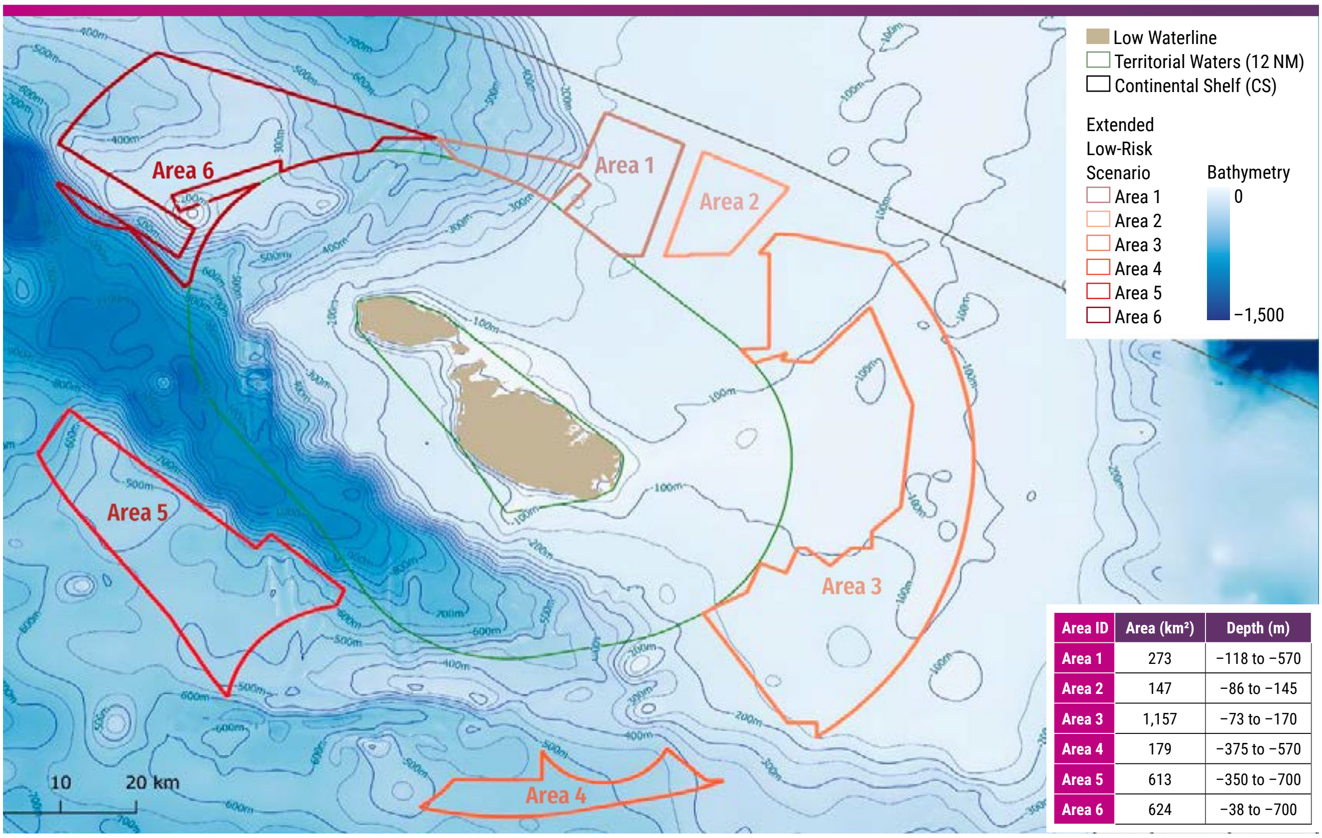
This maritime area is home to a substantial number of marine protected areas, offering opportunities for environmentally friendly activities such as eco-tourism and small-scale fisheries. However, it is essential to recognise the **potential for conflicts with other sectors such as maritime transport and trawling.** The overarching plan for this region promotes the development of multifunctional platforms that facilitate multiple uses, embracing the concept of multi-use. These platforms aim to support energy production, including harnessing energy from waves or wind, along with other forms such as solar, waves, wind, and currents. In addition, these platforms can accommodate various activities such as aquaculture and marine biotechnologies. Figure 23 provides an integrated representation of the key elements characterising the plan in this area.

Malta's framework

The following chapter is an extract of the National Policy for the Deployment of Offshore Renewable Energy, redacted by the Maltese Energy and Water Agency (EWA).

The main legislative act for development in Malta is the Development Planning Act of 2016 (Cap. 552). The Maritime Spatial Planning (MSP) Directive has been transposed into Maltese legislation through subsidiary legislation, "Maritime Spatial Planning Regulations" (S.L.552.27) under the Development Planning Act.

As defined in the National Policy for the Deployment of Offshore Renewable Energy, the potential areas identified, defined by EWA in the dedicated assessment to determine the potential for offshore wind, have been identified in the Extended Low-Risk Scenario, following the exercise carried out and updated after consultations with main stakeholders. This assessment may be updated further following feedback which shall be gathered as part of the **public consultation process**.



Area ID	Area (km²)	Depth (m)
Area 1	273	−118 to −570
Area 2	147	−86 to −145
Area 3	1,157	−73 to −170
Area 4	179	−375 to −570
Area 5	613	−350 to −700
Area 6	624	−38 to −700

Figure 24 – Potential areas assigned to offshore wind energy by the Maltese Ministry for the Environment, Energy and Enterprise; The National Policy for the Deployment of Offshore Renewable Energy. The indicated areas have no bearing on the final designation of EEZ areas.

6 High-Level Results on Offshore Network Infrastructure Needs

Among many aspects referring to the planning process, in recent years the evolution of the generation power plants has played an increasingly important role in assessments aimed at identifying infrastructure development needs.

The process of decarbonising the electricity system, which is necessary to meet national and international energy and climate targets, 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 with high polluting and climate-damaging emissions, while simultaneously 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 national and international level will require a significant increase in generation capacity from renewable sources, in particular from intermittent and non-programmable wind and photovoltaic (PV) sources (e.g. in Italy +70 GW by 2030 compared to installed capacity in 2019 in the Fit-for-55 policy scenario).

This planning effort is essential so that the future grid 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, in order to respond quickly, effectively and efficiently to the various exogenous factors that may influence the energy and electricity system.

In this first ONDP exercise, the Mediterranean West Basin has not had significant results in terms of infrastructure needs corridor for hybrid OWF development.

However, the lack of results does not imply a lack of interest of the region in the Offshore wind integration. On the contrary, as explained in previous chapters, for different aspects, the regions is mostly concentrated on the integration of OWF via radial connections often accompanied by adequate network reinforcements. A growing evolution trend of future OFW installed capacity can be observed in the scenario data in the region, ranging from 5 GW in 2030 up to 20 GW in 2050.

The development of hybrids projects, also conceptual ones, requires deep further investigation on a bi/multi-lateral basis among TSOs.

Table 1 summarises the offshore generation considered in the ONDP process for each country and time horizon for the West Mediterranean basin.

	Offshore transmission capacity [GW] needed to connect the foreseen offshore RES generation		
Country	**2030**	**2040**	**2050**
Italy	4	11.5	11.5
France	0.1	3.6	7.6
Greece	0	0.2	0.2
Malta	0.05	0.4	0.4
Portugal	0	0	0
Spain	1.4	1.4	1.4
Total	**5.6**	**17.1**	**21.1**

Table 1 – Offshore Generation Capacity for each country in the South and West offshore grids corridor.

The amount of radial transmission assets serving the connection of the generation capacities illustrated in Table 1 will match the generation values, meaning that overall in the corridors **5.6, 17.1 and 21.1 GW of transmission infrastructure** will be needed in 2030, 2040 and 2050 respectively to connect the offshore RES deployed in West Mediterranean and Gulf of Cadiz waters.

These assets will cover a maritime distance of almost **1,700 km**, potentially requiring up to **21 offshore substations** (between AC and HVDC).

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. It is expected that 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 summary and Table 5, including the potential costs for transmission infrastructure connecting the offshore RES foreseen in the South and West Offshore grids corridor.

In Italy

In addition, to face the challenges regarding 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. Target capacity is defined as the economically efficient transmission capacity to develop grid infrastructure when related benefits are of major importance compared to investment costs, and it is achieved through an iterative heuristic process, with the ultimate goal of maximising the benefit/cost ratio at the system level. The analysis underlines the need to develop significant cross-border additional transmission capacity, both on the Italian Eastern and Norther borders. The detailed results of the assessment carried out in the framework of Italian Network Development Plan 2023 are returned in the **Identification of Target Capacity Report 2023**.

Looking to the **2023 National Development Plan by Terna**, it is characterised by the ambition to provide a structured and organic response to the challenges posed by the energy transition and geopolitical changes at the international level, by defining a basket of projects, for the achievement of the energy and climate objectives set, which also includes, among other things, the integration of the new Offshore Power Plant.

The innovative approach adopted for planning the new grid infrastructures is characterised by a holistic view of the electricity system as a whole, taking into account 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 the following pages, the amount of assets and the related costs are summarised, for both in the event of availability (DC Grid) and unavailability (DC Link) of the DC breakers.

7 Reflections for the South and West Offshore Grids Corridors and Conclusions

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

As of today, the offshore transmission infrastructure is mostly composed of pure transmission assets (cross-border interconnectors and internal reinforcements). The total amount of offshore RES connected to the continental systems totals 110 MW.

From this perspective, it can be observed that the South and West offshore grids corridor, covering the West Mediterranean waters and the Gulf of Cadiz, is facing the first steps of offshore expansion. This development will occur mostly at local level with, **the large majority of OFW to be integrated in the grids via radial connections**.

To connect the offshore RES capacities to the mainland, a considerable amount of transmission assets will need to be laid down in the corridor's waters. **5.6, 17.1 and 21.1 GW of transmission assets will be needed in 2030, 2040 and 2050 respectively**. The overall investments up to 2050 could total 14.3 billion euros, just considering the transmission infrastructure connecting the units. The needed internal reinforcements ensuring the adequate dispatch of the energy produced are not considered in the estimated total investment.

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)	0	0	246	0	0	0	293	0	0	293	246	539,13
Offshore DC Cables (updated)				0	0							
Onshore AC Cables (updated)	485	420	0						485	420	0	904,62
Offshore AC Cables (updated)												
Offshore DC converters	0	0	2			0	2	0	0	2	2	4
Onshore DC converters	0	0	2	0	0	0	2	0	0	2	2	4
Offshore AC substation	8	13	0						8	13	0	21
Offshore node expansion (incl. DC breaker)				0	0				0	0	0	0
											Total Route Length	1,443.75

Table 2 – Amount of offshore transmission equipment to connect the RES generation in South and West 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 km of cables to cover that distance.

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)	0	0	827	0	0				0	667	827	
Offshore DC Cables (updated)				0	0	0	667	0				1,493
Onshore AC Cables (updated)	499	420	0						499	420	0	
Offshore AC Cables (updated)												919
Offshore DC converters	0	0	2,200			0	1,595	0	0	1,595	2,200	3,795
Onshore DC converters	0	0	1,000	0	0	0	725	0	0	725	1,000	1,725
Offshore node expansion (incl. DC Breaker) E20				0	0				0	0	0	0
Offshore AC substation	2,381	3,970	0						2,381	3,970	0	6,351
												14,283

Table 3: Costs for transmission infrastructure connecting RES generation in South and West Offshore Grid corridor, in the event of the availability of DC breakers (DC Link 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)	0	0	246	0	0	0	293	0	0			539
Offshore DC Cables (updated)				0	0					293	246	
Onshore AC Cables (updated)	485	420	0						485	420	0	905
Offshore AC Cables (updated)												
Offshore DC converters	0	0	2			0	2	0	0	2	2	4
Onshore DC converters	0	0	2	0	0	0	2	0	0	2	2	4
Offshore AC substation	8	13	0	0	0				8	13	0	21
Offshore node expansion (with converter), E18	0	0	0	0	0				0	0	0	0
											Total Route Length	**1,444**

Table 4 – Amount of offshore transmission equipment to connect the RES generation in the South and West 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 km of cables to cover that distance.

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)	0	0	827	0	0				0			
Offshore DC Cables (updated)				0	0	0	667	0		667	827	1,493
Onshore AC Cables (updated)	499	420	0						499	420	0	
Offshore AC Cables (updated)												919
Offshore DC converters E18	0	0	2,200			0	1,595	0	0	1,595	2,200	3,795
Onshore DC converters	0	0	1,000	0	0	0	725	0	0	725	1,000	1,725
Offshore node expansion (with converter), E18	/	/	/	0	0				0	0	0	0
Offshore AC substation	2,381	3,970	0	0	0				2,381	3,970	0	6,351
												14,283

Table 5 – Costs for transmission infrastructure connecting RES generation in the South and West Offshore Grid corridor, in the event of the unavailability of DC breakers (DC Link modelling configuration).

For the 2040 and 2050 time horizons, expansion loops have been performed on top of the starting grid considered in the optimisation. In this optimisation process, one hybrid transmission corridor was tested between Spain and France. Finally, the model only points out radial connections for Spain and France in the South and West Offshore Grids for all the grid configurations and costs that have been tested. It is important to note that the cross-border capacities between Spain and France considered as the starting hypothesis in this ONDP exercise reach 11 GW, which implies that several capacity increase projects will be put into service by 2040. For the time being, future projects at the France–Spain border would allow 8 GW to be reached.

This first assessment identified a few concepts for hybrid transmission at the cross-border level among countries. 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 here below:

- The necessity of further investigations aimed at enhancing the whole benefits that could arise from this kind of complex infrastructure compared to radial solutions;
- Difficulties related to the different characteristics of the seabed involving different types of technology, whose maturity is limited;
- The different timing for the adoption of MSP that could support the identification of appropriate areas for the expansion of OFW; and
- Early stage of a common planning (including spatial planning) strategy for development of hybrid projects at regional level.

It is important to state that the challenges above are deemed as present challenges. Once they are solved, opportunities for hybrid interconnections are expected to open in the SWOG corridor too.

For instance, looking to 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 and 200 MW in the West Mediterranean Sea basin, considering the data available at the time.

Based on the above, the results of this study should be considered as a future possibility rather 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.

In the next few years, Italy is experiencing a remarkable increase of RES increase in the country, related not only to the high request of connection of OFWs but also other renewable power plants.

To this aim, the future transmission infrastructure planned by Terna, marked in Italian NDP 2023, plays a crucial role in the energy transition and is a significant contribution to the reduction of internal congestions by enabling RES integration from South to North and through Italian borders towards EU and non EU countries.

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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