WORLD BANK GROUP

Offshore Wind Development Program

OFFSHORE WIND ROADMAP FOR TÜRKİYE

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ABBREVIATIONS

General acronyms and abbreviations:

ABEX	Abandonment expenditures
AC	Alternating current
AEP	Annual energy production
BoP	Balance of plant
BST	Basic safety training
CAPEX	Capital expenditures
CCH	Cetaceans' critical habitats
CfD	Contract for difference
COD	Commercial operation date
CPT	Cone penetrating testing
CTV	Crew transfer vessel
DBFO	Design, build, finance, operate
DC	Direct current
DEVEX	Development expenditures
EBSA	Ecologically or Biologically Significant Marine Areas
EENS	Expected energy not served
EHS	Environmental, Health, and Safety
EIA	Environmental impact assessment
ENS	Energy not served
EPC	Engineering, procurement, and construction
EPCI	Engineering, procurement, construction, and installation
EUR	Euro
FiT	Feed in tariff
FTE	Full time equivalent
GDP	Gross domestic product
GVA	Gross value added
GW	Gigawatt
H&S	Health and safety
HV	High voltage
HVDC	High voltage direct current
IAC	Inter array cables
IBA	Important Bird and Biodiversity Areas
IEIA	Initial environmental impact assessment
IMMA	Important marine mammal areas
IRA	Internationally recognized areas

KBA	Key biodiversity areas
kWh	Kilowatt hour
LCOE	Levelized cost of energy
LIDAR	Light Detection and Ranging
LLD	Loss of Load Duration
LOLE	Loss of Load Expected
LPA	Legally protected areas
MAF	Mid-term adequacy forecast
MSP	Marine Spatial Plan
MVAC	Medium voltage alternating current
MW	Megawatt
MWh	Megawatt hour
INDC	Intended Nationally Determined Contribution
NSIP	Nationally significant infrastructure projects
O&M	Operation and maintenance
OEM	Original equipment manufacturers
OnSS	Onshore substation
OPEX	Operational expenditures
OSH	Occupational Safety and Health
OSS	Offshore substation
OWF	Offshore wind farm
PoC	Point of connection
PPA	Power purchase agreements
PPP	Public private partnership
R&D	Research and development
RE	Renewable energy
ROV	Remotely operated vehicle
SOV	Service operation vessel
SPA	Special protection areas
SS	Electrical power substation
TEU	Twenty-foot equivalent unit
TP	Transition piece
TSO	Transmission system operator
UDL	Uniformly distributed load
UNFCCC	United Nations Framework Convention on Climate Change
USD	United States dollars
UXO	Unexploded Ordnance
VRE	Variable renewable energy

WACC	Weighted average cost of capital
WTG	Wind turbine generator
XLPE	Cross-linked polyethylene
YEKA	Renewable energy resource zone

Company and institute acronyms and abbreviations:

ADB	Asian Development Bank
BEIS	Business, Energy, and Industrial Strategy
DEA	Danish Energy Agency
EBRD	European Bank for Reconstruction and Development
EMRA	Energy Market Regulatory Authority
ESMAP	Energy Sector Management Assistance Program
EU	European Union
GDEA	General Directorate for Energy Affairs, Türkiye
GE	General Electric
GWA	Global Wind Atlas
GWO	Global Wind Organisation
IEA	International Energy Agency
IFC	International Finance Corporation
IMCA	International Marine Contractors Association
IMO	International Marine Organization
INDC	Intended Nationally Determined Contribution
MENR	Ministry of Energy and Natural Resources, Türkiye
MoEUCC	Ministry of Environment Urbanization and Climate Change
MoTI	Ministry of Transportation and Infrastructure
MVOW	MHI Vestas Offshore Wind
NEWA	New European Wind Atlas
OECD	Organisation for Economic Co-operation and Development
OFTO	Offshore Transmission Owner
SGRE	Siemens Gamesa Renewable Energy
TEIAS	Türkiye Elektrik Iletim A.S
TWEA	Turkish Wind Energy Association (also known as TUREB)
WBG	World Bank Group
YEKDEM	The Renewable Energy Resources Support Mechanism

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Through the WBG, ESMAP works to accelerate the energy transition required to achieve Sustainable Development Goal 7 (SDG7) to ensure access to affordable, reliable, sustainable, and modern energy for all. It helps to shape WBG strategies and programs to achieve the WBG Climate Change Action Plan targets.

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EXECUTIVE SUMMARY

This roadmap provides strategic analysis of the offshore wind development potential in Türkiye, considering the opportunities and challenges under different, hypothetical, growth scenarios. It is intended to provide evidence to support the Government of Türkiye in establishing policy, regulations, processes, and infrastructure to enable successful growth of this new industry.

It was initiated by the World Bank country team in Türkiye under the umbrella of the World Bank Group's Offshore Wind Development Program—which aims to accelerate offshore wind development in emerging markets—and was funded by the Energy Sector Management Assistance Program (ESMAP) in partnership with the International Finance Corporation (IFC), and with support from the World Bank's blue economy program, PROBLUE.

RATIONALE FOR OFFSHORE WIND IN TÜRKİYE

Türkiye's rapid growth over the recent decades has meant the country has not been able to meet its energy demand through domestic sources alone, and currently relies on imports to meet around 70 percent of its energy demand. With energy demand expected to continue increasing, Türkiye needs to expand local energy generation to reduce its reliance on imports and the associated foreign exchange burden on its economy.

Türkiye has areas with good natural conditions for offshore wind. This offers a new source of domestic renewable energy generation that could contribute to Türkiye's transition to net-zero carbon by 2053. The main drivers and rationale for Türkiye to consider developing offshore wind include:

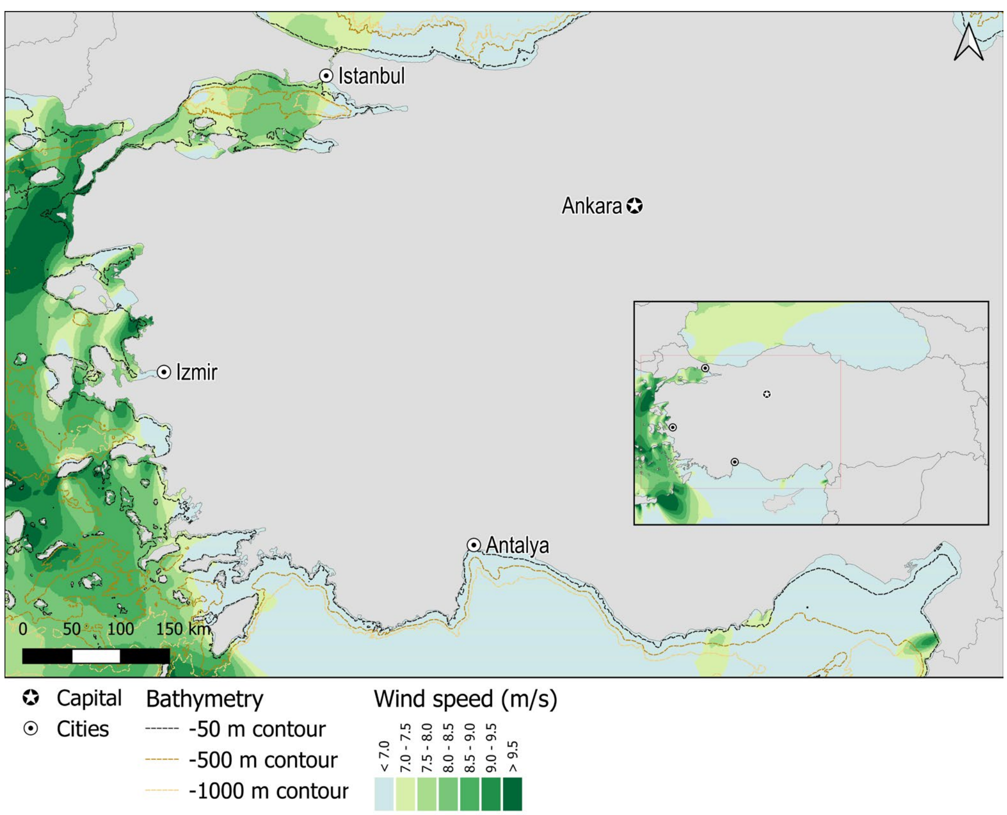
- **Decarbonization with increasing demand:** Türkiye's electricity demand is expected to continue growing with an annual, compound rate of 3.5 percent, reaching 511 terawatt hours by 2035; a 67 percent increase from 2020. To meet this demand, Türkiye will need to add around 100 gigawatts (GW) of new generation capacity between 2020 and 2035, more than doubling the current generation capacity. While a large proportion is expected to be low-carbon generation, new coal and gas plants are planned which will, inevitably, increase fuel imports. As a new form of large-scale, domestic power generation, there is an opportunity for offshore wind to contribute to the future electricity mix, complementing other forms of variable renewable energy, potentially displacing new and retiring thermal generation, and reducing energy imports.
- **Proximity to demand:** The populous and industrial areas along Türkiye's west coast create a region of high power demand. This is met by local thermal and renewable generation or by generation across the country which the transmission grid supplies to the western provinces. Offshore wind provides a new generation option which is close to demand centers, thereby reducing the need for additional, lengthy transmission lines.

- **Supply chain growth and job creation:** Türkiye has the world's 12th largest onshore wind capacity and has a very capable onshore wind supply chain. Furthermore, its ports and maritime industries are strong and cost competitive with neighboring markets. There is high potential for these sectors to service the offshore wind industry. At least 75 percent of firms engaged in the local onshore wind industry already export to international markets. The Cemre and Tersan shipyards have already built or received contracts to build vessels for the offshore wind industry. Given Türkiye's geographic location, close to European and Asian markets, competitive cost of labor and materials, and its ability to deliver to high quality and standards required by international offshore wind clients, it is well placed to expand its supply chain into offshore wind. In addition to the future potential to supply the domestic offshore wind market, there will also be numerous opportunities to supply regional (and global) projects—the 50 to 100 GW of floating wind capacity planned across the Mediterranean Sea being a clear, future export opportunity.

TÜRKİYE'S OFFSHORE WIND POTENTIAL

Türkiye's waters have areas with reasonable offshore wind resources with a total technical potential[i] resource estimated[ii] at 75 GW. Average wind speeds, particularly along the country's west coast, can exceed 9.5 meters per second (see Figure ES.1), however, the majority of areas with energetic winds also have waters deeper than 50 meters, so will be suited to floating offshore wind solutions.

FIGURE ES.1 MAP OF TÜRKİYE'S OFFSHORE WIND POTENTIAL.

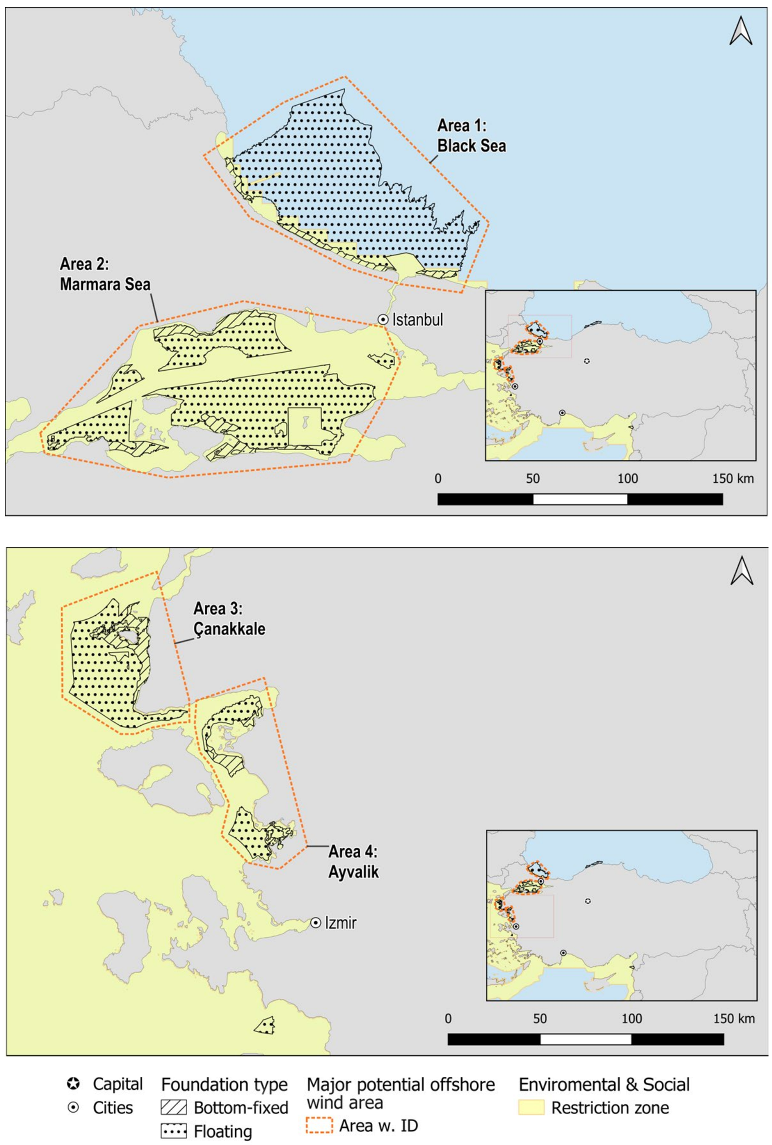


i The offshore wind technical potential is an estimate of the amount of generation capacity that could be technically feasible, considering only wind speed and water depth. This is intended as an initial, high-level estimate and does not consider other technical, environmental, social, or economic constraints.

ii ESMAP. 2020. Offshore Wind Technical Potential in Turkey https://documents1.worldbank.org/curated/en/694551586852099074/pdf/Technical-Potential-for-Offshore-Wind-in-Turkey-Map.pdf.

The majority of areas with good offshore wind resource, however, feature high environmental and social sensitivities including many protected areas, critical habitats, and characteristics that, without careful planning and mitigation, are potentially at risk from detrimental impacts of the development and operation of offshore wind farms. Analysis for this roadmap assessed a wide range of environmental, social, and technical issues to identify technically attractive initial exploration areas that, based on the data available, are likely to have lower negative impacts associated with development. After removing areas unsuitable for offshore wind, four exploration areas remain (see Figure ES.2) and these are found in the Aegean Sea (around Çanakkale and Ayvalik), the Sea of Marmara, and to a lesser extent, the Black Sea.

FIGURE ES.2 MAPS OF INITIAL EXPLORATION AREAS FOR OFFSHORE WIND.



Taking into consideration environmental, social, and technical constraints, the potential development is estimated at about 66 GW, equivalent to around 60 percent of the total existing generation capacity in the country. Very little of this resource potential is in shallow water (less than 50 meters) suited to fixed-foundation offshore wind, representing around 6.8 GW of potential across 1,510 km^2. The majority of the initial exploration areas for offshore wind are in deeper water (greater than 50 meters deep) suited to floating-foundation offshore wind, representing over 59 GW of potential across 13,270 km^2 (see Table ES.1). Stakeholder engagement and further data will be required to better understand these areas; the roadmap recommends this as one of the priority next steps as part of a wider marine spatial planning exercise.

TABLE ES.1 OFFSHORE WIND DEVELOPMENT POTENTIAL IN THE INITIAL EXPLORATION AREAS.

	Floating Potential		Fixed Potential		Wind speed
	KM2	GW	KM2	GW	m/s
Area 1: Black Sea	5,530	24.9	290	1.3	7.0—7.5
Area 2: Marmara Sea	4,330	19.5	610	2.7	7.0—8.5
Area 3: Çanakkale	1,660	7.5	380	1.7	8.5—10.0
Area 4: Ayvalik	610	2.7	230	1.0	7.0—9.5
Minor areas[iii]	1,140	5.1	-	-	7.0—8.5
TOTAL	**13,270**	**59.7**	**1,510**	**6.8**	

Source: Author's estimate. Based on a nominal power density assumption of 4.5 MW per km^2. This representative density is a reasonable assumption for this level of analysis and certainty; actual projects may have a higher capacity density once sites and wind turbine generator (WTG) layouts are refined. These estimates assume that floating foundations will be more applicable for depths greater than 50 meters, but it may also be possible to use fixed-foundations in water deeper than 50 meters.

SCENARIOS FOR OFFSHORE WIND DEVELOPMENT

To illustrate possible development paths for offshore wind in Türkiye, two deployment scenarios have been developed—a low and a high growth scenario (see Table ES.2 for a summary of each). The purpose of these scenarios is to illustrate the potential effect of industry scale on cost, consumer benefit, environmental and social risks, and economic impact. The scenarios are based on feedback from stakeholders, assessments of the state of offshore development today, statements on the political aspirations of Türkiye, and an assessment of the overall potential for offshore wind in the country. The scenarios were not established (and have not been tested) through a least-cost power generation expansion exercise; the roadmap recommends this as another one of the next steps.

The two development scenarios are summarized as:

- **Low growth**: assumes that offshore wind is relatively low priority as a new form of renewable power generation, with little support or encouragement from the Government. Under this scenario, some small projects are delivered over the coming decade, but capacity additions are modest compared to the country's energy demands.
- **High growth**: assumes that offshore wind is given a higher priority and its contributions are more meaningful, especially in the mid- to longer-term. The larger volume, scale of projects, and use of local content, helps to reduce the cost of energy and drives down costs as the industry develops.

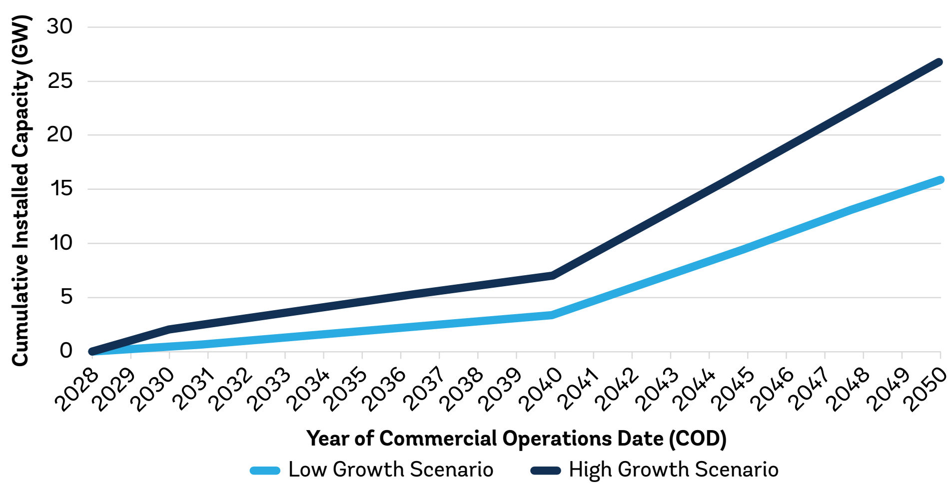
The cumulative deployment of capacity under these scenarios is shown in Table ES.2 and Figure ES.3.

iii Four smaller areas are also suitable for floating wind; two in the central Black Sea; one south of Izmir; and one near Samandag.

TABLE ES.2 OVERVIEW OF FIXED AND FLOATING OFFSHORE WIND CUMULATIVE CAPACITY UNDER THE LOW GROWTH AND HIGH GROWTH SCENARIOS.

Offshore wind	By 2030	By 2040	By 2050
Low growth (Cumulative)	**0.5 GW**	**3.5 GW**	**16.0 GW**
Bottom-fixed	0.5 GW	2.5 GW	6.0 GW
Floating	–	1.0 GW	10.0 GW
High groth (Cumulative)	**2.0 GW**	**7.0 GW**	**26.8 GW**
Bottom-fixed	2.0 GW	5.0 GW	6.8 GW
Floating	–	2.0 GW	20.0 GW

FIGURE ES.3: CUMULATIVE OPERATING CAPACITY UNDER THE TWO SCENARIOS.



The low growth scenario could be achieved with moderate action by the Government, focusing on the first few small scale projects. The high growth scenario, however, would require substantially greater Government action to prioritize offshore wind development and support local industrial development. More detail on the recommended actions is provided in the corresponding sections that follow.

These two scenarios are hypothetical and were devised to demonstrate the impacts of government policy and actions. Therefore, the actual volumes of offshore wind installed in Türkiye will likely differ from these scenarios, both in terms of overall volume and phasing of installation. The high growth scenario should not be seen as a ceiling; should the Government and other actors follow the recommendations in this roadmap, there is potential for offshore wind to exceed this scenario.

CHALLENGES FOR DEVELOPING OFFSHORE WIND

This roadmap demonstrates that offshore wind could deliver substantial value to Türkiye but that there are many challenges faced in establishing a successful industry at a large scale. Some of the main challenges include:

- **Türkiye still has ample capacity for expansion of solar and onshore wind energy, at a lower cost than offshore wind**—the benefits of offshore wind will need to be further assessed and should be deemed to outweigh the additional cost of generation. This should be considered as part of long-term energy and economic planning. Offshore wind should be developed in parallel to new onshore renewable energy projects, and should not be viewed as displacing other renewables.
- **Offshore wind speeds are low to moderate in Türkiye and offshore wind turbine technology is not yet optimized for these lower speeds**—the majority of offshore wind turbine models currently available are designed for wind climates in energetic resources such as the North Sea. Future turbines may be designed to suit lower energy offshore wind climates. In the interim, project developers could consider more novel solutions, utilizing onshore, lower windspeed turbines. Developers should also look at the solutions being proposed for other markets with comparable wind conditions, like South Korea.
- **Expectations regarding local content of offshore wind must be finely tuned to the ability of the industry to economically meet them**—the capabilities of local suppliers should be assessed to inform the local content expectations. The industry should also be engaged to ascertain whether local content expectations can be met economically. Other markets, such as Taiwan, have shown that overly optimistic or prescriptive local content requirements can result in much higher prices of power as well as delays to project delivery.
- **All sites suitable for bottom-fixed wind farms are currently located in 'restricted' areas**—Türkiye's waters have numerous environmental and social sensitivities. Further data and stakeholder engagement is required to better assess the issues identified in the areas of fixed offshore wind potential. It is likely that offshore wind development will not be possible in all of these areas, but it is not yet possible to say which areas may or may not be possible.
- **Cost of capital and exchange risks are essential to mitigate**—the high capital cost of offshore wind means that financing costs have a large bearing on the cost of energy. To make offshore wind affordable in Türkiye, these need to be reduced as far as possible. This could require innovative financing and mitigation measures, or using lessons from comparable industries such as geothermal.

RECOMMENDED ACTIONS

From the analysis and findings of this Roadmap, we recommend 21 actions that mainly focus on actions to be taken in the short term, but some can span over the entire timeframe up to 2050. Most of these recommendations are equally valid for the low growth or high growth scenario.

Each of these recommendations is described in more detail in Section 5 of the roadmap and evidence is provided in the Supporting Information found within Section 6 through to 14 of the roadmap.

The following points summarize the roadmap's 21 recommended actions:

Vision and volume targets

1. Ministry of Energy and Natural Resources, Türkiye (MENR) should communicate clear **offshore wind installation targets** in line with the preferred growth scenarios. Note: in 2022, during the drafting of this Roadmap, the Turkish Government published a target of installing 5 GW of offshore wind by 2035. This target conveys positive signals to the industry, helping to build the confidence needed to invest in Türkiye.
2. MENR should establish **mid- and long-term visions beyond 2035**, during which the market will deploy further capacity and achieve the volumes required to trigger economies of scale and reduce prices.
3. MENR should plan the deployment of floating offshore wind technology, targeting the installation of the first **floating pathfinder projects in the 2030s, followed by the installation of larger, commercial floating wind farms in the 2040s.** This long-term view beyond 2040 will enable the industry to progressively drive down the levelized cost of energy (LCOE) of floating wind.

Regulatory and policy framework

4. MENR should **establish an offshore wind policy and long-term development plan, based on the vision and volume targets.**
5. To inform the setting of targets and plans, the Government should **develop a Marine Spatial Plan (MSP) to help identify potential offshore wind farm areas.**
6. MENR proactively **de-risks projects, to a sufficient level, prior to tendering**. The **level of de-risking should be determined through dialogue** with industry and prospective bidders.
7. The Government should **streamline the regulatory framework and permitting processes.** This can be achieved either by establishing a coordinating body or by facilitating project developers in the permitting process and their applications to different authorities.
8. The Government should ensure the **permitting process incorporates environmental and social impact assessment (ESIA)** that is carried to the standard of Good International Industry Practice (GIIP).
9. The Government **publishes detailed guidance on the permitting process,** including a list of all the permits, authorities, and timelines to be considered along with guidance on the ESIA process.
10. The Government **introduces tenders for projects, driving competition among developers and thus progressively further reducing LCOE of offshore wind energy**.

Financial and economic

11. The Government utilizes a variety of financial tools to **reduce the weighted average cost of capital (WACC) of the first offshore wind projects.** This should be informed through discussions with prospective project developers/investors and financial institutions.
12. The Government, possibly with Electricity Generation Company (EUAS), **establishes a bankable power purchase agreement (PPA) which fairly allocates risk** between off-taker and developer, including exchange rate risk and appropriate levels of indexation to mitigate inflation. The terms of this PPA should reflect the offshore wind specific risks and learn from experiences in established offshore wind markets.

Health and safety

13. The Government **should introduce health and safety (H&S) requirements in alignment with industry best-practice standards**. Türkiye should base these H&S requirements on the approach taken in established offshore wind markets and not seek to develop completely new approaches.

Grid and port infrastructure

14. The Government should **complete long-term port planning and upgrades based on the long-term offshore wind development plan**.
15. The Government should **enable upgrades for at least one installation port in the same region (Aegean Sea or Marmara Sea) as the wind farm it serves**.
16. The Government should further **facilitate the upgrade of smaller local ports to use in operation and maintenance (O&M) phase**.
17. The Government and TEIAS should perform **grid impact analyses based on the long-term offshore wind development plan.** This will identify the grid expansion and reinforcement works required to connect the planned offshore wind capacity in both the short- and longer-term.

Supply chain

18. The Government should **support the development of the domestic supply chain in the short-term for local content requirement expectations to be met**.
19. The Government should establish a medium-term aim of increasing **major supply from domestic manufacturing within the period 2030-2035, once first domestic supply has been mobilized**.
20. The Government **should encourage the export of major components and floating foundations to international markets**.
21. The Government should **initiate training and skills assessments of the Turkish workforce** and prepare them for the establishment of a local supply chain.

1 INTRODUCTION

Over the past decade, offshore wind has continued to mature as technology, with increasing scale driving down costs. Offshore wind has become an affordable, large-scale, and modern form of renewable energy generation. Recent tenders in Europe saw offshore wind power prices fall below 50 USD/MWh and many governments include large volumes of offshore wind in their future energy plans. Projections suggest that annual, global installations of offshore wind will be between 8 to 22 gigawatts (GW) per year during the period of 2022 to 2025, increasing to between 25 to 40 GW per year from 2025 to 2030 [1].

Recognizing this shift in maturity of offshore wind, the World Bank Group (WBG) launched a new global initiative in March 2019. The Offshore Wind Development Program is led by the Energy Sector Management Assistance Program (ESMAP) in close partnership with the IFC[iv]. The Program's objective is to support the inclusion of offshore wind into the energy sector policies and strategies of emerging market countries and support the preparatory work needed to build a pipeline of bankable projects.

Development of domestic renewable energy (RE) resources are critical to further strengthen Türkiye's economic growth and to meet its global commitment for climate change mitigation and environmental sustainability. In October 2021, Türkiye ratified the Paris Agreement on climate and pledged to achieve net zero carbon emissions by 2053. Analysis by the World Bank Group (WBG) [2] estimated that Türkiye has 75 GW of technical potential[v] for offshore wind and could therefore help contribute to meeting the country's climate targets and complementing its onshore wind and solar power generation.

The Turkish Ministry of Energy and Natural Resources (MENR) requested support from WBG in developing an offshore wind roadmap to provide inputs to the Türkiye's Power Development Plan and inform the Government on the potential role of offshore wind in Türkiye's future energy mix. The World Bank commissioned the international consulting firm COWI to lead the development of the Offshore Wind Roadmap for Türkiye, working closely with the WBG team based in Ankara and Washington DC, as well as the Biodiversity Consultancy, and local Turkish consultants GazDay and RE-Consult. This roadmap is part of a series of country roadmap studies supported by the WBG Offshore Wind Development Program.

The objective of this roadmap is to provide strategic analysis and support the Government of Türkiye in making evidence-based decisions as well as providing a reference point for all stakeholders associated with establishing a new offshore wind market in Türkiye. The analysis considers the role that offshore wind could play in meeting future energy demand and sustainability objectives, and the key opportunities and challenges in delivering offshore wind including the potential costs and economic benefits. It provides recommendations on next steps in terms of policy formulation as well as planning and developing a pipeline of bankable projects.

iv IFC—International Finance Corporation is an international financial institution that offers investment to encourage private-sector development in less developed countries. IFC is a member of the World Bank Group.

v The offshore wind technical potential is an estimate of the amount of generation capacity that could be technically feasible, considering only wind speed and water depth. This is intended as an initial, high-level estimate and does not look at other technical, environmental, social, or economic constraints.

The development of this roadmap has benefited from a wide range of input received from stakeholders representing government and nongovernmental organizations, as well as the industry. In addition to the data collected from existing, publicly available sources, four stakeholder consultations were undertaken with the purpose of obtaining feedback from different stakeholder groups. The following organizations were invited to these consultations:

- **Government stakeholders**: MENR, General Directorate of Energy Affairs (GDEA), and Energy Market Regulatory Authority (EMRA)
- **Private sector stakeholders**, including project developers: Turkish Wind Energy Association, Ronesans, STFA, Enerjisa, and CIMTAS/ENKA
- **Domestic financial institutions**: AKBANK, Yapi Kredi Bank, and IS Bank
- **International financial institutions**: IFC and European Bank for Reconstruction and Development (EBRD)

Depending on the extent to which any roadmap recommendations are implemented, and market conditions, there are a range of possible growth outcomes for the offshore wind industry in Türkiye. To illustrate possible development paths, this roadmap considers two hypothetical deployment scenarios—a low growth and a high growth scenario. The scenarios are based on feedback from stakeholders, assessments of the state of offshore development today, statements on the political aspirations of Türkiye, and an assessment of the overall potential for offshore wind in Türkiye. These two growth scenarios are presented in detail in section 5.2.

The Turkish Government was in continuous collaboration with World Bank Group throughout the preparation of this roadmap and it is our understanding that this collaboration helped to inform the National Energy Plan for 2020-2035 [3], which was published in December 2022 during the finalization of this study. The Plan establishes new targets for renewable electricity and storage, including a target of 5 GW of offshore wind by 2035 (which is broadly in line with the high growth scenario presented in this roadmap). This is part of the Government's longer-term plan to achieve net zero by 2053.

The structure of this roadmap comprises a main body (chapters 2 to 5), which summarizes the key findings and conclusions of this report, as well as presenting the roadmap. Chapters 6 to 14 contain detailed analysis relating to the roadmap's themes and the evidence used to support the roadmaps findings and recommendations.

2 BACKGROUND

Türkiye's economic and social development since the early 2000s has been remarkable, resulting in a significant increase in employment opportunities and income levels, making Türkiye an upper-middle-income country [4]. However, this impressive economic growth, coupled with a rapidly growing population, has led to a substantial increase in energy demand. Türkiye has not been able to meet this demand through domestic sources alone, and currently relies on imports to meet around 70 percent of its energy demand [5]. In response to this dependency and demand growth, during the past decade, the Turkish Government has set a focus on:

- Achieving energy security through domestic production;
- Diversifying energy sources; and
- Becoming a regional energy trade center.

During this time, Türkiye has been successful at nearly tripling renewable energy generation, to the point that 42.3 percent of annual electricity generation in 2020 was from renewable sources, which exceeded the goal of 38.8 percent set out in the Eleventh Development Plan [6].

2.1 ELECTRICITY DEMAND

Turkish annual electricity demand was 306.1 TWh in 2020, which rose from 128 TWh in 2000 (equivalent to an annual increase of 4.4 percent). According to MENR's electricity demand projection in the National Energy Plan 2020-2035, it will continue to increase significantly over the coming 15 years [6]. MENR has prepared a reference for the growth in electricity demand, as presented in Table 2.1.

TABLE 2.1 MENR ELECTRICITY DEMAND PROJECTIONS 2020-2040 [3].

Scenario	Reference
TWh in 2035	510.5
Annual growth rate	3.5%
Percentage increase from 2020	66.8%

The demand growth projections are the result of the electrification of the Turkish energy sector, transitioning energy supply away from fossil fuels. The Türkiye Energy Outlook projects that electricity use will grow strongly over the coming years, but also that energy efficiency policies, to some extent, will offset the growth. However, there is no question that demand for electricity in Türkiye will be significant and growing [7].

Türkiye is a vast country, spanning over 1,700 km from east to west and over 1,000 km from north to south. The majority of the industrial centers and major cities that drive energy demand are located in the western part of the country, often near the coast. As a result, the distribution of electricity demand in Türkiye is not uniform across the country. It is also heavily influenced by meteorological conditions, particularly the high temperatures of the south and south eastern regions, and the significant load centers associated with larger cities such as Ankara, Istanbul, Bursa, and Izmir. These cities have experienced rapid population growth and industrialization, leading to a surge in energy demand.

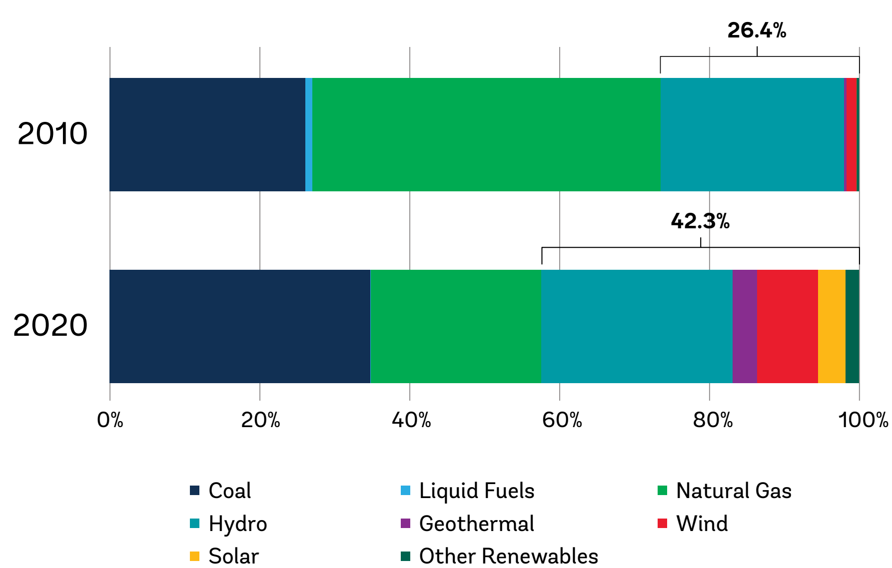
This load distribution means that most of the transmission lines are loaded in the east-west direction, where the large base of hydropower plants in eastern Türkiye supply power to the load centers in the west. The main east-west 380 kV transmission corridors are therefore critical to the Turkish system. Based on the demand and generation profiles, west of Türkiye typically imports approximately 6,000 MW from east of Türkiye.

Given the substantial growth in electricity demand and the various possibilities from existing and planned interconnections, Türkiye can easily consume the electricity generated by future offshore wind farms. Other offtake or storage possibilities as "power to X" (e.g., in the form of hydrogen production) are therefore not of immediate interest but may become interesting in the long term.

2.2 ELECTRICITY MIX

Türkiye's electricity generation mix is diverse. Figure 2.1 shows that renewable energy has become increasingly prominent over the last decade. In 2010, renewable energy accounted for 26.4 percent of Türkiye's yearly electricity generation (211 TWh at the time) and hydropower was by far the dominant source of RE generation. In 2020, renewable energy production increased to 42.3 percent of the total generation (307 TWh annually at the time) and this increase was mostly from new wind and solar generation.

FIGURE 2.1 SHARE OF GENERATION SOURCES BY PERCENTAGE OF TOTAL ANNUAL POWER GENERATION [8].



Nuclear is expected to be added to the energy mix as a strategic energy source to help reduce fossil fuel imports. The Akkuyu nuclear plant is currently under construction and, when fully complete, will add a power generation capacity of 4,800 MW. The full capacity is expected to come online in phases, with the first phase consisting of 1,200 MW scheduled to be grid-connected by the end of 2023. Planning for two additional nuclear plants is underway [9]. In the mid-term, natural gas use is expected to decrease as the Turkish Government steers electricity industry away from imported gas and towards renewable sources and storage [6].

According to the National Energy Plan published by MENR, by 2053, Türkiye could see an enormous increase of the current installed capacity of renewable sources reaching up to 69 percent of generation, with over 60 percent comprising wind and solar generation capacity [3]. The plan also emphasizes that the share of natural gas-fired power plants in total electricity generation, which was 23.1 percent in 2020, will decline in the long term. Natural gas-fired power plants may periodically make higher or lower contributions as they are used to offset variations in electricity generation from other sources. The typical daily dispatch would look dramatically different from the current generation, with nuclear providing a stable output and wind generating consistently around the clock.

Over the next decade, electricity generation is expected to increase substantially to meet the growing demand. MENR expects that the share of wind and solar will increase dramatically, along with nuclear generation. Thermal generation (coal and gas) will continue to grow to 2030 but is expected to decline thereafter. See Table 2.2 for a summary of the generation trends between 2020 and 2035.

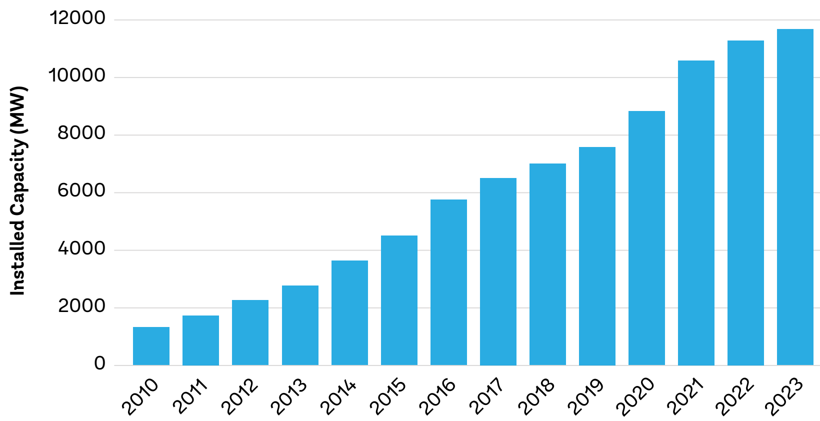
TABLE 2.2 SHARE OF TOTAL ANNUAL GENERATION FROM DIFFERENT SOURCES BETWEEN 2020 AND 2035 [3], [8].

	2020		2025		2030		2035	
	TWh	% of total generation	TWh	% of total generation	TWh	% of total generation	TWh	% of total generation
Thermal	175.9	57.6%	196.4	51.7%	201.2	44.4%	173.7	34.2%
Nuclear	0.0	0.0%	18.6	4.9%	37.2	8.2%	55.8	11.0%
Hydro	78.1	25.6%	81.9	21.5%	87.9	19.4%	87.9	17.3%
Wind	24.7	8.1%	38.3	10.1%	53.7	11.9%	90.1	17.7%
Solar	11.2	3.7%	28.3	7.4%	52.2	11.5%	84.0	16.5%
Other	15.4	5.0%	16.7	4.4%	20.5	4.5%	16.2	3.2%
Total	**305.3**		**380.2**		**452.7**		**507.7**	

2.3 WIND ENERGY IN TÜRKİYE

Onshore wind power has been a major Turkish success story, particularly as it has catalyzed local economic growth. The installed capacity has increased from around 1.3 GW in 2010 to almost 9 GW in 2020, as presented in Figure 2.2.

FIGURE 2.2 ONSHORE WIND CAPACITY OPERATING IN TÜRKİYE BETWEEN 2010 TO 2022 [10].



In 2021 there was more than 10 GW of onshore wind energy operating and Türkiye was ranked 12th globally in terms of installed onshore wind capacity. According to MENR, onshore wind capacity is continuing to grow and, in 2022, the installed capacity in Türkiye reached 11.3 GW with an additional 2.1 GW under construction.

The majority of onshore wind farms have been constructed in the west of the country, in areas of energetic wind resource and close to demand centers. There are also areas of good wind potential in the middle of the country, however few projects have been built there. The overall onshore wind power potential in Türkiye is estimated to be over 100 GW, according to MENR [11], which means there is still significant untapped potential, although not all of this will be close to areas of electricity demand.

Since 2005, Türkiye has supported investments in renewable energy projects through various renewable regulations and laws, as further described in chapter 7. Under the support schemes, renewable energy plants such as wind, hydropower, geothermal, biomass, and solar can qualify for feed-in tariffs. There are often additional incentives offered if the mechanical and/or electro-mechanical components of a plant are manufactured domestically.

Due to incentives for domestic production and local research and development, more than 70 companies are involved in manufacturing wind turbine generators (WTGs) and onshore wind components in Türkiye. As a result, Türkiye has become the fifth largest producer in the wind sector in Europe and exports 75 percent of its production capacity [12].

In 2018, the Turkish Government announced an ambition to construct an offshore wind farm with a capacity of between 840 MW and 1.2 GW, built with the latest technologies, with local content requirements, and with 80 percent of personnel being Turkish. However, the 2018 tender was not completed due to several reasons including a combination of both tender-specific and macro-economic factors which made the overall project too risky for developers. Some of the key issues included: unclear permitting procedures; lack of site-specific data; expensive financing; and direct competition with other renewable sources like onshore wind and solar. See section 7.3.3 for further discussion.

Based on the experiences of the 2018 tender, both the Government of Türkiye and developers realized that more preparatory work would be beneficial and needed before a new tender could be launched. It is intended that the recommendations presented in this roadmap will assist the Government of Türkiye in successfully achieving this goal.

2.4 COST OF ENERGY

As with all other generation resources, offshore wind must be seen in the context of the cost of energy. Table 2.3 illustrates the current typical costs of energy of various energy sources in Türkiye, as estimated by the Istanbul International Centre for Energy and Climate (IICEC) at Sabanci University (2019). Given the moderate wind resource and the high cost of capital in Türkiye, the LCOE of the first offshore project with a commercial operation date (COD) in 2030, is expected to be in the range of US$94 per MWh to US$117 per MWh (see section 3.4 for further analysis and assumptions).

TABLE 2.3 OVERVIEW OF ESTIMATED COST OF ENERGY IN TÜRKİYE IN 2019, ACCORDING TO SABANCI UNIVERSITY IICEC [7].

	Capital expenditures (CAPEX) (US$per kW)	LCOE (US$per MWh)
Coal	1,300	50 to 55
Natural gas	750	50 to 55
Hydro	1,700	75 to 80
Geothermal	3,750	100 to 110
Onshore wind	950	45 to 50
Solar	550	50 to 55

As the table demonstrates, offshore wind in the short term will be costlier than most other energy sources including onshore wind. This is consistent with a pattern that has been seen in other countries where the first offshore wind projects are built at a relatively high cost due to first-of-a-kind risks and the lack of local supply chain and capability. Experience in established offshore wind markets has shown [13] the LCOE will fall over time as more offshore wind is deployed in the market. Internationally, cost reductions have been driven in large part by technology development, improved operational efficiency, and local industry maturation, as well as increasing competition and reduced margins across the value chain. A large share of the cost reductions can be attributed to the introduction of ever larger WTGs and project sizes which significantly lower the relative share of installation, balance of plant (BoP), and operations and maintenance costs. Furthermore, improved project management and risk reduction across the maturing sector have attracted lower financing costs.

Recent developments in the US and in Taiwan, where the awarded projects have come in close to European cost levels, signals that the technology development and industry maturation can be transferred across regions. This speaks to a positive outlook for cost reductions in Türkiye as well. However, the main driver for cost reductions will still be volume. The offshore wind industry must see sufficient future volume to consider investing in Türkiye and the Turkish industry needs to see the same potential.

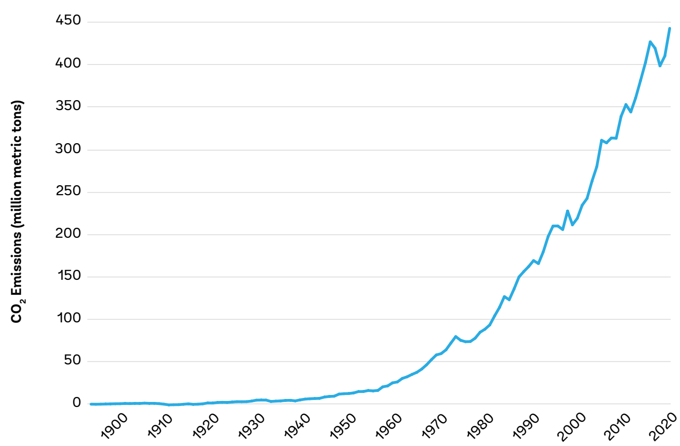
Thermal generation is expected to be comparable to or lower than offshore wind costs in the medium-term. Coal and natural gas, however, are likely to increase in price over the long-term rather than remain stable, as Türkiye is considering implementing a carbon pricing scheme [14]. Hydro, solar, onshore wind, and offshore wind are the renewables with the lowest predicted long term cost. These energy sources will be the lowest cost renewable energy sources and can all contribute to increasing Türkiye's domestic production and energy security.

2.5 DECARBONIZATION

According to Türkiye's Intended Nationally Determined Contribution (INDC) [15] under the Unmited Nations Framework Convention on Climate Change (UNFCCC), Decision 1/CP.16 recognized the special circumstances of Türkiye and placed Türkiye in a different situation than the other Parties included in Annex I.[vi]

Türkiye's CO_2 emissions have been rapidly increasing over the recent decades, as presented in Figure 2.3, and exceeded 446 million metric tons in 2021.

FIGURE 2.3 ANNUAL CO_2 EMISSIONS IN TÜRKİYE [16].



At COP27, Türkiye announced its ambitions of a 41 percent reduction in greenhouse gas (GHG) emissions, with the year of emissions peaking in 2038. In 2021, Türkiye announced its 2053 net zero target [17], and Türkiye's updated Nationally Determined Contribution (NDC) was announced in April 2023 [18].

According to the NDC, Türkiye aims to contribute to the collective efforts to combat climate change in line with its national circumstances and capabilities. Türkiye has not pledged to any specific target for the share of RE sources in its energy mix. Although, the INDC states an intention of increasing capacity of production of electricity from wind power to 16 GW by 2030, the Turkish National Energy Plan, published in 2022, increased this target to 18.1 GW by 2030 and 30 GW by 2035. In the longer term, offshore wind will play a role in achieving further reductions and increasing the share of RE source. This progress is well underway to achieve the goals in terms of electricity from wind power, as shown by the rapid growth of wind capacity in Figure 2.2.

Türkiye has ambitious targets for renewable energy generation, to which offshore wind can contribute significantly. However, in the short term, with a lot of untapped onshore wind potential at a lower cost of energy, offshore wind will have to be specifically nurtured and prioritized to take off. Reaping the long-term benefits of offshore wind requires accepting that, in the short term, offshore wind will carry

vi Annex I Parties include the industrialized countries that were members of the OECD (Organisation for Economic Co-operation and Development) in 1992, plus countries with economies in transition (the EIT Parties), including the Russian Federation, the Baltic States, and several Central and Eastern European States.

higher cost than onshore wind. Moving successfully through this establishment stage will require a different tariff, financing schemes, and government support.

2.6 DRIVERS FOR OFFSHORE WIND

As the global offshore wind industry has matured over the last 20 years, experience from European early adopters shows that each country has charted its own path and that there are multiple ways to establish a successful offshore wind industry. The paths that these countries have taken are influenced by the existing regulatory frameworks, political priorities, and characteristics of the available wind resource. What they have in common is that these countries have been able to find their own ways to fulfill the key requirements for first establishing and then growing an offshore wind industry.

Though Türkiye has extensive experience in developing onshore wind, there are major differences between the two technologies and their respective industry requirements. In addition to the challenges of marine planning and construction, a principal difference lies in the investment size of offshore wind farms (OWFs). In Europe, the average wind farm size has been continually increasing, as larger sizes create economies of scale and reduce LCOE. In 2020, the average European offshore wind farm size was 788 MW and developers in new markets are typically looking for wind farm sizes of at least 500 MW to provide sufficient volume to be commercially viable [19]. A representative 700 MW OWF typically requires a capital expenditure of US$1.75 to 2.50 billion, with a development expenditure often exceeding US$50–70 million; although these figures could be higher in a new, emerging market with higher uncertainties.

Due to the large investments required and the long project development time, experience from established markets has shown that both certainty and clarity from a government are critical to reduce risks and costs [13]. The World Bank Group's report *Key Factors for Successful Development of Offshore Wind in Emerging Markets* [13] discusses in depth what is required to build up an offshore wind industry in emerging markets, from the fundamental strategic drivers, to policy to frameworks and delivery.

Drivers for developing offshore wind often differ between markets. Some of the main drivers for Türkiye considering offshore wind include the following factors.

Economic benefits: Existing Turkish industry and supply chain for onshore wind, shipbuilding, and marine activities will have the opportunity to expand into the offshore wind industry. These suppliers could primarily serve the local Turkish offshore wind market but also benefit from exports across Europe and further internationally. In particular, many countries across the Mediterranean region are beginning to plan their own offshore wind markets and this will predominantly focus on floating wind due to the natural characteristics.

Decarbonization: Investing in offshore wind will increase the amount of renewable energy and hence contribute to the green transition of the electricity production and thereby reduction of CO_2 emissions. Through the NDCs, the Turkish Government has committed to a net-zero target by 2053. With offshore wind sites in Türkiye showing large potential capacities, wind power can be a key driver to sustain the Government's ambitions. However, there is the need for large scale generation to drive down cost after the first projects. Wind output could also aid system balancing as the temporal generation profile from wind is known to complement the generation profile from solar.

Electricity demand: The location of potential offshore wind sites being close to some of the large demand centers is also an advantage. Today, Türkiye transmits large quantities of energy produced in the east of the country to the industrial and population demand centers in the west. Offshore wind can add significant new renewable generation capacity much closer to these heavy load demand centers (e.g., Istanbul and Izmir).

Analysis undertaken for this roadmap focuses on providing evidence to help answer some fundamental questions relating to establishing a new offshore wind industry, including:

- **Favorable natural site conditions**–Does Türkiye have large areas with energetic wind speeds? What proportion of these areas contain environmental and social sensitivities that could restrict the deployment of offshore wind due to potential impacts? Based on the seabed characteristics, what is the potential for fixed vs. floating wind?
- **Regulatory framework**–How can the risk of project development be fairly allocated? Are permitting frameworks transparent and as simple as possible while meeting appropriate standards for environmental and social protection?
- **Financing**–What are realistic costs in the short term? Is the power offtake secure and bankable? How can Türkiye attract project developers in what is increasingly becoming a seller's market?
- **Health and safety**–What must Türkiye do to ensure that the jobs provided by offshore wind are safe? Are existing regulations sufficient to be applicable to offshore wind development?
- **Grid and port infrastructure**–How much of Türkiye's port and grid infrastructure can be used for offshore wind? What kind of upgrades are expected to be necessary?
- **Supply chain**–How much capacity and experience do Turkish companies have in offshore wind or related sectors? What are the incentives for wind farm developers to source within Türkiye?

These topics are reflected in the structure of the key findings (chapter 3) and the detailed analysis (chapters 6 to 13).

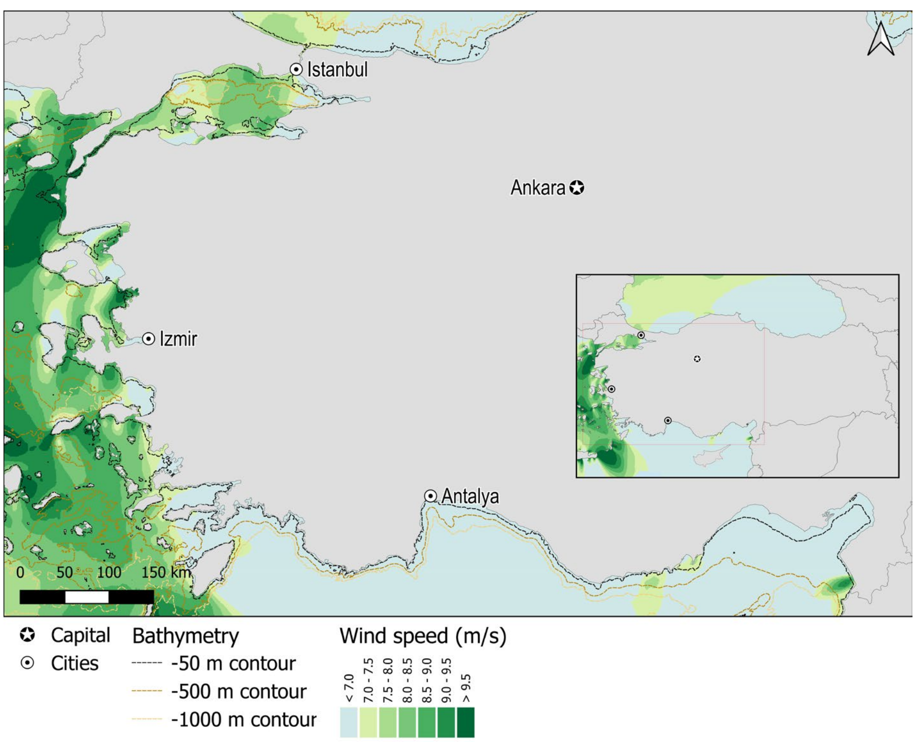
3 KEY FINDINGS

Analysis for this roadmap covers a broad range of themes including: technical, regulatory, environmental, social, and economic issues. Outputs from this analysis is reported in chapters 6 to 15 and the following subsections summarize their key findings.

3.1 SUITABILITY ASSESSMENT OF OFFSHORE WIND AREAS

In a global context, Türkiye's offshore wind speeds are moderate to low[vii] with the best resources found along the western coast in the Aegean (typically 8.0-9.5 m/s), followed by parts of the Marmara Sea (typically 7.0-8.5 m/s), as shown in Figure 3.1. The wind speeds in the Black Sea are spatially consistent, but lower (around 7.0-7.5 m/s or less). With the exception of a small, isolated region, the southern coast does not have wind speeds adequate for economically viable offshore wind using current technology.

FIGURE 3.1 AREAS WITH MEAN WIND SPEED HIGHER THAN 7.0 M/S AT 150 M BASED ON GLOBAL WIND ATLAS [20].

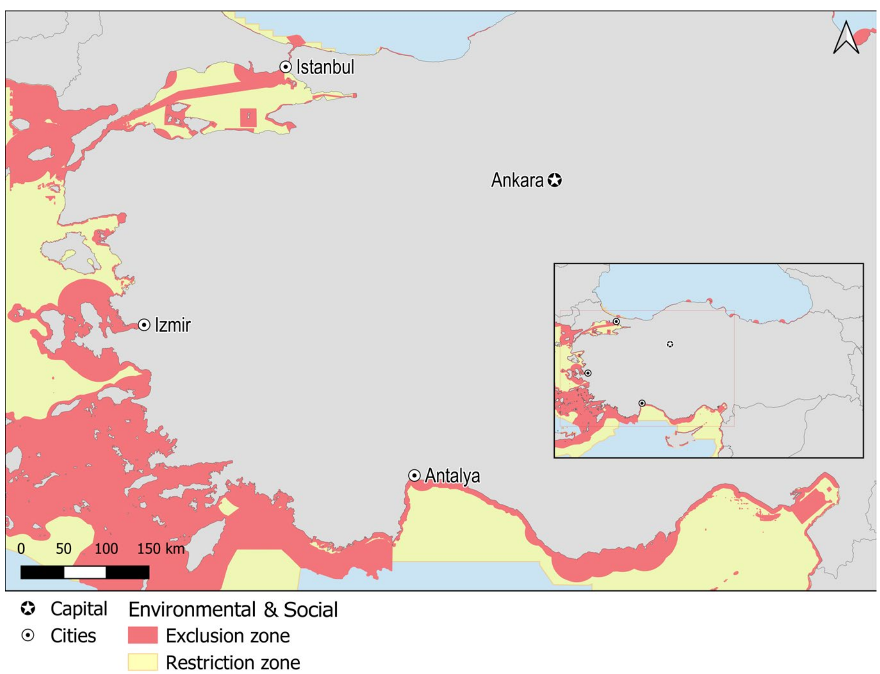


vii The majority of current WTG technology is designed for sites with annual average hub height wind speeds of ideally 9 m/s and higher. Sites with speeds of <9 m/s are less optimal. Sites with average speeds <7 m/s are technically viable, but will be economically marginal as the cost of energy will be high due to the reduced energy yield. WTG technology is rapidly evolving, however, so this assumption may change in future years as WTGs are developed for lower wind speed conditions.

Shallow areas suitable for bottom-fixed WTGs, up to 50 m water depth,[viii] are found along the western coast of Türkiye and very near to the shoreline of the Black Sea and Marmara Sea. Floating installations are possible in large areas, but may be limited in practice by sloping escarpments and seabed topography. Furthermore, for navigational safety of shipping, the locations of floating wind farms should be carefully selected to account for shipping traffic and to avoid the heavily trafficked routes. See Figure 6.1 in section 6.2 for a map showing Türkiye's bathymetry, and section 6.4.2 for an assessment of shipping activities.

In areas with adequate wind speeds (typically greater than 7m/s annual average), Turkish coastal waters are heavily constrained by environmental and social sensitivities, as shown in Figure 3.2. In this figure, exclusion zones represent areas with very high environmental or social sensitivities, and offshore wind development in these areas is not recommended as the impact of offshore wind is likely to be unacceptably high, or that mitigation measures are unlikely to be economically viable. The major constraints within the exclusion zones include protected areas, internationally recognized areas for biodiversity (e.g., Key Biodiversity Areas (KBAs)), foraging areas and nesting areas for sea turtles, threatened natural habitats (e.g., seagrass beds), and core areas for Mediterranean monk seals, which are endangered. Social and technical constraints, such as military zones and International Maritime Organization (IMO)-registered shipping lanes also add to the exclusion zones. Restriction zones represent areas containing high environmental and social sensitivities but could host offshore wind developments following further investigation including careful site selection, appropriate environmental and social studies, and consideration of appropriate mitigation. Table 3.1 summarizes which constraints fall into each category.

FIGURE 3.2 ENVIRONMENTAL, SOCIAL, AND TECHNICAL EXCLUSION AND RESTRICTION ZONES IN TÜRKİYE [21].



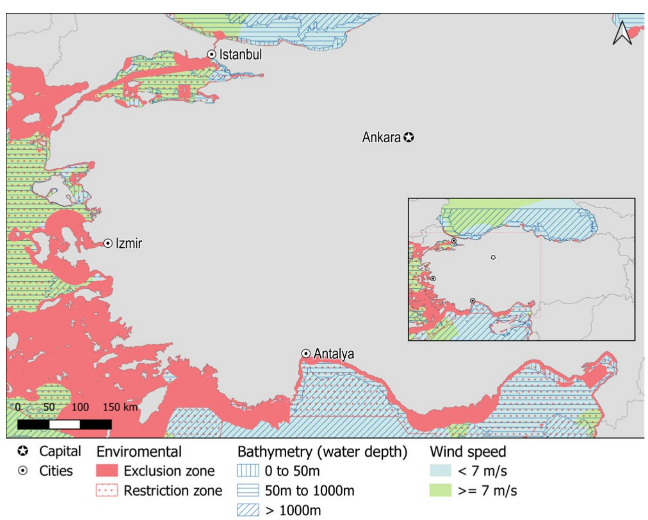
viii Typically, fixed foundations have been used for offshore wind in water depths less than 50 m, however, as technology continues to evolve, this limit has continued to change. In some cases, fixed offshore wind may be deployed in water deeper than 50 m, but this will be determined based on engineering and economics. Similarly with floating wind, it is possible to deploy floating foundations in water deeper than 50 m but, with current technology, the economics tend to improve with water deeper than 70tom. In this roadmap, the boundary depth between fixed and floating offshore wind has been assumed to be 50 m, but this will be considered further on a project by project basis.

TABLE 3.1 ENVIRONMENTAL, SOCIAL, AND TECHNICAL EXCLUSION AND RESTRICTION ZONES.

Exclusion zones	Restriction zones
Protected areas and internationally recognized areas (i.e., special protection areas; Ramsar sites; Key Biodiversity Areas (KBAs), including Important Bird Areas and Alliance for Zero Extinction (AZE) Sites	Protected areas and internationally recognized areas (i.e., Ecologically or Biologically Significant Marine Areas (EBSAs), ACCOBAMS Cetaceans Critical Habitats (CCH)) and Important Marine Mammal Areas (IMMAs))
Important natural habitats	Threatened natural habitats (partial)
Important sites for Mediterranean monk seal and marine turtles	Migratory birds
Military exercise areas	Shipping lanes
Airports and radars	Subsea cables
Oil and gas pipelines	Fishery, tourism, coastal communities
Cultural heritage	
IMO-registered shipping lanes	
İmrali no-go zone (government-designated area around İmrali island)	

By combining the data on wind speed, environmental and social constraints, and bathymetry, it becomes clear that there are few suitable areas for fixed offshore wind farms, but a larger number of areas for floating. Ideally, fixed foundation wind farms are located in areas which meet the basic technical requirements—wind speeds greater than 7 m/s and water depth of 50 m or less[ix]—and avoid high risk environmental and social sensitivities. Figure 3.3 shows that there are no areas in Türkiye which have all three of these characteristics. The outlook is better for floating wind farms; there are large areas in the Black Sea with acceptable (but low) wind speeds and no identified exclusions or restrictions. Areas in both the Marmara and (to a lesser extent) Aegean Seas have good wind speeds but are within restriction zones, and so further investigation of the constraints in these areas will be required before confirming their suitability for offshore wind development.

FIGURE 3.3 COMBINED TECHNICAL CHARACTERISTICS AND CONSTRAINTS TO IDENTIFY SUITABLE OFFSHORE WIND AREAS.



ix It may be possible to install fixed offshore wind farms in deeper water, up to 70 m water depth is sometimes considered. Deeper water will increase the capital cost of the wind farm. As a conservative estimate, this work considers 50 m as a reasonable upper limit for fixed offshore wind.

In the absence of areas without exclusion or restriction zones, the next best alternative is to consider potential wind farm sites within restriction zones. **Figure 3.4 and Figure 3.5 show the remaining potential areas for fixed and floating offshore wind after filtering out unsuitable areas for low wind speed, deep water, and exclusion zones. As many of these potential areas are located in restriction zones, they will need additional studies to better understand the restrictions and whether a project could be developed to meet international environmental and social standards.** For the purposes of this roadmap, these areas have been divided into four major potential areas, as labeled in the following maps.

FIGURE 3.4 POTENTIAL AREAS FOR FLOATING AND FIXED FOUNDATION OFFSHORE WIND PROJECTS IN THE MARMARA SEA AND BLACK SEA.

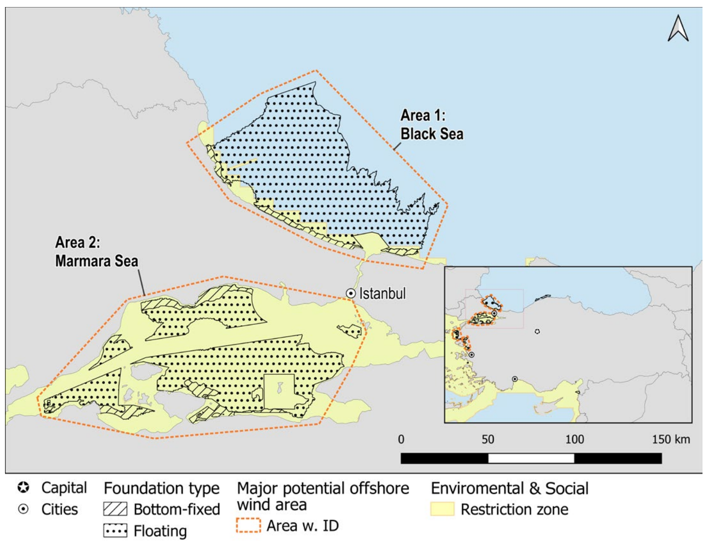
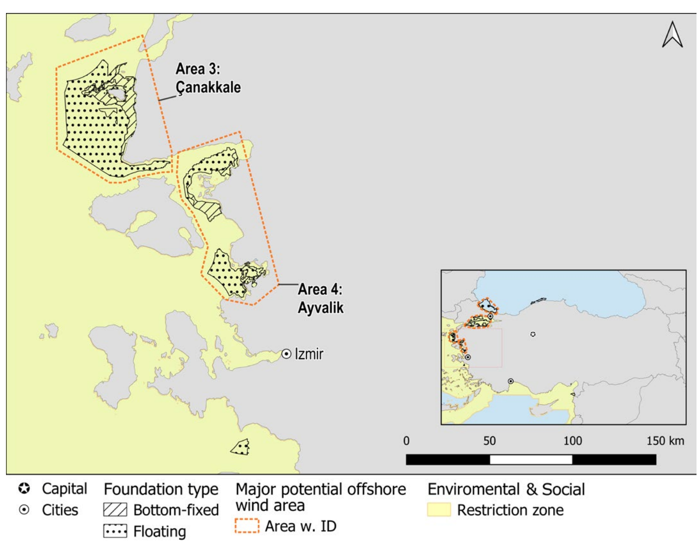


FIGURE 3.5 POTENTIAL AREAS FOR FLOATING AND FIXED FOUNDATION OFFSHORE WIND PROJECTS IN THE AEGEAN SEA.



The characteristics of the major areas of potential are given in Table 3.2.

TABLE 3.2 CHARACTERISTICS OF MAJOR OFFSHORE WIND AREAS IN TÜRKİYE.

	Floating Potential		Fixed Potential		Wind speed
	KM²	GW	KM²	GW	m/s
Area 1: Black Sea	5,530	24.9	290	1.3	7.0 to 7.5
Area 2: Marmara Sea	4,330	19.5	610	2.7	7.0 to 8.5
Area 3: Çanakkale	1,660	7.5	380	1.7	8.5 to 10.0
Area 4: Ayvalik	610	2.7	230	1.0	7.0 to 9.5
Minor areas[x]	1,140	5.1	-	-	7.0 to 8.5
TOTAL	**13,270**	**59.7**	**1,510**	**6.8**	

Total potential of the identified sites is estimated at 6.8 GW for fixed and 59.7 GW for floating offshore wind, assuming a WTG density of 4.5 MW/km². This representative density is a reasonable assumption for this level of analysis and certainty; actual projects may have a higher capacity density once sites and WTG layouts are refined. By including environmental, social, and other siting constraints, the total locational potential including restriction zones, is slightly lower than Türkiye's overall technical potential, which was previously estimated to be 12 GW for fixed and 63 GW for floating [2].

It is important to realize that it will not be possible to deliver all of the fixed and floating potential summarized in Table 3.2. All of the 6.8 GW of fixed potential is located within areas that have high environmental and social sensitivities; it is very likely that the development of projects in some of these areas may ultimately not be possible. Furthermore, these potential figures do not consider the economic factors, and projects in some areas will be deemed too expensive. Thus, it should be emphasized that if fixed potentials may not be deemed feasible in the proposed areas, it could increase the focus on floating windfarms, which would increase the short-term cost. However, with vast export opportunities in the coming future, this might be beneficial long term. The large floating potential far surpassing what is expected to be exploited in the scenarios, means that shortfalls in the fixed potentials could be suitably compensated by any floating capacity.

3.2 GROWTH SCENARIOS

To illustrate possible development paths for offshore wind in Türkiye, two hypothetical deployment scenarios were developed—a low growth and a high growth scenario.[xi] The scenarios are based on feedback from stakeholders, assessments of the current state of the offshore wind industry, statements on the political aspirations of Türkiye, an assessment of the overall potential for offshore wind in Türkiye, and estimates of Türkiye's future electricity demand. These scenarios are indicative and do not suggest targets or development pathways for the country. The scenarios were not established (and have not been tested) through modelling of current or future energy systems and they do not consider least-cost planning.

x Four smaller areas are also suitable for floating wind; two in the central Black Sea, one south of Izmir, and one near Samandag.

xi While developing this roadmap, the government of Türkiye was independently assessing potential growth scenarios. During the finalization of this study the Government of Türkiye announced a target of 5 GW of offshore wind by 2035, which is broadly in line with the capacity deployment under the high growth scenario.

In both scenarios, the period up to 2030 is foreseen to support a momentum in offshore wind development in Türkiye by procuring and delivering the country's first offshore wind projects. As a result, the Turkish industry would develop new skills and expertise that can be further developed post-2030 and support the establishment of a strong domestic offshore wind supply chain. The successful realization of the projects would demonstrate that the regulatory framework including the YEKA (renewable energy resource zone) offshore wind tenders, transmission and port infrastructure, and financing conditions are suitable for offshore wind. During the post-2030 period, offshore wind could become a fully industrialized sector supporting higher export capacities, including floating offshore wind components.

The main differences between the two growth scenarios include the:

- Sizes of the 2030 operational capacity;
- Number of ports upgraded;
- Number of transmission lines that must be upgraded; and
- Local content requirements.

Results in terms of employments effects, contribution to GDP, and resulting LCOE are presented in chapter 8.

The preliminary analysis in this study estimates that Türkiye has 6.8 GW locational potential for bottom-fixed wind and 59.7 GW for floating. The scenarios consider that part of this potential could be utilized by 2050. Summaries of the two scenarios are provided in Table 3.3, Table 3.4, and Figure 3.6.

TABLE 3.3 OVERVIEW OF FIXED AND FLOATING OFFSHORE WIND CUMULATIVE CAPACITY UNDER THE LOW GROWTH AND HIGH GROWTH SCENARIOS.

Offshore wind	By 2030	By 2040	By 2050
Low growth (Cumulative)	**0.5 GW**	**3.5 GW**	**16.0 GW**
Bottom-fixed	0.5 GW	2.5 GW	6.0 GW
Floating	–	1.0 GW	10.0 GW
High groth (Cumulative)	**2.0 GW**	**7.0 GW**	**26.8 GW**
Bottom-fixed	2.0 GW	5.0 GW	6.8 GW
Floating	–	2.0 GW	20.0 GW

FIGURE 3.6 GRAPH COMPARING THE CUMULATIVE CAPACITY UNDER THE LOW GROWTH AND HIGH GROWTH SCENARIOS.

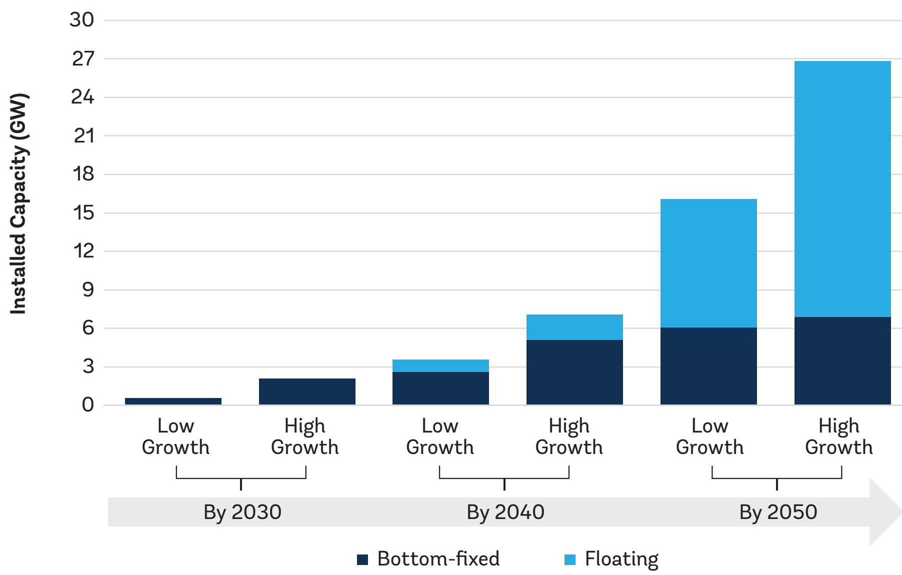


TABLE 3.4 OVERVIEW OF THE IMPACT OF THE TWO SCENARIOS BY 2050, INCLUDING PERCENTAGE SHARE OF TOTAL INSTALLED GENERATION CAPACITY, ANNUAL CO_2 AVOIDANCE, AND ECONOMIC IMPACT.

2050 Scenario	Percentage share of total installed generation capacity by 2050	CO_2 emission reduction (metric tons of emissions per year)	GDP contribution (US$per year)
Low growth	≈ 4%	Up to 2.7 million	5 billion
High growth	≈ 7%	Up to 4.5 million	6 billion

3.2.1 Low growth scenario

Under this scenario, MENR publishes a relatively modest vision for offshore wind development, with most of the growth occurring in the period of 2040-2050.

A 500 MW project would be the first Turkish OWF and would be delivered in close collaboration between public and private stakeholders, and with financial de-risking from international donors and financial institutions. To achieve this, the next few years would be spent gathering site data, designing and optimizing the tender, improving the regulatory framework, putting in place financial support packages, and running a project tender by 2025. This would allow the winning project developer two years to reach financial close, after having secured the final permits and approvals, and a further three years to construct the project.

Over the coming years, and prior to the tender in 2025, the regulatory framework for offshore wind in Türkiye should be streamlined to reduce development risks and increase project developers' interest in this market opportunity. This could be done through well organized government coordination of the permitting process, providing clarity on the permits required, and even the government providing some in-principle permits as part of the project tender to reduce the burden on the winner.

In addition, the terms of the YEKA should be refined to ensure the tender is acceptable and achievable (ideally resolving some of the major issues identified in section 7.3.3); this refinement should be done in consultation with the wider offshore wind industry. The sensitivity mapping started under this roadmap's analysis should be further developed and used in a stakeholder engagement process to identify a site suitable for Türkiye's first 500 MW project. Then, MENR should begin a data collection campaign to characterize the physical conditions of the site as well as undertaking baseline environmental and social surveys. This preparation should lead to a successful tender for this project in 2025.

Through the process of delivering the first Turkish OWF, the Turkish authorities will gain valuable experience. Furthermore, the improved permitting procedures developed during this period will provide a solid foundation for further offshore development beyond 2030.

During the following decade, a further 3 GW of capacity would be delivered by 2040. Preparation for this should commence during 2025 to 2030 with site identification and data collection commencing. Tenders for this capacity should occur during the early 2030s and should incorporate improvements based on the learning from the first tender and the experience of permitting and delivering the first project. It is important that the timing of these tenders is considered in the context of local suppliers, as the rate of demand for components and services should match the capacity and rate of local supplier capability. Suppliers prefer a long-term, steady rate of business, rather than intense periods of activity, followed by inactivity and lack of demand. This decade would also see the deployment of Türkiye's first floating offshore wind farm, most likely in the deeper waters of the Aegean Sea.

In the remaining period to 2050, an additional 3.5 GW of fixed offshore wind and 9 GW of floating offshore wind projects, would be deployed. By 2040, Türkiye's local supply chain would have had experience with both fixed and floating wind, plus local firms should already be exporting to other markets. The cost of subsequent projects should therefore reduce due to the mature local supply chain, as well as the development of other offshore wind markets in the Mediterranean region.

In the low growth scenario, by 2050, offshore wind could make up approximately 4 percent of Türkiye's total installed capacity of all plants (estimated total installed capacity by 2050 is 405 GW [22]), avoiding up to 3.4 million metric tons of emissions per year, and annually adding US$5 billion per year to Türkiye's economy.

A proposed roadmap considering the low growth scenario is given in Figure 5.1 (see section 5.2).

3.2.2 High growth scenario

Türkiye commits to fast-tracking a centralized approach (such as the Dutch/Danish "one-stop shop" approach) to site development and permitting, which greatly increases the interest from international offshore wind developers, leads to increased competition, and lowers costs. This is complemented by a political commitment to an ambitious, yet achievable offshore wind target and associated pipeline of tenders and dates. During the finalization of this roadmap, the Turkish Government declared a 5 GW target of offshore wind power by 2035, which shows great commitment to the technology and political will, as well as being in line with the high growth scenario presented here.

In this scenario, a target of an aggregated capacity of 2,000 MW distributed across multiple projects (with project sizes typically being 500 MW to 1,000 MW) would establish the first Turkish offshore windfarm build out. These would be delivered by early 2030 in close collaboration between public and private stakeholders, and significant financial de-risking from international donors and financial institutions.

To achieve this, similarly as in the low growth scenario, the next few years would be spent gathering site data, designing and optimizing the tender, improving the regulatory framework, putting in place financial support packages, and running a project tender by 2025. This would allow the winning project developers two years to reach financial close, after having secured the final permits and approvals, and a further three years to construct the projects.

Furthermore, one of the compromises that must be made to reach this milestone is a relaxing of local content requirements in comparison to the low growth scenario. The expectation is that local content will grow in the medium term, as a local Turkish offshore wind supply chain responds to the positive offshore wind outlook. However, to bring in international expertise and manufacturing capacity to ensure the installation of 2 GW offshore wind by 2030, it is recommended for Türkiye to reconsider its local content requirements. Based on stakeholder feedback, a local content requirement of around 25 percent could be a reasonable starting point, and this requirement should be open to developer proposals rather than being prescriptive. As a result, more competition makes the opportunity more attractive to the industry and leads to lower prices. Furthermore, the lower risk leads to a lower project WACC and lower tariffs.

By 2040, around 5G W of fixed offshore wind would have been installed and in the period to 2050, a further 1.8 GW of fixed offshore wind capacity would be installed. This growth, optimistically, assumes that Türkiye's entire 6.8 GW of fixed offshore wind potential could be constructed. All of the area with fixed offshore wind potential in Turkish waters, has environmental and/or social sensitivities (restriction zones) which will constrain development. Furthermore, not all of this capacity will be economically viable, as projects in some areas will have high costs due to technical challenges, or low output due to less energetic wind conditions.

In this scenario, by 2050, offshore wind could comprise 7 percent of Türkiye's total electricity generation capacity, avoiding 4.5 million metric tons of emissions per year, and annually adding US$6 billion per year to Türkiye's economy. A proposed roadmap for the high growth scenario is provided in Figure 5.2.

3.3 REGULATORY FRAMEWORK

There is no bespoke regulatory framework for offshore wind in Türkiye. The Law on the Utilization of Renewable Energy Resources for the Purpose of Generating Electricity (No: 5346) [23] is the primary regulation for renewable electricity generation. It covers the procedures and principles regarding the protection of renewable energy resources zones, the certification of the electricity generated from these resources, and the utilization of them. However, the Turkish legal framework for offshore wind activities is essentially based on the existing legal framework for development of onshore wind projects. This means that the clarity and certainty needed for a particular OWF project will be supplemented in detail by the YEKA tender documents. This emphasizes a need for precise and unambiguous YEKA OWF tender design specifications.

Although the Turkish legal framework and specific tender design provide support to such needs, the findings in this study reveal some uncertainty and lack of clarity related to the coordination amongst the competent authorities in permitting, the process and timing involved, and the de-risking in terms of site readiness. Such conditions may limit the interest for international as well as local lead consortium investor participation.

The current permitting regime may be manageable by resource-strong developers if the project is deemed bankable based on an attractive rate of return of the investments. However, this resource demand, and the overall risk involved in the process for delays and uncertainties, may discourage investors and developers from participation, in particular international investors not familiar with the Turkish permitting regime. Following international good practice, streamlining of the permitting process is therefore recommended to be done where feasible. This could include further clarity in permitting procedure, so that all stakeholders are fully aware of process, coordination and their own responsibilities, and cognizant of the timeframes in which they are required to fulfill them.

3.4 FINANCIAL AND ECONOMIC ANALYSES

A wide range of technical as well as economic risks will drive up the cost of financing for Turkish offshore wind projects, unless they are sufficiently managed and mitigated. Offshore wind developers considering projects in Türkiye are faced with a significant foreign exchange rate risk as well as very high interest rates on loans in Turkish Lira. When combined with the regulatory risk, uncertain site conditions and low-price expectations in the YEKA systems, the overall risk profile is high and calls for careful management.

Lower cost international finance will be important to deliver affordable offshore wind projects in Türkiye. The high cost of local financing would drive up the cost of capital and in turn, increase the project LCOE and required generation tariff. In Türkiye, the rate of loans in Turkish Lira could exceed 50 percent and, depending on the risk, could be even higher. In comparison, international debt, in hard currencies such as USD and EUR, is typically far cheaper and lending rates for European projects are often 3 percent to 5 percent. Significant risk instruments, such as hedging and guarantees, will be required to access international financing and lenders will apply a risk premium commensurate with the residual project and market risks.

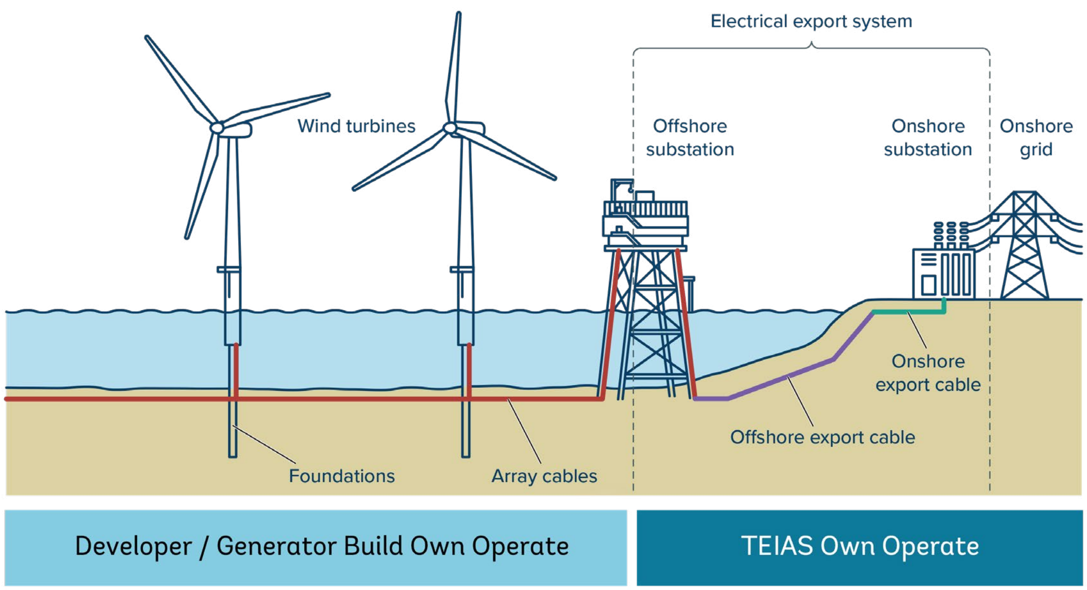
The Turkish Government should act to reduce project and market risks. This would in turn, reduce the risk premium that lenders would apply and reduce the cost of electricity generated by offshore wind in Türkiye. The Turkish Government has already taken a first step in this direction by applying an approach similar to the Danish model, kicking off preliminary site surveys. These measures will significantly support reducing risks on the first projects.

The Turkish Government has taken another step through YEKDEM mechanism to support offshore wind. A Presidential Decree was published on 30 April 2023 regarding the new incentive prices to the electricity generated based on renewables. For the first time, the Turkish Government determined an incentive price for the offshore wind, which has a floor price of US$67.5 per MWh (US$0.0675 per kWh) and a ceiling price of US$82.5 per MWh (US$0.0825 per kWh). The support duration is 10 years, and the mechanism is valid for offshore wind projects which will become operational by 31 December 2030. Also, an incentive price which is around US$0.02 per kWh for the local equipment support is offered. The support duration is five years, and it is valid for the generators which will become operational by 31 December 2030. This mechanism is expected to contribute to increase the predictability in the market.

Concessional financing could provide another source of low-cost public and private capital, especially for the first projects in Türkiye. The cost of the first offshore wind projects in any new market is usually high; developers and lenders perceive high risks due to the unproven regulatory framework, inexperienced local suppliers, and numerous other factors associated with first-of-a-kind projects in a new geography. On the private side, the use of concessional financing could be catalytic by ensuring projects are sufficiently de-risked, allowing commercial lenders to finance projects.

Concessional finance may also be applied on the public side of projects, such as the financing of the electrical export and transmission system with financing being offered to Türkiye Elektrik Iletim A.S (TEIAS—the Turkish state-owned transmission system operator) for taking ownership of this (see Figure 3.7 for an example of the split of public-private ownership of an offshore wind project). This approach has been recognized in the Electricity Market Connection and System Usage Regulation of 2014, with the term for repayment by TEIAS to be a maximum of five years [24].

FIGURE 3.7 ILLUSTRATION OF TEIAS OWNERSHIP OF EXPORT AND TRANSMISSION SYSTEM.



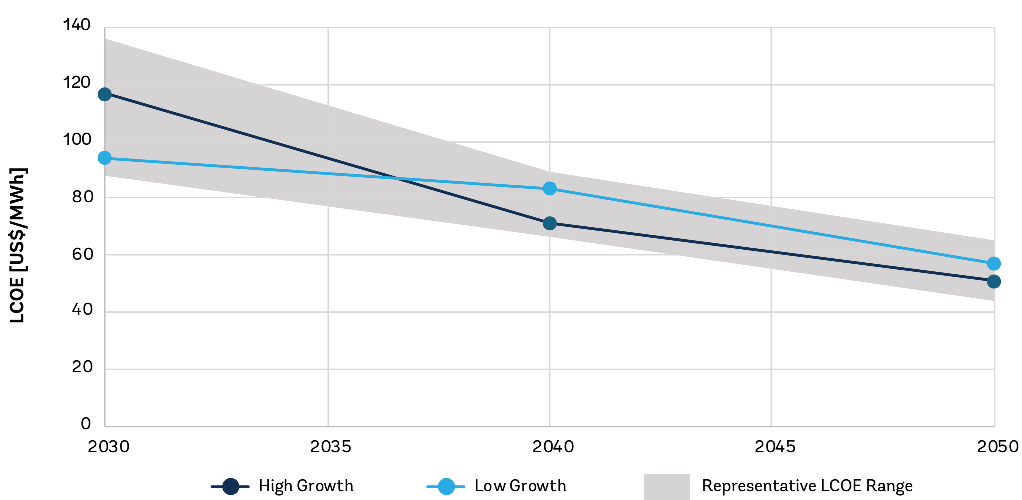
Experience in established offshore wind markets has shown that the development and construction of the electrical export system carries substantial risk, particularly relating to the delivery schedule and quality. This is a significant liability for the transmission operator to bear so, in some cases, it may be more effective for the project developer to be responsible for delivering the export system. This ensures that the export system will be available in time for evacuating the power once the wind farm enters into operation and removes the liability from the transmission operator. Once in operation the ownership of the electrical export system could be transferred from the wind farm developer to the public transmission system operator. A pricing mechanism must be agreed upon to ensure that the transmission assets are priced right and in a competitive way. Such a pricing mechanism could be based on an "open book" principle, i.e., the project developer documents the investment cost by opening their internal accounts for an independent auditor assessing the costs and the total divestment price. But it should be kept in mind that verifying investment costs of this magnitude always proves difficult.

Access to international and concessional finance will be dependent on projects meeting lenders' environmental and social standards. Appropriate levels of social and environmental regulation should therefore be put in place, including the delivery of ESIA for offshore wind to the standards required by GIIP as per the World Bank and IFC or other equivalent environmental and social standards. Amendments to the permitting process could facilitate this by requiring ESIA to be delivered to this standard.

In the low and high growth scenario, the average LCOE in 2030 is estimated to be between US$94 per MWh to US$117 per MWh. This assumes an aggressive support from concessional finance and risk mitigation measures that brings the WACC down to 6 percent. This would be a successful result for the first offshore wind farm in Türkiye and well within the norm for early-stage European offshore wind markets. In the high growth scenario, average LCOE is expected to be higher than in the low growth scenario. This unusual fact is due primarily to the distribution of wind speeds in Türkiye, which has a modest area of high winds around Çanakkale, which are exploited first in the low growth scenario. For the high growth scenario, additional wind farms must also be built in areas with lower wind, driving up the average LCOE.

The estimated LCOE trajectories for the low growth and high growth scenarios are provided in Figure 3.8. From a level of approximately US$94 per MWh (low growth) and US$117 per MWh (high growth), the LCOE of offshore wind in Türkiye is forecast to reduce to US$83 per MWh (low growth) and US$71 per MWh (high growth) in 2040, and US$57 per MWh (low growth) and US$51 per MWh (high growth) by 2050. LCOE in the low growth scenario starts out lower due to the aforementioned situation.

FIGURE 3.8 LCOE TRAJECTORIES IN THE LOW GROWTH AND HIGH GROWTH SCENARIOS, INCLUDING A RANGE OF REPRESENTATIVE LCOE DUE TO UNCERTAINTIES.



These cost trajectories are based on the installed capacities provided in section 5.2., a WACC of 6 percent, and a P50 best case wind resource. As with the main estimates for 2030, these cost trajectories are heavily dependent on the cost of capital and the wind resource. A representative range of LCOE has been shown to highlight the large uncertainties in project economics at this high level of analysis.

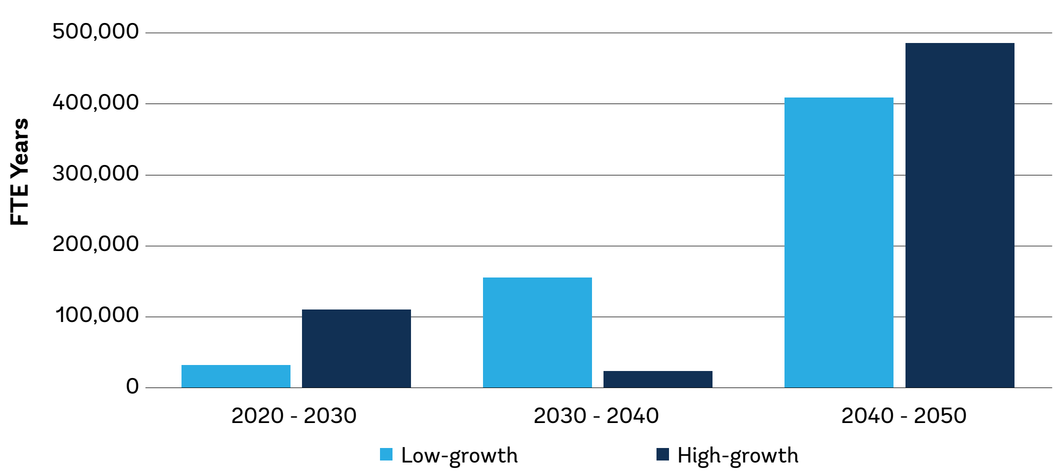
Local value creation is a high priority in the YEKA. However, there are limits to the potential for local content in the very first offshore projects in Türkiye. The requirements of developers, manufacturers, and constructors are much higher and on a larger scale than for onshore wind. It will take quite some time to establish a local offshore wind supply chain and transfer international experience and technology.

To provide the best possible foundation for the development of a local supply chain, there must be a clear political commitment to a realistic, long term, and gradual increase in installed offshore wind capacity. Visibility of this long term plan will give confidence to the local industry, enabling the preparatory investments needed to supply goods and services to the offshore wind sector. The results provided illustrate a progression in the local content share in offshore wind construction, as the total installed capacity increases. This is to illustrate a steady progression in developing a local supply chain. The underlying assumption is that capacity is built out gradually beginning with a demonstration project of less than 500 MW and continuing with a subsequent build out at a steady pace. Starting with a 2 GW project as the first OWF in Türkiye will likely not achieve the same local content, as the local supply chain will not have time to build up capacity and experience. Once established, the local supply chain has the potential to contribute as an exporter to neighboring European markets. This is especially relevant, considering the emerging floating offshore industry.

Offshore wind can bring significant employment benefits (between 32,000-110,000 direct and indirect Full Time Equivalent (FTEs) years) and economic benefits to Türkiye by 2030 (between US$4 to 16 billion in Gross Value Added (GVA)) across the value chain. The main objective of offshore wind projects is often a combination of increasing electricity generation capacity and meeting national renewable energy targets. However, the large scale of these projects and the need for public funding also often leads to interest in how the investments impact economic growth and employment. In essence, the return on investment for the nation, in addition to CO_2 emission reduction benefits can be measured in terms of jobs and income. The impact can be measured in GVA and FTE years.

The impact on employment of investments in offshore wind over time is summarized in Figure 3.9. The FTE impact in each 10-year period corresponds to the necessary additional investments needed to meet the target installed capacities at the end of that period. This takes into consideration that some of the capacity was installed in a previous 10-year period.

FIGURE 3.9 IMPACT ON EMPLOYMENT FROM INVESTMENTS IN OFFSHORE WIND.



In the period from 2040 to 2050, meeting the 2050 target for installed capacity will require installing as much as 20 GW additional capacity in the high growth scenario. This will require almost 500,000 FTE years delivered by Turkish labor, or almost 50,000 full time jobs for ten years.

The impact of offshore wind in Türkiye, based on the low growth and high growth scenarios, is summarized in Table 3.5.

TABLE 3.5 SUMMARY OF OFFSHORE WIND IMPACT IN TÜRKİYE.

	Low growth 2030	High growth 2030
Local jobs created	32,000 FTEs (16,500 direct and 15,400 indirect)	110,000 FTEs (57,000 direct and 53,000 indirect)
Impact on GDP	US$4 billion impact on GDP (US$2.1 billion from direct investment and US$1.8 billion indirect investment)	US$15.8 billion impact on GDP (US$8.5 billion from direct investment and US$7.3 billion indirect investment)
LCOE	US$74 to 114 per MWh[xii] depending on the wind resource, assuming a WACC of 6 percent	US$95 to 141 per MWh[xiii] depending on the wind resource, assuming a WACC of 6 percent
Annual CO_2 reduction[xiv]	90,000—110,000 tonnes of CO_2 depending on wind resource	300,000—340,000 tonnes of CO_2 depending on wind resource
Wind areas utilized	• One wind farm: 500 MW in Çanakkale (Area 3) • Best wind resources with wind speeds of 8.5 to 9.5 m/s	• Four wind farms: Çanakkale (Area 3) utilized with 1 GW, plus three additional areas in Marmara Sea (Area 2) utilized for a total of 1 GW • Average wind speed of 7.3 to 7.9 for all sites

The rise in LCOE from the low growth to high growth scenario is due to two factors: 1) the average wind resources of the high growth scenario are less than the low growth, leading to less average energy production; and 2) the per-MW CAPEX and OPEX costs remain the same between the two scenarios, as 2 GW is not large enough to achieve the economies of scale which typically lower these costs. However, the total of 7 GW installed capacity expected in the mid-term (2030 to 2040), as per the high growth scenario roadmap, would deliver such economies of scale and lead directly to the growth phase in which even higher volumes continuously drive down LCOE. Accordingly, LCOE values should always be considered in context of long-term cost and benefit.

xii Mesoscale wind models like those used as a basis for this report, carry a moderate level of uncertainty. To represent this uncertainty, COWI has used two datasets—the New European Wind Atlas (NEWA) and Global Wind Atlas (GWA)—to derive a range of wind conditions for each calculated subset.

xiii See the detailed analysis for further explanation.

xiv Based on crowding out of coal.

3.5 HEALTH AND SAFETY

The first OWF project in Türkiye requires a clear H&S policy to be put in place, including requirements for contractors delivering services during surveys, construction, and O&M building on, for example, European experience and Global Wind Organisation (GWO) standards. This statement should be drafted by local H&S experts but would benefit from guidance and support from international offshore wind H&S experts. It is important to incorporate clear H&S requirements for contractors delivering services during surveys, construction, and O&M. It is imperative that the right level of H&S expertise is attracted to the project at an early stage.

Currently, companies in Türkiye prepare H&S procedures pursuant to ISO 18001. The Turkish occupational H&S law (Law no. 6331—20/06/2012) provides some outline and regulation for H&S requirements such as requirements to H&S organization, risk assessment, control, measurement and documentation, and inspections. It states that employers must ensure the safety of their employees and take the required measures to protect the environment.

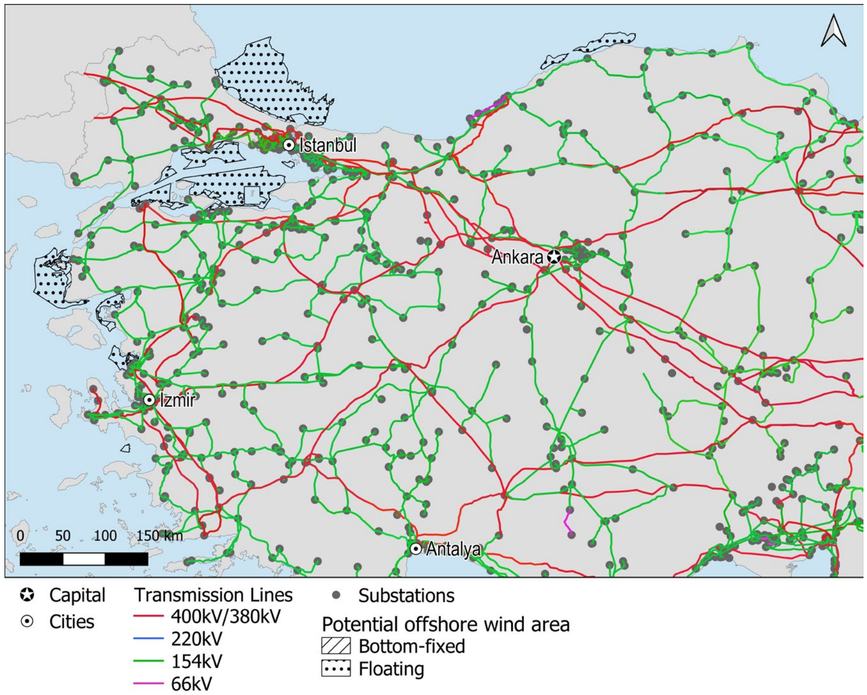
While Europe is considered the world leader in offshore wind power, in the early days of the industry's development, many standards and procedures were adopted from the oil and gas industry. However, over the past 25 years the guidelines and procedures for offshore wind in Europe have become tailor made to the wind industry, incorporating experience and lessons learned. It is recommended that these lessons are, as much as possible, incorporated into the guidance on H&S for the first offshore wind farms in Türkiye. Furthermore, it is recommended to look towards the GWO standards for guidance on training requirements.

3.6 GRID INFRASTRUCTURE

Initial observations confirm that the existing back-bone transmission system and planned reinforcements will make a robust basis for an increase of wind power injection to the overall generation mix. Türkiye's transmission system networks are generally strong, but in order to accommodate up to 5 GW of new offshore capacity as targeted in the Turkish National Energy Plan [3], reinforcement and further planning will be needed for connection of large GW-scale offshore wind farms. The power grid's ability to absorb power provided from offshore wind naturally will depend on the size and location of the grid connection point selected. The most promising offshore wind farm sites are identified in the western part of Türkiye where also the heaviest load demand centers are located. Upgrading of the transmission system is an ongoing process that shall be consolidated with the future development of generation plants and the load demand in the various regions to secure a stable and reliable power transfer capacity also having an acceptable voltage quality.

Figure 3.10 shows potential offshore wind areas and the current transmission grid of Türkiye, which shows that areas around the Marmara Sea (Area 2) and Izmir (near Area 4: Ayvalik) are particularly well developed. In the future, TEIAS is planning some 380 kV reinforcement projects with the target to improve the power transfer between the load demand hubs Istanbul and Bursa and to establish a new transfer corridor from Çanakkale to Istanbul. These initiatives will facilitate an increased transfer of power in the region.

FIGURE 3.10 CURRENT TRANSMISSION GRID INFRASTRUCTURE AND POTENTIAL OWF AREAS.



Installing and connecting 1 to 5 GW of offshore wind into the Türkiye transmission system is considered viable and possible for the most promising sites since a strong 380 kV transmission grid already is available and today it transmits power between the thermal/hydro power plants to the load centers. The heavy presence of thermal power plants near the potential wind areas can in the short term be complementary to offshore wind, as the thermal plants can provide flexibility and play a stabilizing role in a grid with large percentage of wind power. In the long term, the aim would be that offshore wind would support the decommissioning of thermal power capacity and connect in areas where capacity is freed up by retired generation. Türkiye's hydropower plants are located mostly in the east of the country, quite far from potential offshore wind areas, but will still be able to support offshore wind by ensuring transmission system flexibility and helping to balance generation and demand.

Grid interconnection of 0.5 to 1 GW of offshore wind can be implemented with 220 to 275 kV subsea export cables connected to 220 to 275/380 kV transformer stations. The actual extent and outline of the OWF grid interconnection topology and eventual extensions in the 380 kV back-bone grid imposed by the individual OWF will be determined during the three to five years development phase of an OWF project. High voltage direct current (HVDC) systems are unlikely to be economically feasible in Türkiye because most wind farm areas are quite close to shore; however, they may be considered on a project-specific basis.

Connecting OWFs to regions where only 132 kV transmission systems exist will likely require substantial reinforcements either with new 380 kV overhead lines or point to point HVDC interconnectors to reach the existing 380 kV back-bone power grid.

Consideration of potential export cable landfall locations and onshore cabling routes will need to take place to ensure that environmental and social issues are taken into account, particularly if new overhead cables will be required to connect offshore wind farms.

The Transmission System Operator's (TSO's) duty will be maintaining the transmission grid operation within acceptable technical constraints and enable an optimal power balance (generation/load demand) to obtain a reliable power supply with maximum availability. The power balance and system frequency will be controlled in regional/national dispatch centers via agreements with the thermal/hydro/solar/wind generating operators being set up for basic, fluctuating, and emergency production pattern. Due to the large fluctuation of the wind and PV solar generation plants, an increased amount of variable renewable energy (VRE) will require more flexibility incorporated in the generation mix. The goal should be minimizing/eliminating curtailment of OWF generation since the energy is near zero marginal cost when the plant is built.

The most obvious approach to avoid curtailment of wind power during peak wind periods will be to temporarily reduce production from hydro power plants or, alternatively, to implement pumped storage facilities. Due to the fast reaction time of the Turkish grid, these hydro power facilities can be used even though they are located far away from the potential offshore wind areas.

Over the short term, improved flexibility can also be implemented in the thermal power plants that traditionally have been used to generate a relatively constant output. A successful integration of extensive VRE to the power system will require that both the technical challenges in respect to the flexibility (fast regulation) of the thermal power plants, eventual pumped storage facilities and the agreements, tariff structure, etc. for the power market is properly set up. Then the TSO will have a sound basis for executing its duties as the dispatcher for the power grid connected with a large VRE portion.

The successful build-out of the offshore wind industry will heavily depend on a close collaboration between MENR and TEIAS in order to ensure relevant grid upgrades as well as interconnected developments have been performed to sustain the integration of offshore wind.

3.7 PORT INFRASTRUCTURE

Türkiye has many ports and a sufficient number which could be used, with minor to moderate upgrades, as offshore wind installation ports for bottom-fixed wind farms. The most common upgrades needed are: 1) to increase the bearing capacity at quayside and storage area; and 2) increase the yard area available for storage up to 20 hectares (ha). Many ports in Türkiye benefit from their experience in handling import/export of onshore WTG components.

While there are only a few leading floating foundation technologies, the required port characteristics differ greatly among the floating concepts which vary from semi-submersible to spar buoy. Due to this stark divergence and lack of installation track record, a global benchmark for port requirements for floating wind installation cannot yet be derived. Typically, due to the large size of the structures, a large port area and quayside space will be required to fabricate multiple floating foundations in parallel.

Four potential ports have been discussed with the Turkish authorities. The suitability of each potential port for offshore wind is summarized in Table 3.6.

TABLE 3.6 SUMMARY OF SUITABILITY OF POTENTIAL PORTS FOR BOTTOM-FIXED INSTALLATION.

	Port suitability	Comments
Bandırma	Suitable with minor upgrades	• Ownership: government • Can serve entire Marmara Sea • Mainly used for roll-on/roll-off, general cargo, container, and dry bulk cargo operations • Congested, high-volume area with 20 docks • Currently serves import/export for onshore WTGs • Need to create some additional yard area in hilly terrain • Some restrictions on vessels due to short quay length • Existing port with minor upgrades posing little environmental and social impact
Çanakkale	Suitable with moderate upgrades	• Ownership: private • Can serve only northern half of the Aegean • Main activities are roll-on/roll-off, general cargo, chemical, liquid bulk, container, dry bulk, and cruise • Currently serves import/export for onshore WTGs • Single quay perpendicular to coast would likely need to be widened • Too little yard area, would need to add some adjacent area, which is currently in use • Existing port with upgrades posing limited environmental impact
Çandarli	Construction halted — biodiversity threat	• Ownership: government • Status: under construction, work paused • Construction in an internationally important wetland (Bakırçay Delta KBA)
Aliağa	Suitable with moderate upgrades	• Ownership: private • Main activities are bulk liquid, dry bulk, and general cargo • Congested industrial center • Can serve entire Aegean • Only one terminal in port partially compatible with offshore wind requirements • Existing port with upgrades that may have environmental and social impact depending on what upgrades are necessary

Potential O&M ports are plentiful in Türkiye, as most of the country's numerous local ports can be used with minor upgrades.

The 1915 Çanakkale bridge, which connects the Marmara Sea and the Aegean Sea in the Dardanelles Strait, presents a significant obstacle to efficient use of port infrastructure, as it effectively splits the Marmara Sea and the Aegean Sea into two separate areas, each needing their own installation port. With installation volumes of up to 2 GW in the high growth scenario, it is conceivable that a single installation port could serve the entire volume, given the right location and staggered installation. However, the bridge clearance prevents WTG installation vessels from passing under it normally. Workarounds may be found on a project-specific basis.

Due to the anticipated moderate volume of offshore wind expected, it is also important that any upgrades made to the ports for offshore wind are also designed with a multi-functional use. The upgrades should not serve only offshore wind alone, but also give an added value to the port between offshore wind installation cycles.

In order to best coordinate wind farm areas with port locations and to make most efficient use of the investment in port upgrades, Turkish authorities should take detailed port planning (including consideration of the environmental and social impacts of port development) when carrying out marine spatial planning, setting lease areas for offshore wind, and awarding the leases.

3.8 SUPPLY CHAIN

Currently, Türkiye has no track record in offshore wind, but good capabilities in parallel sectors, primarily onshore wind. Offshore wind projects would benefit most from the Turkish production expertise already established within onshore wind.

Despite this capacity for growth, there are relatively few benefits for projects to source locally for many of the other items because they either carry relatively large investments with significant risk, or there is a very established international (European) capacity to meet the demand which would be difficult for Turkish companies to naturally compete with.

The supply chain capability scoring, based on metrics keeping alignment with similar roadmaps from other countries in the World Bank Group's offshore wind roadmap series, are explained in Table 3.7 and the results are presented in Table 3.8 [25]. A higher score is more beneficial, and a lower score is less beneficial.

TABLE 3.7 SCORING METRIC USED TO EVALUATE THE SUPPLY CHAIN IN TÜRKİYE.

Track record and capacity in offshore wind	1	No experience
	2	Experience in supplying wind farm ≤ 100 MW
	3	One company with experience of supplying wind farm > 100 MW
	4	Two or more companies with experience of supplying wind farm > 100 MW
Capability in parallel sectors	1	No relevant parallel sectors
	2	Relevant sectors with relevant workforce only
	3	Companies in parallel sectors that can enter market with high barriers to investment
	4	Companies in parallel sectors that can enter market with low barriers to investment
Benefits of local supply	1	No benefits in supplying projects locally
	2	Some benefits in supplying projects locally but no significant impact on cost or risk
	3	Work for projects can be undertaken from outside country but only with significant increased cost and risk
	4	Work for projects must be undertaken locally
Investment risk	1	Investment that needs market certainty from offshore wind for five or more years
	2	Investment that needs market certainty from offshore wind for two to five years
	3	Low investment ≤ US$50 million that can also meet demand from other small sectors
	4	Low investment ≤ US$50 million that can also meet demand from other major sectors with market confidence
Size of the opportunity for Türkiye	1	< 2% of lifetime expenditure
	2	2% to ≤ 3.5%
	3	3.5% to 5.0%
	4	> 5% of lifetime expenditure

TABLE 3.8 ASSESSMENT OF TURKISH SUPPLY CHAIN POSSIBILITIES.

Category	Local notable companies	Türkiye track record and capacity in offshore wind	Türkiye capability in parallel sectors	Benefits of Türkiye supply	Investment risk in Türkiye	Size of the Opportunity
Developing and permitting	TERON Energy, BFP Enerji A.Ş.	1	4	4	4	2
Nacelle, hub, and assembly	Siemens Gamesa	1	3	2	1	4
Generator	Gamak, Atescelik, Aemot	1	3	4	3	2
Blades	LM Wind Power, TPI Composites, Siemens Gamesa	1	3	2	1	4
Tower	Ateş Çelik, CS wind, Çiltug, Çimtaş, Gesbey, Temsan	1	4	2	4	2
Foundation supply	Berdan, Civata, Kaleliler, Dresselhaus, Ronenans Holding	1	4	2	1	4
Array and export cable supply	HIES Kablo, ZTT Cable, Prysmian Kablo	1	3	2	2	4
Offshore substation supply	BEST, Eltaş, Astor, Beta	1	1	2	1	3
Onshore infrastructure supply	GE, BEST, Eltaş	1	3	2	1	1
WTG and foundation installation	STFA Yatrim Holding, Ronenans Holding	1	1	2	1	2
Array and export cables installation	STFA Yatrim Holding, Ronenans Holding	1	4	2	1	4
Wind farm operation	Tersan	1	3	4	4	4
WTG maintenance and service	GE, Siemens Gamesa, Vestas	1	4	4	4	4
BoP and various maintenance	Various	1	3	4	4	4
Decommissioning	STFA Yatrim Holding	1	1	2	4	2

The moderate volume of offshore wind expected in Türkiye does not offer natural incentives to localize the supply chain. This is directly reflected in the assessment of supply chain, where project development (though this is likely to be a joint venture between local companies and international developers) and O&M show the greatest benefits in local sourcing. The other areas, which primarily compose the "purchased parts" as defined in the YEKA tender, are classified as low-level local benefit because the capital and workforce investments needed to establish these parts of the supply chain in Türkiye cannot be recouped by the foreseen volumes.

On the other hand, efforts to achieve a higher local content through requirements may backfire as project developers prefer to do business in countries where they are able to decide their own supply chain. In the coming years, the offshore wind industry is expected to become a seller's market as many countries have announced ambitious offshore wind goals within the 2030 time frame and beyond. In this environment, countries that make the development of offshore wind farms easy will have a competitive advantage, and vice versa.

An interesting opportunity for Türkiye is the potential export market for offshore wind, similar to the one that has already been established for onshore wind. Currently, 75 percent of Turkish manufacturers in the onshore wind industry export components to the global market [12]. In fact, based on their current experiences onshore and favorable rates for labor, Turkish companies could begin targeting export markets for offshore wind already. With additional experience and capability in offshore wind gained through national projects, this will only make Türkiye more attractive to export markets in the long term.

Regarding supply chain and the required local content for offshore projects, it is essential that the Turkish Government clearly communicate its plans. When determining the appropriate level of local content, the Turkish Government is advised to adopt a holistic perspective and consider the potential benefits of local vs. export markets.

Currently, the EU is targeting 300 GW of offshore wind by 2050, from which 50-100GW could be in the Mediterranean Sea. The cost of materials and labor in Türkiye is competitive and can support the supply of relevant components (e.g. blades, jackets, and floating structures) to EU projects. The Turkish supply chain could already start to develop by targeting international export opportunities, while at the same time benefit the development of the domestic offshore wind market.

4 OPPORTUNITIES AND CHALLENGES

This wide-ranging roadmap report examines many facets of a potential Turkish offshore wind industry and presented recommendations and plans for realizing it. In the Turkish context, some of these plans and recommendations will be particularly challenging, while some others will present large opportunities that can only be achieved with offshore wind. This chapter describes the most important of those challenges and opportunities.

4.1 OPPORTUNITIES

1. **Offshore wind can generate large amounts of power conveniently located near demand centers.** Today Türkiye transmits large quantities of energy produced by hydropower plants in the east to the industrial and population demand centers in the west, requiring the maintenance of the transmission infrastructure. Offshore wind can add the significant new renewable generation capacity that Türkiye needs while keeping the physical cost of transmission infrastructure low. Offshore wind can also contribute to the system security in terms of adding a new option to maintain the voltage and frequency balance.
2. **With sufficient volume, Türkiye's successful onshore wind and maritime supply chains can serve as a springboard to build the offshore supply chain.** Turkish companies have good parallel competencies in manufacturing related to offshore wind, such as production of major WTG components, shipbuilding, and ports. Seventy-five percent of Turkish onshore wind manufacturers already export their components all over the world, bringing jobs and revenues.
3. **Floating foundations can add one more product with a massive export potential to Europe and Asia.** While bottom-fixed sites are limited in Türkiye, floating wind has a much higher potential volume in the Mediterranean region. Turkish companies will be able to hone their skills in floater production in the domestic market and take advantage of export potentials that are expected to open up in the coming decade, as demo projects are successfully completed, and first commercial projects go into the water. Floaters can be type-certified and produced in series, rather than the custom design that fixed foundations require. This makes them a product that can easily be exported at scale and Türkiye's shipbuilding industry and ports are well positioned to grasp the opportunity. In the short term, Asian countries like South Korea are betting big on floating offshore, while Spain, Portugal, Italy, and France are lining up to pursue floating in the mid term. Long term, neighboring Black Sea countries like Bulgaria and Romania are also showing interest in floating. Six demonstrator floating wind farms are expected to commence operation in Europe in the near future using different floater technologies such as the semi-submersible, barge, tension leg, and spar [16]. These technologies are maturing at a rapid pace. One of the first commercial floating wind farms, using the spar concept, is the 30 MW Hywind Scotland which has been in operation since 2017 and has claimed the highest capacity factor of all UK windfarms[xv] to date. One of the most important potentials for bringing costs down compared to bottom-fixed, is the absence of the WTG installation vessel with its requirements for an uninterrupted installation

xv See the Hywind project website for further information https://www.equinor.com/energy/hywind-scotland.

schedule. In addition, one of the key drivers for the supply chain to become efficient, would be a standardized production cycle of the floaters.

4. **With the next tender for offshore wind, Türkiye has a high-profile opportunity to show market stakeholders that it is serious about offshore wind by implementing the lessons learned from the 2018 YEKA tender.** Energy markets and the global offshore wind industry have changed substantially since Türkiye's first offshore wind tender, and it's crucial to consider these dynamics when planning the next tender. Many countries have recently set out to establish new offshore wind markets, with varying degrees of success. These experiences are beginning to coalesce into a global "good practice" for jump-starting the wind industry in a country. Türkiye has the advantage that it can learn from these other countries, but also from its own experiences in the last tender. The nascent floating OSW industry and the lessons learned from the YEKA 2018 tender could open up the possibility of even exploring a twin-track approach: A model similar to the Dutch or Danish model for the congested, high potential zones, and a more developer-led model for floating OSW zones, with separate procurement processes. Türkiye could even consider a YEKDEM feed-in tariff specifically for floating wind pilots, to help get things started and apply a developer-led process. Overall, implementing the insights gained until now will certainly lead to a positive reception from the offshore wind industry and its successful start in Türkiye.
5. **Offshore wind can create an opportunity for Türkiye by contributing to the target of becoming an energy hub.** Offshore wind helps to diversify energy mix and to provide new collaboration opportunities with neighboring countries, including the ability to export zero carbon power.

4.2 CHALLENGES

1. **Türkiye still has ample capacity for expansion of solar and onshore wind, at a lower cost than offshore wind.** Although LCOE for offshore wind is expected to reduce over the coming decades, relatively high LCOE is expected in any new market and is reduced with market volume and maturity. Experience shows that building momentum for offshore wind in the early stages of a market is necessary and one of the best ways to do so is through ensuring that technologies are competing only with other technologies at the same maturity level. The YEKDEM tariffs, rightly, provide separate tariffs for offshore wind, and it will be important for future YEKA tenders to do similarly. Given the large cost differences between fixed and floating wind technologies, it is recommended to treat these as different technologies and reflect their technological maturity. If the competitive framework remains unchanged, renewables developers may prefer to stick with the existing onshore wind and solar industries. In doing so, the Turkish transmission system would miss out on the benefits provided by the higher capacity factors for offshore wind power, as well as the benefits of this large capacity being installed in proximity to load centers. Higher capacity factor yields more production per installed MW, produced by offshore wind. While solar capacity factors range from 10 to 21 percent and onshore wind from 23 to 44 percent, offshore wind tops them both at 29 to 52 percent [26].

2. **Offshore wind speeds are low to moderate in Türkiye and offshore WTG technology is not yet optimized for these lower speeds.** The offshore WTG models on the market are currently optimized for high wind conditions because this has historically been the market segment with highest demand. These WTGs are technically suitable for lesser wind speeds, but are not fully optimized for them economically, or in terms of energy production. As the global market demand for medium and low wind speed offshore WTGs picks up in the next decade (South Korea, for example has similar wind conditions to Türkiye and has a target of 12 GW by 2030), manufacturers are expected to respond with specialized models, similar to the product development that has been seen in onshore wind. Floating offshore wind might open up the opportunity to also exploit areas with higher wind resources further away from shore.

3. **Expectations regarding local content of offshore wind must be finely tuned to the ability of the industry to economically meet them.** The establishment of new offshore wind markets typically follow three phases: 1) building momentum, where a few pioneering projects test market and show they can be successful; 2) achieving volume, during which confidence in the market sustains a high growth rate and cumulative installations reach several gigawatts; and 3) LCOE reduction, where measures to increase progressively increase competition are introduced to the mature industry. In the first two stages, high market interest and competition is crucial for a fast uptake. Measures which effectively reduce competition, such as local content requirements, can cause the first two phases to take an overly long time, or even fail, meaning that a large-scale market is not achieved. Historically, Türkiye's local content expectations have been high compared to the market volume and will need to be revised if the offshore wind industry is to achieve significant scale.

4. **All sites suitable for bottom-fixed wind farms are currently located in restricted areas.** It will require additional effort to determine whether the restrictions can be managed or mitigated to meet the requirements of international lenders, avoiding unacceptable detrimental environmental and social impacts. Stakeholders may not perceive the national legal framework or any environmental and social impact assessment processes, to fully ensure safeguarding of marine environment and coastal communities as well as meet the environmental and social standards of international lenders. Thus, the Turkish Government should actively work to reduce this permitting risk through marine spatial planning, baseline survey and data collection, stakeholder engagement, and other enabling activities. Such de-risking measures could be further explored through the YEKA processes.[xvi] The Turkish Government has taken the first steps in the right direction by commencing activities like the Instrument for Pre-accession Assistance (IPA) funded work on site surveys and planning.[xvii] This is an example of a good approach to increase feasibility of the first projects, which is needed for a strong public sector-role in optimizing the allocation of sites.

   Restriction areas do not ultimately mean that installation of offshore wind farms cannot be commenced under any circumstances, as long as correct mitigation measures have been implemented. Several examples on OWFs exist, which have been built in protected areas such as in the North Sea, Baltics, and Irish Sea. Also, Türkiye has already shown the successful execution of infrastructure projects such as the Canakkale Bridge or the Istanbul Airport, by applying mitigation measures to meet environmental and social standards. This showcases the same potential for the implementation of offshore wind. Nevertheless, should the sites suitable for bottom-fixed still turn out to be infeasible, it could be compensated by the larger floating offshore wind potential at a short-term cost premium, but with highly beneficial long-term opportunities.

xvi As to further develop the approach applied for the 2018 Offshore Tender, where sites were first determined by the Ministry involving the competent authorities and stakeholders' engagement.

xvii See the EU IPA funding support for Türkiye which includes the surveying of sites for offshore wind, and is being managed by the World Bank: https://neighbourhood-enlargement.ec.europa.eu/system/files/2019-12/c_2019_8726_ad_energy.pdf.

5. **Cost of capital and exchange risks are essential to mitigate.** The cost of capital in Türkiye is very high. Stakeholder feedback suggests that interest rates on loans in Turkish Lira currently typically run higher than 12 percent and, depending on the risk, could be even higher than 50 percent. The alternative to that is financing in USD or EUR through international financial institutions, which could provide a significantly lower cost of capital, but at the same time increase the project's exposure to exchange rate fluctuations. Managing the exchange rate risk will be central to any offshore wind project in Türkiye in the foreseeable future. The exchange rate risk is often split between off-taker and developer through a combination of several strategies. One positive feature of both the YEKDEM and YEKA mechanisms is their indexing of the tariff (e.g. to PPI — producer price index, CPI — consumer price index, EUR, and USD), which help to alleviate some of the investor's exposure to the local currency. YEKDEM tariff regarding both generation and local content support is a good example that demonstrates how the support tariff escalation formula can be derived by taking into account the exchange rate.

5 ROADMAP AND RECOMMENDATIONS

The previous chapters have summarized the current situation regarding offshore wind and its potential in Türkiye and presented the findings and major themes. This chapter aims to transform those findings into a concrete set of recommendations for the Government of Türkiye. Depending both on the extent to which these recommendations are implemented and market conditions, there are a range of growth outcomes possible for offshore wind. This study considers two possible growth scenarios which represent an approximate lower bound (the low growth scenario) and a higher bound (the high growth scenario). Finally, the recommendations and growth scenarios are combined with a time schedule, resulting in two roadmaps for the development of offshore wind in Türkiye (see section 5.2).

5.1 RECOMMENDATIONS

Kick-starting an offshore wind industry can be done at different speeds of growth, but the overall development milestones and recommendations for Türkiye remain the same. The recommendations mainly focus on actions to be taken in the short term, but some can span over the entire timeframe up to 2050. Most of these recommendations are equally valid for the low growth or high growth scenario.

Vision and volume targets

1. 1. MENR should **communicate clear installation targets in line with the preferred growth scenarios.** Note: in 2022, during the drafting of this Roadmap, the Turkish Government published a target of installing 5 GW of offshore wind by 2035. This target conveys positive signals to the industry, helping to build the confidence needed to invest in Türkiye.

   In the short term, i.e., the period up to 2030, the Turkish Government should start to build momentum for the industry by focusing initially on the delivery of the country's first offshore wind projects. The Government announced the incentive scheme in the new YEKDEM supports starting from mid-2023. To make best use of proven technology and at the lowest cost, it is recommended to focus on bottom-fixed projects in the most attractive sites, prior to venturing into floating projects.
2. MENR should also consider **mid-term and long-term visions beyond 2035**, during which the market will **deploy further commercial bottom-fixed wind farm projects** and achieve the volume required to trigger economies of scale and reduce prices. These visions should also be informed by long-term energy system planning and consideration of cost effectiveness in Türkiye's transition to net-zero.
3. MENR should plan the deployment of floating offshore wind technology by **installing floating 'pathfinder' projects in the 2030s, followed by the installation of commercial floating wind farms in the 2040s.** This long-term view beyond 2040 will enable the industry to progressively drive down the LCOE of floating wind.

Regulatory and policy framework

4. MENR should **establish an offshore wind policy and long-term development plan, based on the vision and volume targets.** This plan should identify priority areas for development, informed by the marine spatial planning work (see recommendation #5). The plan will inform the development of grid and port infrastructure, as well as providing the necessary signals to the supply chain to encourage investment. It is the commitment to specific and realistic volume targets for short term as well as long term that not only drives industry interest, but creates long-term confidence for developers and investors, as well as supply chain stakeholders.
5. To inform the setting of targets and plans, the Government should **develop a MSP to help identify potential offshore wind farm areas.** This would build on the work undertaken in this roadmap and could be single sectoral (i.e., focused on offshore wind) or be part of a country-wide, multi-sectoral MSP. The MSP will involve environmental and social sensitivity mapping to identify potential impact risks and to inform broad stakeholder engagement. The MSP should balance potential environmental and social impacts against the benefits and priorities for the use of Türkiye's marine space. This will also benefit the permitting of offshore wind projects by avoiding the areas of highest sensitivity and providing inputs into the assessment of impacts.
6. MENR proactively **de-risks projects, to a sufficient level, prior to tendering.** The Turkish Government has decided to use a model similar to the Danish/Dutch model whereby the Government leads early project development work and de-risking ahead of running a tender for the site concession and power purchase agreement. It has already kicked off preliminary site-surveys to gather data and characterize sites. These measures will significantly support reducing risks on the first projects. The **level of de-risking should be determined through dialogue** with industry and prospective bidders.
7. The Government should **streamline the regulatory framework and permitting processes.** This can be achieved either by establishing a coordinating body or by facilitating project developers in the permitting process and their applications to different authorities. Having a straightforward and transparent permitting approach is a key driver for creating confidence to early movers as well as ensuring a sustainable and robust development of the industry.[xviii]
8. The Government should ensure the **permitting process incorporates ESIA** that is carried to the standard of GIIP. This will ensure that adverse environmental or social impacts do not arise and to facilitate access to international and concessional finance. A clear framework for ESIA within the permitting process will increase developer confidence.
9. The Government **publishes detailed guidance on the permitting process,** including a list of all the permits, authorities, and timelines to be considered along with guidance on the ESIA process.
10. The Government **introduces tenders for projects, driving competition amongst developers and thus progressively further reducing LCOE of offshore wind energy.** This can include refining the YEKA tender for offshore wind considering learnings from the 2018 tender, defining site specific tender conditions to decrease the financial risks, as well as engaging with industry to make sure tender is acceptable and feasible and fit for purpose. Then it sets a plan for dates and sizes of future tenders.

xviii For instance, this could be based on a strengthen refinement to the 2018 YEKA tender design.

Financial and economic

11. The Government utilizes a variety of financial tools, for example public and private concessional finance, and risk mitigation instruments, including guarantees and hedging, in order to **reduce the WACC of the first offshore wind projects.** This should be informed through discussions with prospective project developers/investors and financial institutions.
12. The Government, possibly with the Electricity Generation Company (EUAS), **establishes a bankable PPA which fairly allocates risk** between off-taker and developer, including exchange rate risk and appropriate levels of indexation to mitigate inflation. The terms of this PPA should reflect the offshore wind specific risks and learn from experiences in established offshore wind markets.

Health and safety

13. The Government **should introduce health and safety (H&S) requirements in alignment with industry best-practice standards.** Establishing widely accepted H&S standards, based on the internationally accepted approaches, ensures safe procedures during installation and operation. Türkiye should base these H&S requirements on the approach taken in established offshore wind markets and not seek to develop completely new approaches.

Grid and port infrastructure

14. The Government should **complete long-term port planning and upgrades based on the long-term offshore wind development plan**. Long-term planning, including consideration of environmental and social impacts, can enable the potential joint port usage for floating and bottom-fixed offshore wind. Planning long-term port development will also help to encourage supply chain investment and clustering of industry around those ports, thereby helping to increase local capabilities.
15. The Government should **enable upgrades for at least one installation port in the same region (Aegean Sea or Marmara Sea) as the wind farm it serves**, subject to appropriate consideration of environmental and social constraints**.** By doing so, it ensures that manufacturing, construction and installation sites are developed in close alignment with the sites that will benefit from them.
16. The Government should further **facilitate the upgrade of smaller local ports to use in the O&M phase.** While the initial focus to kick-start the industry lies in the installation ports, it needs to be closely followed by upgrades to smaller ports for O&M use in order to enhance local job creation as well as ensure a reliable, safe, and lasting operation of the wind farms.
17. The Government and TEIAS should perform **grid impact analyses based on the long-term offshore wind development plan** (from recommendation #5). This will identify the grid expansion and reinforcement works required to connect the planned offshore wind capacity in both the short and longer term. Even though Türkiye currently has a robust grid infrastructure, the Government needs to clearly map the locations that will be linked to the offshore wind farm sites under development to ensure robust points of coupling. The environmental and social implications of reinforcements and connections will need to be considered, along with appropriate mitigations, for example careful selection of export cable landfall locations or the undergrounding of onshore cables.

Supply chain

18. The Government should **support the development of the domestic supply chain in the short term for local content requirement expectations to be met**. Türkiye already has the advantage of a strong onshore wind supply chain and capable maritime industries. The Government can harness those existing potentials by enabling the industry to transition to offshore wind and expanding existing facilities by means of financial incentives and subsidy measures.
19. The Government should establish a medium-term aim of increasing **major supply from domestic manufacturing within the period 2030 to 2035, once first domestic supply has been mobilized.** The development follows a progression from initial partnerships with international suppliers to a more self-sustained domestic supply chain.
20. The Government **should encourage the export of major components and floating foundations to international markets.** Industry in Türkiye is well positioned to supply goods and services to future offshore wind development in the Mediterranean and Black Seas. The Government can provide long-term guidance and support to local industry which is able to develop to supply the future floating wind industry.
21. The Government should **initiate training and skills assessments of the Turkish workforce** and prepare them for the establishment of a local supply chain. This is best achieved in close collaboration with international developers, and know-how transfer through experienced suppliers.

5.2 ROADMAPS

FIGURE 5.1 LOW GROWTH SCENARIO FOR OFFSHORE WIND DEVELOPMENT IN TÜRKİYE. THE SCENARIO IS HYPOTHETICAL AND DOES NOT SHOW EXACT CLAIMED GOVERNMENTAL TARGETS.

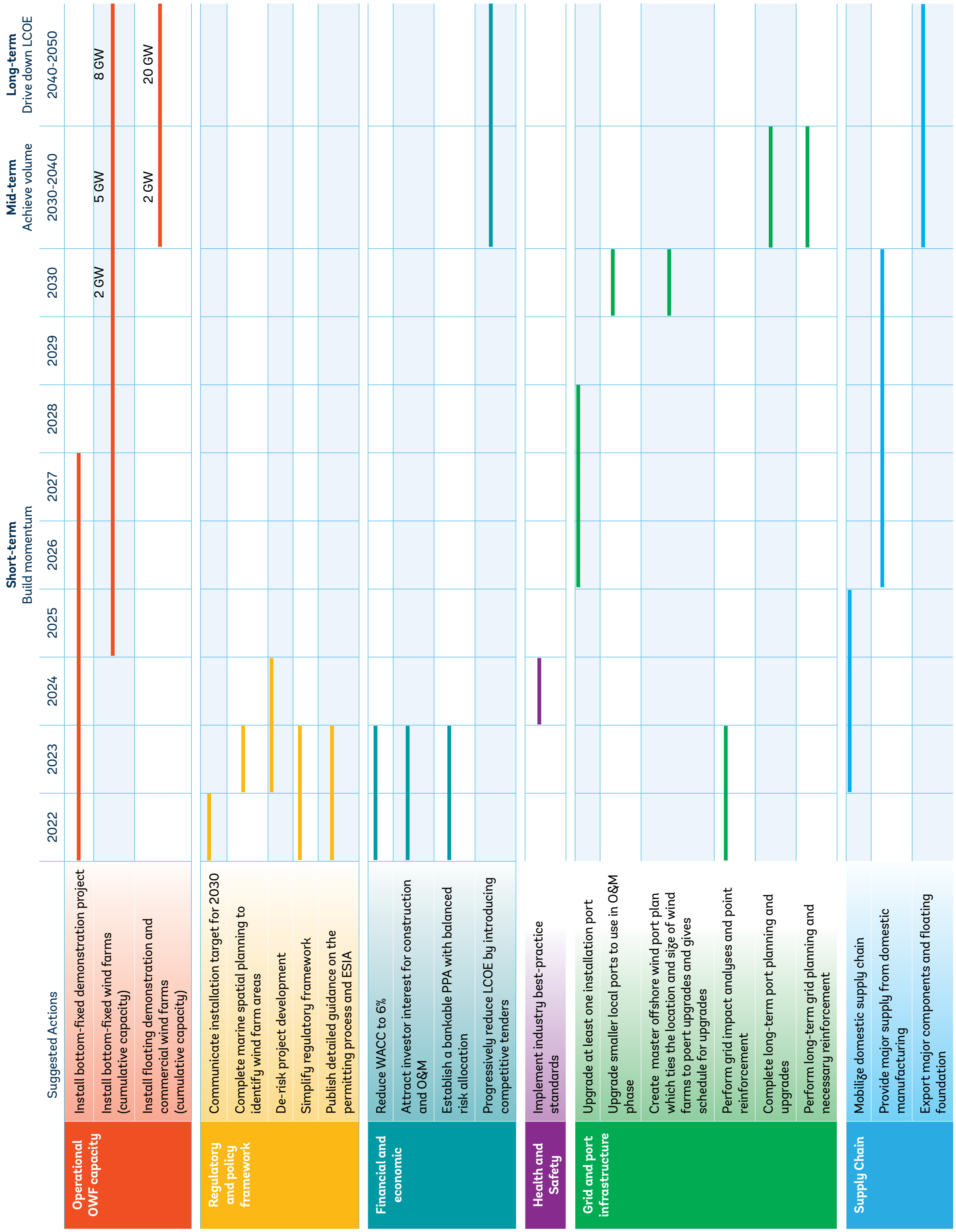
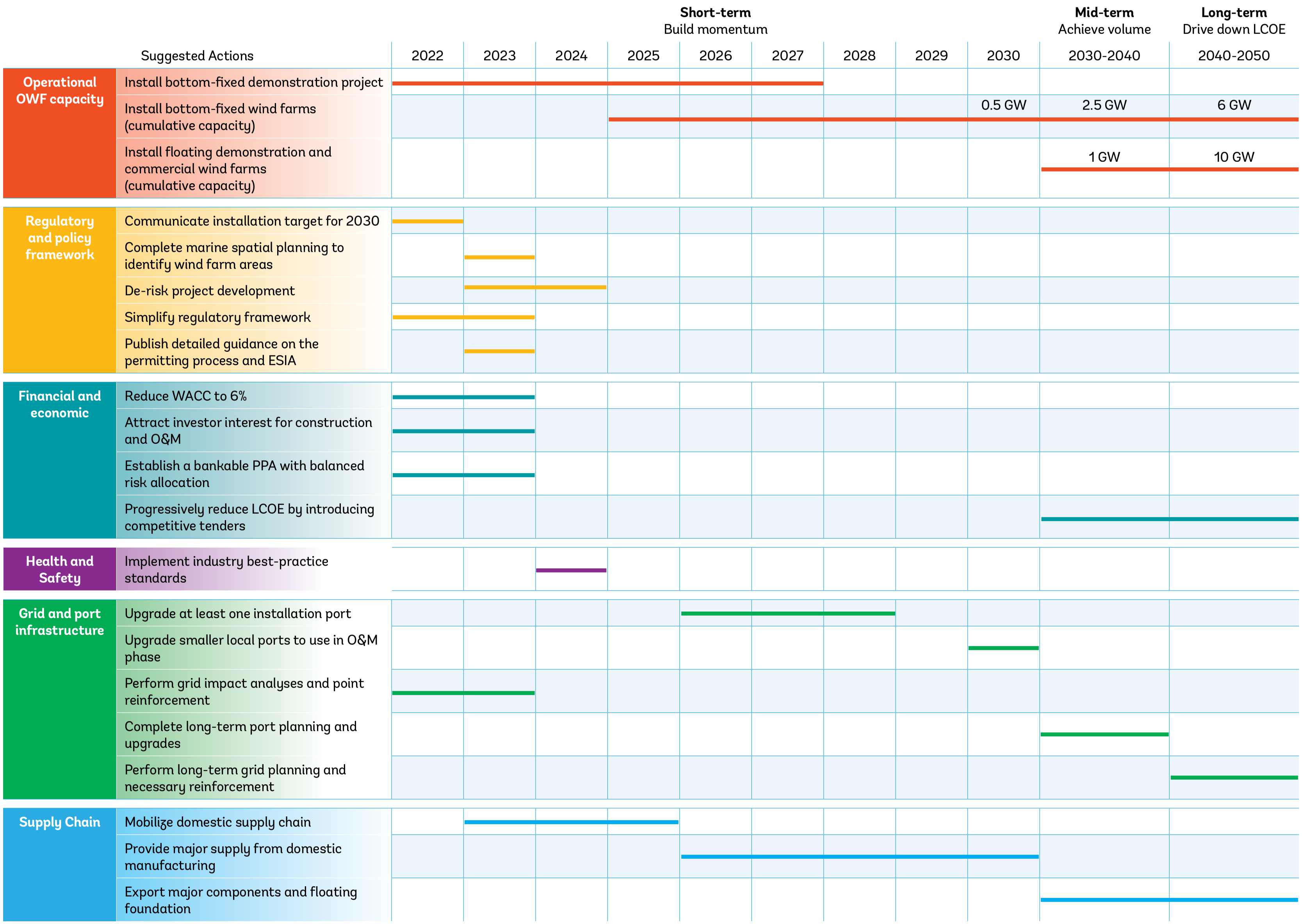


FIGURE 5.2 HIGH GROWTH SCENARIO FOR OFFSHORE WIND DEVELOPMENT IN TÜRKİYE. THE SCENARIO IS HYPOTHETICAL AND DOES NOT SHOW EXACT CLAIMED GOVERNMENTAL TARGETS.



6 SUITABILITY ASSESSMENT OF OFFSHORE WIND AREAS

6.1 PURPOSE

The screening for offshore potential performed under this roadmap consists of an assessment of seabed conditions, wind resource, and environmental and social constraints. This is based on a high-level assessment using existing publicly available data. With these topics mapped, the overall locational potential can be estimated.

6.2 SEABED CONDITIONS

This section provides a preliminary assessment of the seabed, geology, and seismic conditions offshore Türkiye. Geology and seismic conditions are included in the screening as these factors impact foundations and the structural integrity of OWFs. Extreme or harsh conditions may result in exclusion of some areas.

It should be noted that the data presented is not of a quality suitable for design and shall be considered as for information only. Detailed hydrographic, geophysical, and geotechnical surveys and results are required during later stages of the development of offshore windfarms.

6.2.1 Data

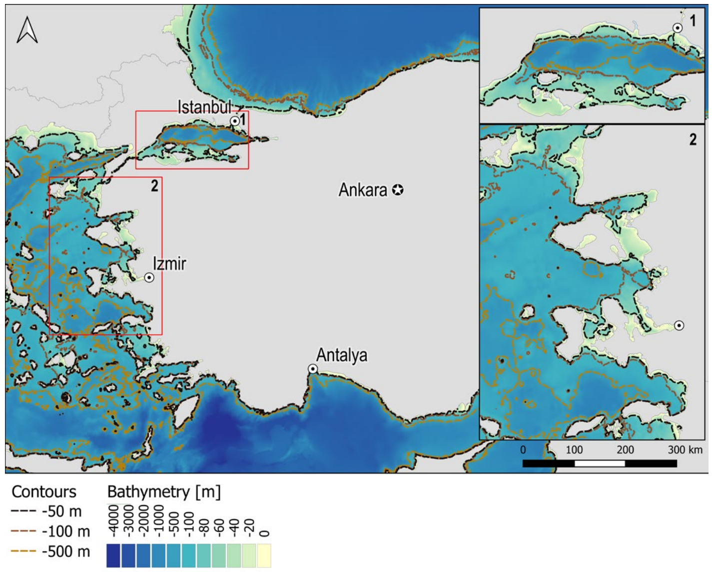
The available data that have acted as basis for the screening is:

- Bathymetry—grid from EMODnet (~100 m resolution) [27]
- Morphology—data from ESRI [28]
- Seabed sediments—map from EMODnet (1:1M) [29]
- Sediment accumulation rates—data from EMODnet [30]
- Coastal stability—map from EMODnet [31]
- Pre-Quaternary bedrock geology—map from EMODnet [32]
- Earthquakes—data from B.U. KOERI-RETMC [33]

6.2.2 Morphology

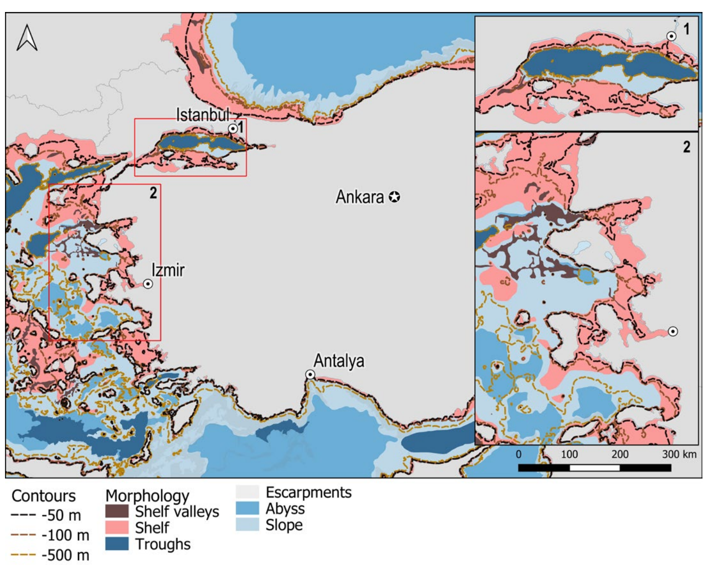
The bathymetry offshore Türkiye shows that relative shallow waters are found on the west coast, whereas water depths are increasing more rapidly on the northern and southwestern coast (Figure 6.1).

FIGURE 6.1 BATHYMETRY OFFSHORE TÜRKİYE [27].



Large-scale morphological seabed features (e.g., shelf valleys and troughs) are shown on Figure 6.2. Escarpments related to steep slopes at the transition from shelf to abyss are dominant on the northern and southwestern coasts, presenting areas of increased risk for foundations and anchoring. On the northern part of the west coast, a few shelf valleys are present.

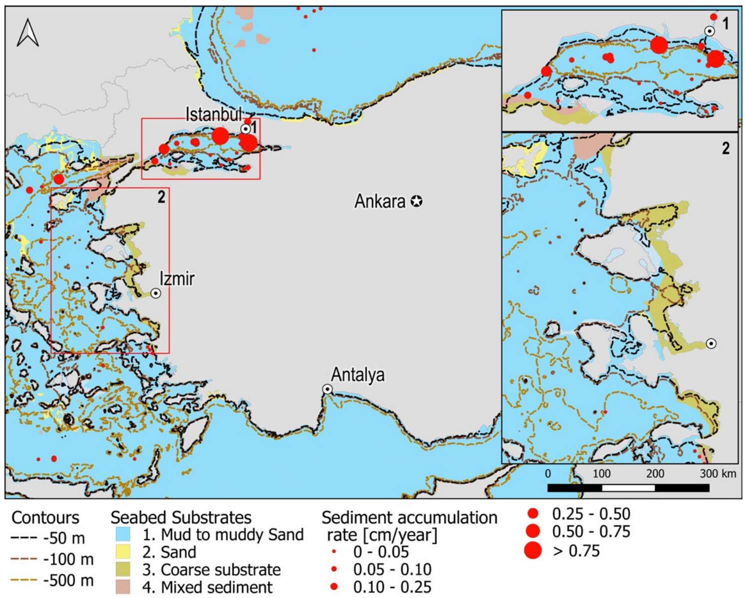
FIGURE 6.2 MORPHOLOGY OFFSHORE TÜRKİYE SHOWING GENERAL LARGE-SCALE FEATURES [28].



Based on the available data, the seabed predominantly consists of muddy sediments. However, nearshore along the northern coast (Black Sea), sediments are sandier, whereas, the western coast (Aegean Sea) has coarser and mixed sediments found nearshore (Figure 6.3).

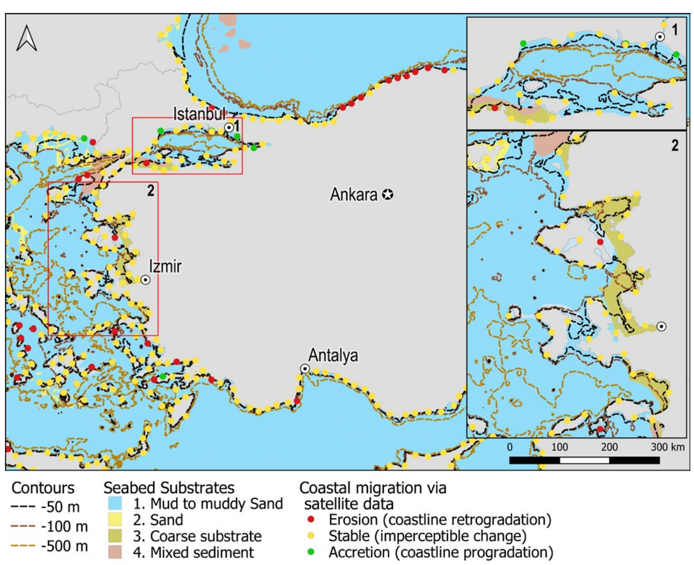
Available data from the west coast indicate sediment accumulation rates of 0.02 to 0.5 cm/year in the northwest and 0.004 to 0.02 cm/year in the southwest.

FIGURE 6.3 SEDIMENT CLASSIFICATION AND SEDIMENT ACCUMULATION RATES OFFSHORE TÜRKİYE [30].



Overall, the coastline appears to be stable except for a larger area along the northern coast where net erosion is reported. Accretion of the coastline is reported in very few places along the northeastern and southeastern coastline (Figure 6.4).

FIGURE 6.4 COAST STABILITY. OVERALL, THE COAST APPEARS STABLE, EXCEPT FOR A LARGER AREA ALONG THE NORTHERN BLACK SEA COAST WHERE NET EROSION IS REPORTED [31].



6.2.3 Geology

Türkiye consists of a complex geology as the country is made up of several continental fragments which were joined into a single landmass in the Neogene period. Furthermore, large parts of Türkiye were intensely deformed and partly metamorphosed during the Alpine orogeny, which has added to the complexity of the geological setting.

In general, basement rocks offshore Türkiye are Pre-Miocene of age and covered by Miocene to Quaternary sediments. Basalts from the Lower Cretaceous are found offshore the northern coast and further nearshore, Miocene clay and Cretaceous sandstone is present. Basalt from Upper Jurassic is identified offshore the southwestern coast, while to the southeast, Mudstone from the Pliocene is found (Figure 6.6).

Conceptualized 1D stratigraphic profiles are shown for four areas along the western coast (Figure 6.5).

FIGURE 6.5 1D CONCEPTUAL STRATIGRAPHIC PROFILES FROM THE WEST COAST [34]. THE COLOURED FRAMES REFER TO THE LOCATION (COLORED SQUARES) ON FIGURE 6.6.

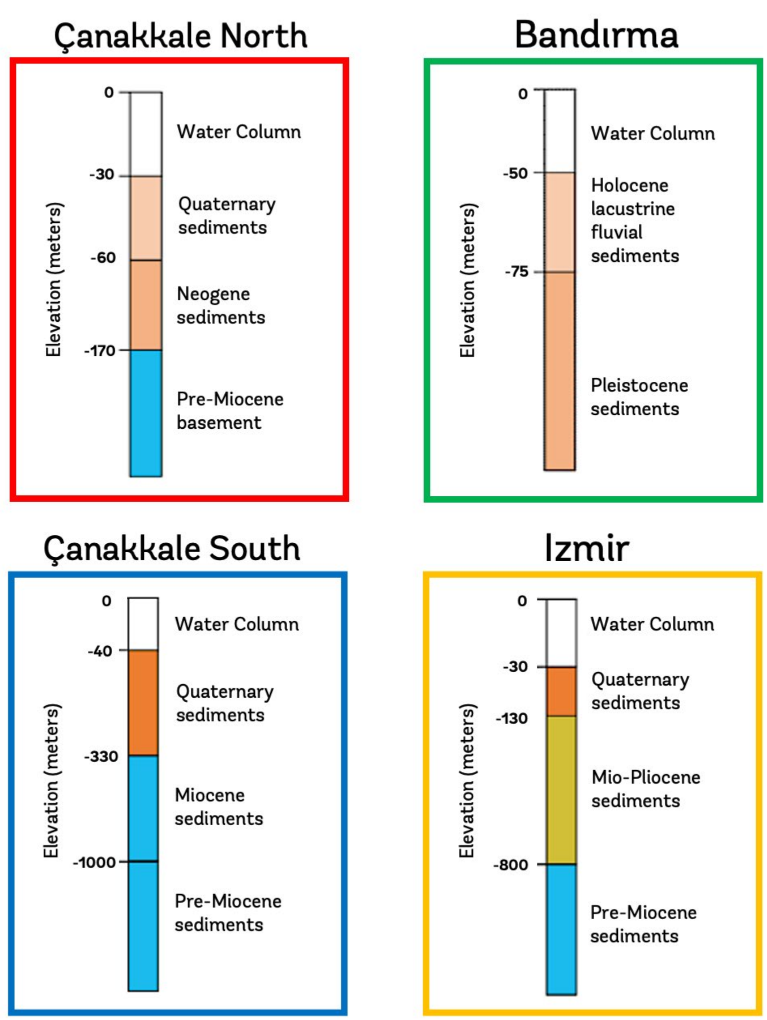
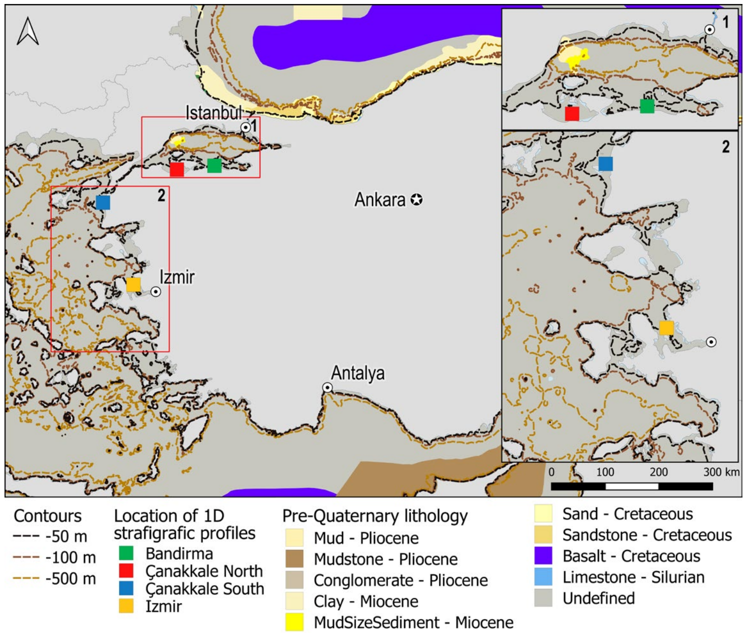


FIGURE 6.6 PRE-QUATERNARY LITHOLOGY. THE COLORED SQUARES INDICATE THE LOCATION OF THE 1D STRATIGRAPHIC PROFILES IN FIGURE 6.5 [32].



6.2.4 Seismicity

Türkiye is part of the great Alpine belt that was formed about 66 to 1.6 million years ago, as the Arabian, African, and Indian continental plates began to collide with the Eurasian Plate. This process is still ongoing, and a compilation of GPS velocities indicates a counter-clockwise rotation of the Anatolian plate which leads to active continental extension and many east-west trending grabens in Western Türkiye [35]. The counter-clockwise rotation as well as the active North and East Anatolian Faults (Figure 6.7), result in a high seismicity in the region.

FIGURE 6.7 SIMPLIFIED MAP SHOWING MAJOR FAULT LINES AND TECTONIC PLATE BOUNDARIES [35].

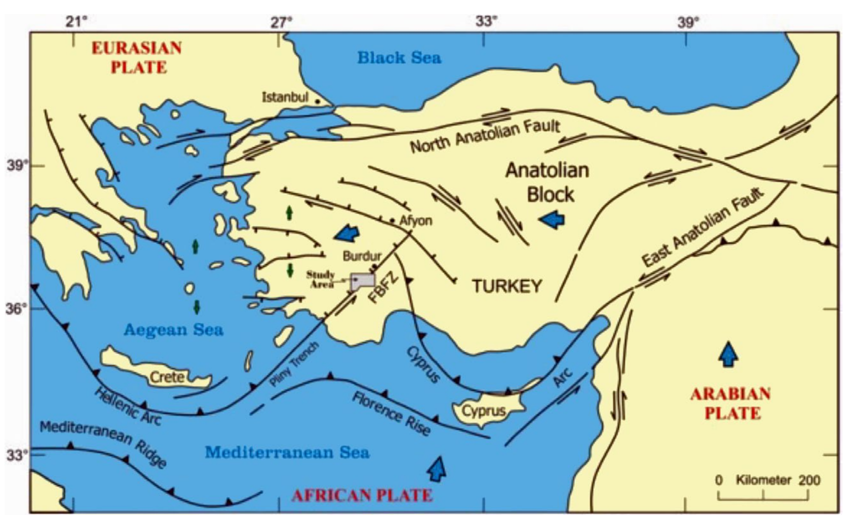
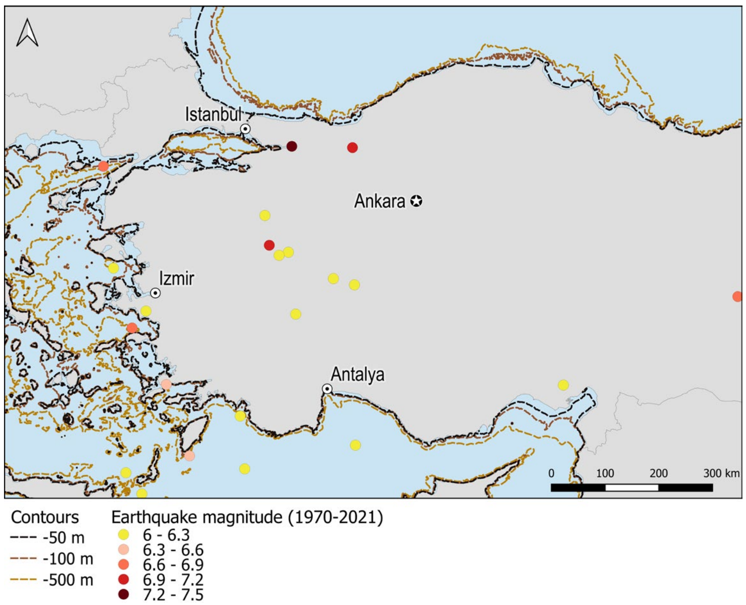


Figure 6.8 shows reported earthquakes with magnitudes above 6 on the Richter Scale from 1970 to 2021. Only earthquakes with magnitudes above 6 (moderate to great) are shown as these are considered potential geohazards.

As a result of the high seismicity in the area, the west coast of Türkiye is prone to tsunami events. This is also evident from historical records which indicate that more than 90 tsunamis have been observed over the last 3,000 years [36]. The waves produced by a tsunami are considered to produce significant scour around offshore foundations, which must be considered in a foundation design [37].

FIGURE 6.8 EARTHQUAKES FROM 1970 TO 2021. ONLY EARTHQUAKES WITH MAGNITUDE ABOVE 6 ON THE RICHTER SCALE ARE SHOWN [33].



6.2.5 Findings

Based on this assessment of Turkish seabed conditions, high-level constraints for location of offshore wind from a seabed point of view are:

- The -50 m depth contour line being a constraint for fixed bottom foundations; and
- Zones of escarpments or shelf valleys when considering floating foundations.

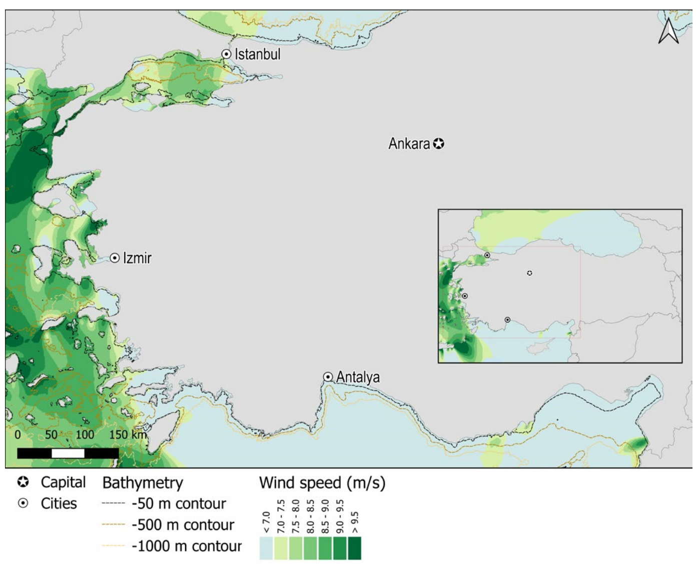
In addition to this, seabed conditions generally seem acceptable, but site-specific conditions such as potential scour around foundations and cables must be considered in the development of projects.

6.3 WIND RESOURCE

To identify and map the potential for offshore wind development in Türkiye, COWI evaluated the wind resource in different areas in Turkish waters. As many of the potential areas for offshore wind are in relatively close proximity to the shore, terrain effects will likely produce complex wind conditions including local acceleration and shadowing effects. Currently, only mesoscale data is available as an input to this analysis and so should be considered with reasonably high uncertainty within 20 km of the shore. The New European Wind Atlas (NEWA) and the Global Wind Atlas (GWA) both represent relevant mesoscale data that can be used for a screening exercise.

For this study, GWA was used as input and basis for the analysis. Currently, 7 m/s is considered the lowest feasible wind speed for economically feasible offshore projects. As can be seen in Figure 6.9, Türkiye has high wind speed sites offshore, particularly in the region of Çanakkale. However, it must be noted that Türkiye also has lower wind speed sites, which are better exploited by low wind speed WTG models. As the offshore wind sector matures, and as the medium-to-low wind speed sites become increasingly viable to develop, we expect OEMs to develop lower wind speed WTG types. In turn, with this market-driven development, development of these WTGs will improve LCOEs of projects.

FIGURE 6.9 AREAS WITH MEAN WIND SPEED HIGHER THAN 7.0 M/S AT 150 M BASED ON GLOBAL WIND ATLAS [20].



Wind farms continuously generate electricity, typically with a higher output during the evening when solar does not generate electricity. While predicting the actual production profiles of onshore wind and solar energy in Türkiye is outside the scope of this roadmap, there is generally a complementarity between wind and solar on a diurnal basis. In addition, combining wind and hydro power can be beneficial, as hydro power can match the variability of wind, allowing for larger shares of intermittent electricity to be integrated in the Turkish power systems without decreasing its stability.

6.4 ENVIRONMENTAL AND SOCIAL CONSTRAINTS

Offshore wind can be a major element in addressing the challenges of climate change and can potentially create both economic and environmental benefits for generations to come. However, multiple uses of ocean resources by many stakeholders require careful consideration and coordination. Poorly located projects could give rise to significant adverse effects on the environment, the economy, and communities, potentially damaging societal acceptance of offshore wind or decreasing investor confidence in the market.

In the following sections, the environmental and social considerations that may influence the future development of Türkiye's offshore wind market are examined. The analysis includes a high-level risk assessment and mapping of potential environmental, social, and technical constraints in relation to offshore wind development in Türkiye. The assessment includes recommendations on how to incorporate and plan for environmental and social constraints and should guide the continuing evolution of Türkiye's offshore sector.

6.4.1 Method

The constraint mapping has been conducted through a review of scientific literature and experience from well-developed offshore wind projects and markets. As far as possible, the environmental, social, and technical constraints have been mapped spatially.

The investigated areas are either categorized as;

- **Exclusion zones**, which are not suited for any development of offshore wind; or
- **Restriction zones**, higher risk areas where development could only proceed with further study and through the adoption of mitigation and other measures controlling how those areas would be developed.

Areas outside of these two zone categories will also have some level of constraint but, from this initial high-level analysis, appear to contain fewer environmental, social, and technical sensitivities.

Gathering stakeholder input into marine spatial planning, the permitting process and ESIA should be an ongoing process, particular for the protection of environmental and social resources. Multiple stakeholders will include environmental groups, non-governmental organizations (NGOs), business interests, offshore wind industry representatives, and local communities. Done in a collaborative manner, participants will be asked to comment on a range of environmental issues, including climate change, important species, habitat, and outdoor recreation specifically in the context of the development of a site-specific location.

Türkiye's governmental stakeholders relevant for the environment and social issues are:

- Ministry of Environment Urbanization and Climate Change (MoEUCC) regulating environmental impact assessment (EIA), environmental and construction permitting, and leasing of seabed

- The General Directorate of Environmental Impact Assessment under the MoEUCC is responsible for regulating, following, and managing activities related to environmental impact assessment
- Directorate General of National Property under the MoEUCC is the competent authority for the leasing of seabed/concession
- Ministry of Culture and Tourism
- Ministry of Transport and Infrastructure

Additionally, further stakeholders like NGOs and social stakeholders, as well as cultural stakeholders need to be considered, as referenced in chapter 14.

6.4.2 Results

Legally Protected Areas and Internationally Recognized Areas

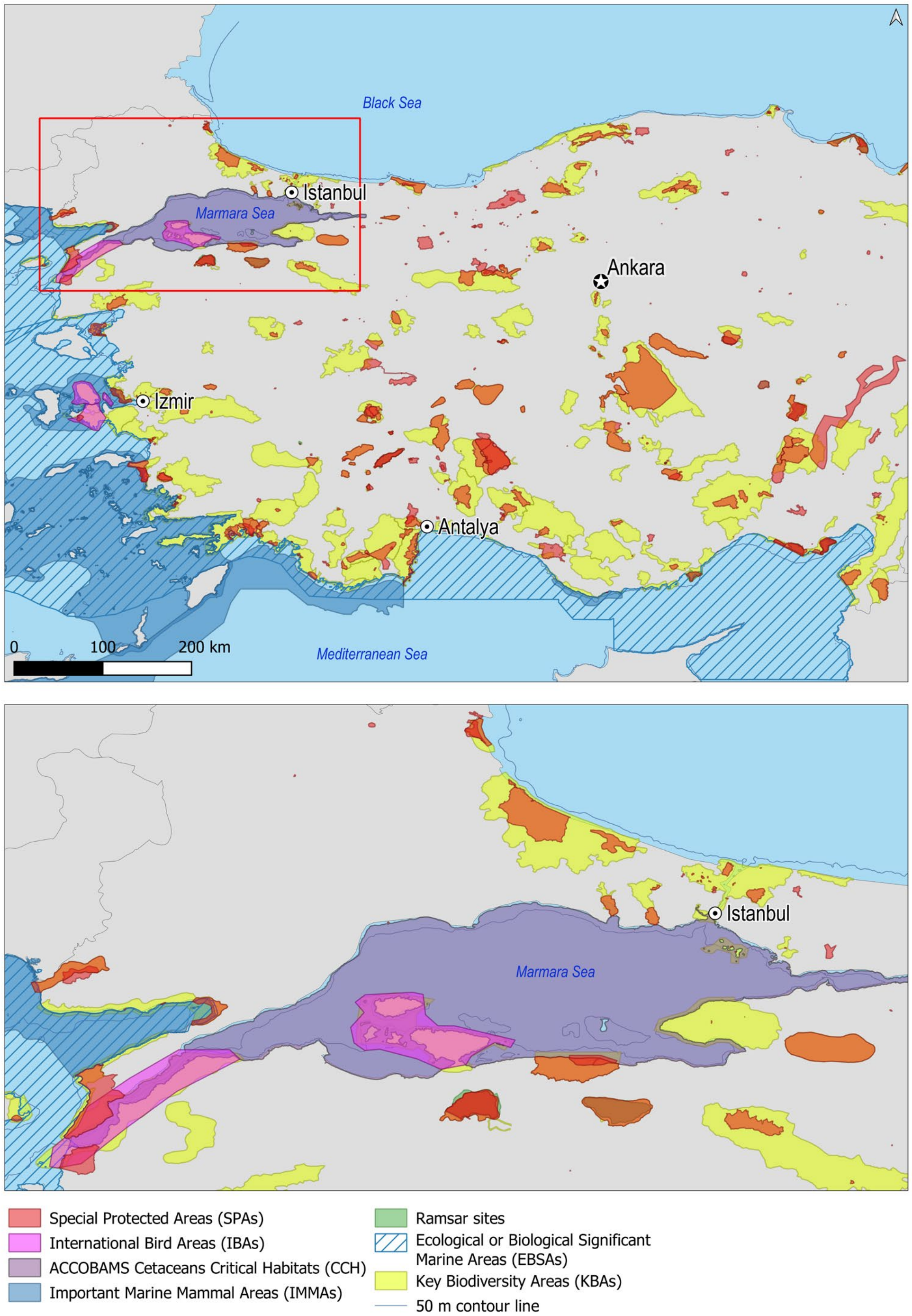
Legally protected areas (LPAs) and internationally recognized areas (IRAs) represent high value areas designated for various biodiversity conservation objectives. Potential impacts on LPAs and IRAs from offshore wind development include habitat loss, degradation and transformation, hydrodynamic impacts, and introduction of invasive alien species, as well as impacts to internationally important species populations. In most instances, offshore wind development would be incompatible with the conservation objectives and effective management of LPAs and IRAS, and some should be excluded from consideration for offshore wind development because of this. The designated sites with marine components that could be negatively impacted by offshore wind development include national parks, nature parks, nature reserves, special protection areas (SPAs), natural protected areas, Key Biodiversity Areas (KBAs) including Important Bird and Biodiversity Areas (IBAs), and Ramsar sites, Important Marine Mammal Areas (IMMAs), Ecologically or Biologically Significant Marine Areas (EBSAs), and Cetaceans Critical Habitats (CCH) sites (Figure 6.10).

It is recommended that national parks, nature parks, nature reserves, SPAs, natural protected areas, KBAs and Ramsar sites are excluded from offshore wind development. Further baseline studies and assessment are required within EBSAs, IMMAs and CCH before it can be determined if it may be feasible for development to proceed in these areas.

These sites are therefore included in the restriction zone layer, with the understanding that the following will be required:

- Careful spatial planning/site selection
- Detailed project-specific ESIA
- Mitigation to meet No Net Loss of natural habitats and Net Gain requirements for critical habitats
- Co-ordination to avoid sensitive periods

FIGURE 6.10 PROTECTED AREAS (PAS) AND INTERNATIONALLY RECOGNIZED AREAS (IRA) IN TÜRKİYE (SOURCE: COWI)



Furthermore, Annex C presents additional details regarding spatial data to be included in Exclusion and Restriction Zone layers. A summary is provided in the following table.

Priority biodiversity feature	Exclusion zone layer	Restriction zone layer
PAs and IRAs	• SPA • Ramsar sites • KBAs, including IBAs and Alliance for Zero Extinction (AZE) sites	• EBSAs • ACCOBAMS CCH (Marmara Sea) • IMMAs
Natural habitats	• MEDISEH modelled Coralligenous formations Mearl beds distribution (>70% probability) • MEDISEH modelled seagrass bed distribution (>70% probability)	• MEDISEH modelled Coralligenous formations Mearl beds distribution (10 to 70% probability) • MEDISEH modelled seagrass bed distribution (10 to 70% probability)
Marine mammals	Important sites for Mediterranean monk seal, plus a 25 km buffer	-
Marine turtles	• WCMC turtle nesting beaches, plus a 5 km buffer • MEDISEH modelled seagrass bed distribution (>70% probability)	• MEDISEH modelled seagrass bed distribution (10 to 70% probability)
Birds	-	• Migratory flight density for large soaring bird species
Fish	-	-

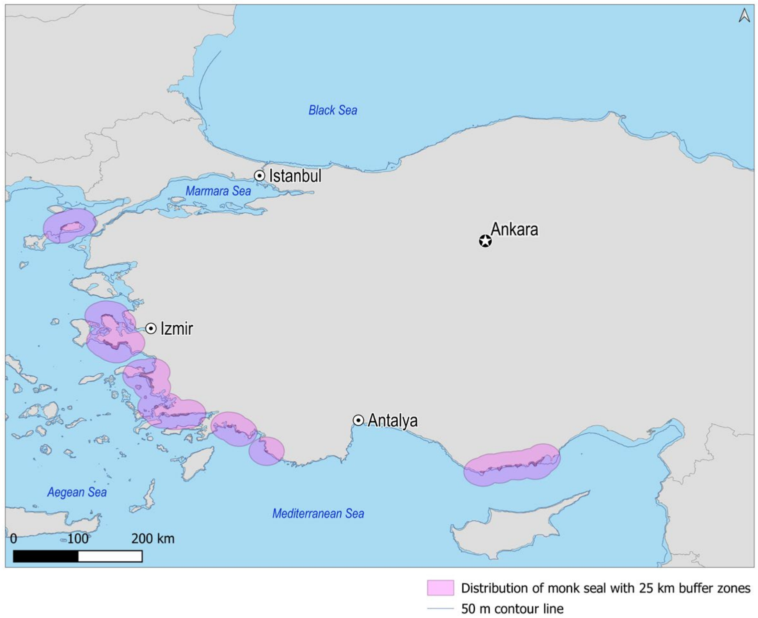
Threatened marine species

Some marine species in Türkiye are sensitive to survey and construction activities. These species are, in general, those that are particularly sensitive to underwater noise, vibration or smothering, or loss of seabed habitat. Developers should consider the likely presence of sea turtles, marine mammals, fish species, and sharks. Some very rare species, such as the Mediterranean monk seal, loggerhead turtle, and green turtle are found in Türkiye and should also be considered carefully.

Offshore wind development poses several risks to the remaining Mediterranean monk seal and sea turtle populations, of which disturbance including loss of seagrass beds and impact to nesting beaches (e.g., cable landfall) is possibly of most concern.

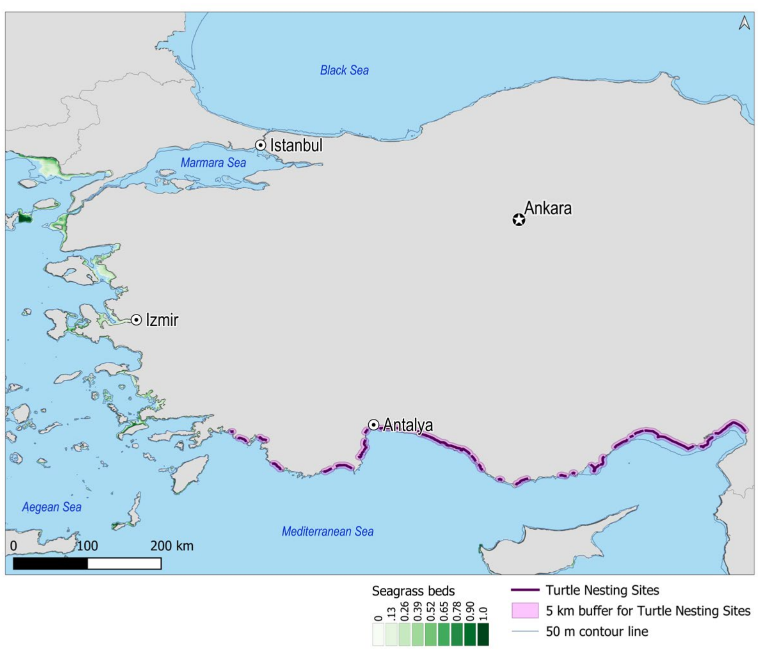
Given a very high sensitivity of Mediterranean Monk Seal, it is recommended that a 25 km buffer is treated as an exclusion zone around known important sites for the species, such as along the southern coast where regular sightings have occurred (Figure 6.11). Monk seals also live in and around the Kapıdağ Peninsula, the Marmara Islands, and Karabiga (within KBA). Mediterranean Monk Seals have recently been re-classified as a 'threatened' species, with their populations increasing, but still at risk. Global experience has shown that, with careful planning and mitigation, offshore wind can co-exist with seal populations. Further information will be required to assess the distribution of seals and their habitats, especially in the Sea of Marmara, and assess the potential impacts of offshore wind.

FIGURE 6.11 DISTRIBUTION OF MEDITERRANEAN MONK SEAL WITH 25 KM BUFFER ZONE [38].



Marine turtles feature in the designations of several overlapping marine protected areas. Taken together, these designated areas are likely to cover most of the area that is important for marine turtles in the Turkish waters. However, it is recommended that nesting beaches for marine turtles, plus a 5 km buffer are excluded for offshore wind development. In addition, seagrass beds on the Turkish Aegean and Levantine coastlines, as well as a small area within the Sea of Marmara are likely to form important foraging areas for green turtles. For the same reason, nesting beaches (+ 5 km buffer zone) and sea grass beds are included in the exclusion zone layer (Figure 6.12).

FIGURE 6.12 NESTING BEACHES FOR TURTLES + 25 M BUFFER ZONE AND DISTRIBUTION OF SEAGRASS (FORAGING GROUNDS FOR SEA TURTLES) (SOURCE: COWI).



Fish are identified as important features of the North-East Levantine Sea EBSA and North Aegean EBSAs. According to the IUCN Red List, there are 15 threatened bony fish and 30 threatened cartilaginous fish species whose global ranges overlap Turkish waters, of which four and seven respectively are critically endangered. There is no spatial data of endangered and critically endangered fish species.

Options for Türkiye to mitigate severe impacts on threatened species include implementation of effective environmental management plans which include ways to mitigate habitat destruction, underwater noise, and disturbance. Negative impact from underwater noise may be mitigated by avoiding pile driving and seismic surveys during breeding seasons, by reducing the noise level by use of sound dampening techniques like bubble curtains or by application of powerful acoustic deterrents.

Threatened natural habitats

Several natural habitats identified as threatened according to the European red list of habitats are likely to be relevant to offshore wind development in Türkiye. The only digitized spatial data of marine natural habitats in Türkiye include modeled distribution of seagrass beds, coralligenous formations, and maerl beds. The data indicate that threatened natural habitats are concentrated in the sub-tidal zone of the Aegean and the Mediterranean Sea. Coralligenous formations and maerl beds are particularly distributed in the northern and southern areas of the Aegean Sea.

Areas modeled as exceeding 70 percent probability of seagrass, coralligenous formations, and maerl beds are included in the exclusion zone layer and areas with a predicted probability of between 10 to 70 percent included in restriction zone layer.

Within the restriction zones options for Türkiye include careful management of the wind farms and reducing physical damage of threatened habitats like seagrass beds by optimizing the positions of the WTGs, considerations of floating foundations, restoration, and management of compensatory biodiversity refuges.

Migratory birds and bats

Birds are included within the designations of several overlapping PAs and IRAs as described earlier in this report, including Ramsar sites, Important Bird Areas (IBAs) and EBSAs. These designated sites are likely to include most seabird nesting colonies and non-breeding aggregations of international importance. However, there are gaps in relation to flyways and migratory bottlenecks. For non-marine bird species, the greatest threat from offshore wind stems from collision with WTGs located on migratory bottlenecks. At the southern eastern corner of Türkiye, migratory birds are concentrated into a bottleneck by the Mediterranean Sea.

To identify the sea areas crossed by large soaring migratory birds during migration, available satellite track data was analyzed for White Stork (*Ciconia ciconia*) and Egyptian Vulture (*Neophron percnopterus*). The sea areas, shown by the analysis to be crossed by migratory birds are included in the restriction zone layer.

More details on the migratory birds can be found in Appendix C.

Commercial fishing grounds

The fishing industry in Türkiye is a sector that directly employs 58,665 people in total with approximately 18,000 fishing vessels, nearly 2,500 aquaculture and processing facilities, and approximately 250,000 people together with logistics and other related sectors.[xix] The main target for the fisheries is the pelagic species such as anchovy, pilchard, sprat, and horse mackerel, which are caught primarily in the Black Sea.

Fisheries using active fishing gear like trawl are more sensitive to the presence of a wind farm compared to static fishing methods like gillnets. Fisheries are generally most intense in the coastal areas where they can be a constraint to offshore wind development.

Areas with high fishery intensity should be analyzed during planning, noting that some fisheries activities may still be possible depending on gear type and the layout of projects. Data on fisheries intensity is not included in the exclusion zone or the restriction zone layer. The impact of aquaculture on potential offshore wind sites also needs to be further considered within a more detailed screening process for a specific site.

Before site selection, as part of marine spatial planning, local fishermen and the fishery industry should be consulted to avoid significant impact on the most important commercial fishing grounds and their biologically linked habitats (spawning, nursery areas). Potential measures include compensation schemes and agreements of multi-use areas (e.g., where transit and use of certain gear is allowed).

Tourism

The economic value of the tourism sector in Türkiye is particularly high in coastal areas close to the bigger cities. Tourism hotspots include areas with bathing beaches, resorts, bigger cities, and popular boating areas.

The Ministry of Culture and Tourism have pointed out certain areas as hot spot areas for tourism. Relevant stakeholders within these areas should be involved in site selection to ensure that the tourism activities would not suffer significantly from offshore wind development. It is recommended to avoid locating WTGs near tourism hot spots, but significant impact can be mitigated by placing windfarms further away from the coast or adjusting the farm layout (e.g., reducing height and number of WTGs).

Special attention to sites with cultural heritage (e.g., World Heritage Sites), as well as marine archaeology sites, will be necessary.

Landscape and seascape

In Türkiye, there is no specific regulation on how far from the coast a wind farm should be.[xx] Since the visual experience of a windfarm is highly culturally dependent, a buffer zone for placing near shore wind is not defined here. It should however be carefully considered during the planning process.

xix Based on consultation with Ministry of Agriculture and Forestry, as well as General Directorate of Fisheries and Aquaculture.

xx Please note that the Coastal Law No:3621 defines the shore edge line, which means that structures should be made at least 50 m distance from this line. The specific distance from the shore is to be determined by the tender dossier, as it was seen in the 2018 tender.

Military exercise areas

There is high uncertainty surrounding military exercise areas in Türkiye since some uses will be confidential. The topic requires further investigation and consultation with the military before selecting a specific development area. Some temporal activities such as laying of cables and transport of material is in many cases accepted by the military, while operation of a windfarm may interfere with the operational requirements of the military and be considered unacceptable. Military training areas at sea are included in the exclusion zone layer (Figure 6.14).

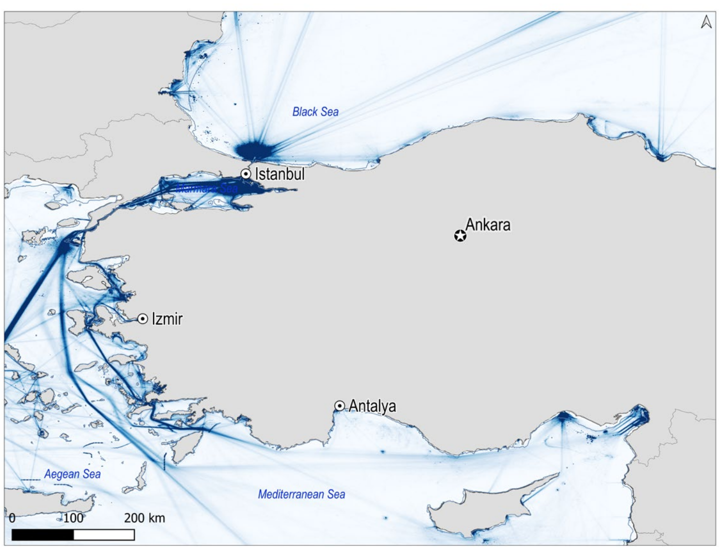
Ships and navigation routes

The Aegean and Marmara Seas host considerable maritime traffic. Areas frequented by ship traffic must be considered as well in relation to the wind farm operation, due to the risk of damaging wind farm infrastructure.

There are two distinct sailing routes from the Aegean Sea, through the Çanakkale Strait and the Marmara Sea towards the Istanbul Strait (Figure 6.13). In addition, there are hotspots for traffic densities around the harbors of the main cities (Bandırma, Tekirdağ, Gemlik, and all the coast from Istanbul to Derince-Golcuk). The most intense traffic is located around Istanbul.

Wind farms can be placed within an area with high intensity of maritime traffic. However, designated shipping routes, traffic separation schemes, as well as registered shipping lanes are considered hard constraints and are therefore included in the restriction zone layer (Figure 6.14). This is particularly relevant for the Strait of Çanakkale and the Marmara Sea where the interaction with shipping routes, increased risk of collision, as well impacts on marine and traffic surveillance station radars should be carefully considered during the planning process.

FIGURE 6.13 MARITIME TRAFFIC, SHIPPING INTENSITY [39].



Subsea cables

Subsea cables for telecommunication or electricity are usually buried beneath the seabed and may constrain the location of windfarms. Known subsea cables are mostly concentrated in the Çanakkale Boğazı (the strait that connects the Marmara Sea and the Aegean Sea).

Coexistence of subsea cables and wind farms or wind farm power cables is possible but may present local constraints. Subsea cables are included in the restriction zone layer (Figure 6.14).

Aviation

Offshore wind farms may interfere with aviation radar or block or degrade the signal for telecommunication and data transmission.

Numerous aviation-related sites exist along the coast of Türkiye which could be a constraint for near-shore wind development. Most are located in the southern part of the Aegean Sea. Airports and radars (including 15 km buffer zonexxi) are included in the exclusion zone layer (Figure 6.14). The Directorate of Civil Aviation regulates civil aviation in Türkiye and should be consulted in the early development stage of a specific offshore wind farm.

Oil and gas operations

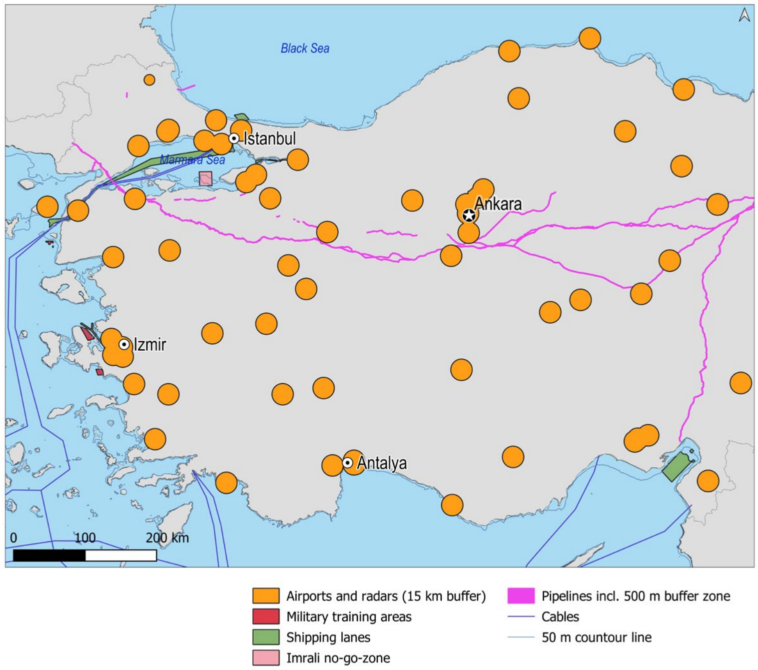
Structures related to oil and gas infrastructure pose a hard constraint for offshore wind farms and are surrounded by exclusion zones. Currently, there is no offshore oil and gas extraction in Türkiye, though future extraction is planned. However, as part of the general oil and gas infrastructure, subsea pipelines are present in the western part of the Marmara Sea. The pipelines are included in the exclusion zone layer (Figure 6.14).

Ímrali no-go zone

Ímrali is a small Turkish prison island in the south of the Marmara Sea, west of the Armutlu-Bozburun peninsula. It is surrounded by a no-go zone which presents a hard constraint since development within this area is prohibited. The no-go zone for Ímrali is included in the exclusion zone layer (Figure 6.14).

xxi 15 km is an international generally applied buffer zone around airports and other radar installation. However, specific buffer zones may apply to specific airports/ radar installations in a given country.

FIGURE 6.14 OVERVIEW OF AIR TRAFFIC, MILITARY, OIL PIPELINE, SHIPPING, AND NO-GO ZONE CONSTRAINTS.



6.5 CONCLUSION

Türkiye has few areas suitable for fixed offshore wind, but more for floating.

In areas with adequate wind speeds, Turkish coastal waters are heavily constrained by environmental and social restriction and exclusion zones. The major constraints include conflict with protected areas, internationally recognized areas for biodiversity (e.g., KBAs), foraging areas and nesting areas for sea turtles, threatened natural habitats (e.g., seagrass beds), and core areas for Mediterranean Monk Seals. However, military zones and shipping lanes also add to the exclusion zones. Restriction zones represent designated areas with important ecosystem functions or species but could host offshore wind developments following further investigation including careful site selection, appropriate environmental and social studies, and consideration of appropriate mitigation.

7 REGULATORY FRAMEWORK

7.1 PURPOSE

The regulatory framework surrounding offshore wind is critical to the success of the industry in any country. This chapter provides a basic analysis of the Turkish regulation relevant for the development and operation of OWF projects in view of international regulatory experiences.

Türkiye is characterized by an elaborated legal and institutional framework, which to a far extent can support complex infrastructure projects. Türkiye also has a long tradition for involving private partnership for the financing, construction, and operation of large infrastructure projects. As indicated by the stakeholder consultations already conducted for this study, the Turkish experience within private partnerships, such as public private partnership (PPP), is valuable also for OWF projects.

The main challenges with large scale OWF projects appear to be process related in terms of permitting and readiness of site and tender. In this respect, the legal and institutional framework must be able to provide the needed support in at least three directions:

- First, the setting out of planning tools and process, such as development and active management of outcome related to feasibility studies and assessments of risks, environmental and social impact, and site conditions, etc. Results from this must be taken diligently into account by sound risk management and mitigation planning.
- Second, to ensure a sound level of public consultation and participation in all planning and project stages.
- Third, to ensure an efficient coordinated involvement of all stakeholders, especially among all relevant public authorities needed for consent and permitting provision at national, regional, and local government levels.

In addition, for offshore wind projects the issue of location and site management may cause challenges as sound planning requires well developed spatial maritime planning, which typically still is under development, for instance, this could be because of the absence of data and comprehensive mapping of constraints. There is the need for well-coordinated and well-integrated planning solutions and outcomes.

The offshore location may also bring about needed transnational coordination with neighboring states and needed alignment with shipping and other activities in international waters. Good ESIA practice includes transboundary consultation on potential environmental and social effects.

Furthermore, the sound development and management of offshore locations may be challenged by military and national security interests as manifested by significant secrecy and security measures in place. Based on international experiences, this may require further efforts to ensure good planning and coordination among competent authorities (civil and military) in order to provide the needed access to site and supply lines, and to ensure proper planning, sharing of data and information, and public consultation.

It is not the intention of this study to provide an independent legal analysis of these aspects, but rather to assess the Turkish legal and institutional framework based on consultations with relevant stakeholders combined with an evaluation of the past YEKA experiences. As such, this study is based on desk studies combined with stakeholder interviews.

For inspiration, section 7.6 provides an overview of international OWF regulatory experiences.

7.2 OVERVIEW OF REGULATORY FRAMEWORK

Türkiye has developed a legal and regulatory framework for renewable energy, which is also being applied for offshore wind. As shown by the YEKA tenders in section 7.3, the legal framework is supplemented with detailed, and project-specific conditions based on procurement processes.

Following the National Renewable Energy Action Plan (2014) [40] and the National Energy and Mining Policy, the MENR issued a Strategy Plan for 2019-2023, which targeted an increase in the installed capacity of wind power plants from 7 GW to 11.8 GW [41], [42]. In addition to The Strategy Plan for 2019-2023, "Increasing capacity of production of electricity from wind power to 16 GW until 2030" was stated in the Intended Nationally Determined Contribution (INDC) of the Republic of Türkiye.

Aforementioned targets helped Türkiye to increase the use of renewable energy potential. At the beginning of 2023, Turkish Government started a new phase in the energy sector and published its first long-term energy plan. Türkiye National Energy Plan study has been developed in accordance with Article 20 of the Electricity Market Law No 6446 entitled Supply Security, and Supplementary Article 2 of the Natural Gas Market Law No 4646, and covers the period up to 2035, based on Türkiye's 2053 Net Zero Emission Target. In this plan, a specific target for offshore wind is declared for the first time in the history of Türkiye. According to plan, the Turkish Government expects to reach 5 GW offshore wind capacity in 2035.

Supporting the long-term plan, Türkiye revised its renewable energy support mechanism (YEKDEM)[xxii] and announced new incentive prices on 1 May 2023, within a Presidential Decree (No 7189). The new scheme includes a distinction between onshore wind and offshore wind. For the first time, the Turkish Government incentivizes offshore wind power plants specifically in terms of electricity generation and local content support.

In addition to YEKDEM support, Türkiye applies the already established procurement schemes based on the YEKA model[xxiii].

As section 7.3 illustrates, past experiences should be taken into account and considered that they may provide some lessons for improvement of the current YEKA regime to optimize market attractiveness and attract both domestic and foreign investors into the future Turkish OWF market.

xxii The Renewable Energy Resources Support Mechanism (Turkish acronym: YEKDEM)

xxiii Renewable Energy Resource Zone (Turkish acronym: YEKA) [121] [44]. YEKA is regulating OWF projects, next sections.

7.2.1 The main legislation

Türkiye undertakes, like any other country, ongoing reforms of its legal system to respond to past experiences and improve the legal framework for future projects. The 2018 reform of the Coastal Law is a good example of improving the planning and certainty associated by site allocation at sea for future OWF projects. It follows from the Costal Law Article 6 that such project will be done by YEKA.[xxiv] Besides the recent 2018 revision of the Coastal Law, there is no specific offshore wind regulation available. Offshore wind is regulated as all other regulations related to electricity market and renewable energy.

An overview of the main regulation relevant for the offshore wind sector is presented as follows:

Renewable energy

- Law on Utilization of Renewable Energy Sources for the Purpose of Generating Electrical Energy (Renewable Energy Law) (Law No. 5346), 2005 with amendments
- Regulation on Supporting Domestic Parts Used in Facilities Generating Electrical Energy from Renewable Energy Sources (No. 30091), 2017
- Regulation for the supporting and certification of Renewable Energy Sources (No. 31304), 2020

Energy law

- Energy Efficiency Law (Law No. 26510), 2007
- Electricity Market Law (Law No. 6446), 2013 with amendments
- Electricity Market Licensing Regulation, 2013 with amendments
- Electricity Market Connection and System Usage Regulation, 2014 with amendments
- Electricity Network Regulation, 2014 with amendments

Environmental/EIA/public consultation

- Environmental Law (Law No.. 2872), 1983 amended by Law no. 5491, 2006
- EIA Regulation (No. 26939), 2008
- Regulation on Permits and Licenses to be Obtained Under the Environmental Law (No. 27214), 2009
- Animal protection law (Law No. 5199), 24 June 2004
- Regulation on management of bathing water quality, 25 September 2019 (No. 30899)
- Regulation on Environmental Impact Assessment, 25 November 2014 (No. 29186)

xxiv Given that renewable energy production plants can be installed in the sea areas that are declared as renewable energy zones by the MENR with the decision of the maritime zoning plans.

- Regulation on environmental permits and licenses, 10 September 2014 (No. 29115)
- Regulation on environmental auditing 21 November 2008 (No. 27061)
- Regulation on strategic EIA 8 April 2017 (No. 30032)

Zoning/concession/seabed lease

- Port Law (Law No. 618) on 14.04.1341
- Law on the protection of life and property at sea (Law No.o 4922), 10 June 1946
- Law (Law No. 5790 dated 16 July 2008) regarding the revision of the Law on the protection of life and property at sea (Law No.o 4922)
- Cabotage law (Law No.o 815 dated 19 April 1926)
- Law on Fisheries (Law No 1380)
- Zoning law (Law No. 3194) 3 May 1985
- Coastal law (Law No.o 3621), 1990 (as amended 2018)—defines the use of shores in Türkiye. Note new Article 6: Renewable energy power plants can be installed in the areas that are declared as Renewable Energy Zones by the Ministry (Ministry of Energy and Natural Resources) with the decision of the maritime zoning plans
- Regulation on the implementation of Coastal Law 03 August 1990 (No. 20594)
- Directorate General of National Property Communique (No. 324)—Regulating the concession and/or lease of offshore areas
- Regulation on the planning endeavours in protected areas, 23 March 2012 (No. 28242)
- Regulation on rules and procedures of identification registration and approval of protected areas 19 July 2012 (No. 28358)
- Regulation on underwater excavating material management, 14 January 2020 (No. 31008)
- Regulation on management of state-owned lands 19 June 2007 (No. 26557)
- Regulation on prohibited military zones and military security zones 30 April 1983 (No.18033)
- Regulation on Navigation, Hydrography and Oceanography Service dated 7 November 2019 (No. 30941)

Procurement and YEKA

- Regulation (Official Journal No. 29582) on Renewable Energy Resource Areas of October 9, 2016 (YEKA)
- Turkish President issued Decision (No 7189), 2023 (new YEKDEM tariff)

- Regulation of 28 May 2021 (No 31494) on the procedures and principles on the implementation of local content prices
- Public Procurement law (Law No. 4734), 2002

Foreign investment

- Foreign Direct Investment Law (Law No. 4875,) 2003

Cultural heritage

- Law on the Conservation of Cultural and Natural Assets (Law No. 2863), 1983
- Law Confirming the Approval for the European Convention on the Protection of the Archaeological Heritage (revised) (Law No. 4434), 1999
- Regulation on the management of state-owned areas located in the natural heritage and protected areas and specially protected area 2 May 2013 (No. 28635)

Construction/building

- Please refer to section 11.4 and the table in appendix A as an example of the permitting involved for the construction part only (not operation) of offshore infrastructure.

7.2.2 The main institutions

The Turkish energy sector is governed by a very large number of institutions attached, related, and affiliated with the main actor and the lead institution, MENR [43]. The main competent authorities relevant for OWF projects are:

- **The Ministry of Energy and Natural Resources (MENR).** Responsible for the development of Turkish energy policy, drafting and enforcement of legislation in all areas of the sector.
- **General Directorate of Energy Affairs (GDEA),**[xxv] being the competent authority under MENR. GDEA is responsible for preparation and launching of renewable energy auctions/tenders, and for determination of renewable energy targets and projections for Türkiye. Also, GDEA is the competent authority for new and renewable energy resources and preparation/conduction of pilot projects for implementation in cooperation with research institutions, local administrations, and NGOs.
- **The Energy Market Regulatory Authority (EMRA).** EMRA is the market regulator. It is an autonomous, public legal entity established to regulate and monitor electricity, natural gas, petroleum, and liquid petroleum gas markets. EMRA is governed by the Energy Markets Regulatory Board. EMRA can create and approve tariff levels, issue licenses, establish quality service standards, and address other matters such as management and consumer complaints arising from lack of quality or interruptions in the power supply

xxv MENR and GDEA are not separate entities. GDEA is one of the central departments of the Ministry and responsible for the development of overall energy policy/legislation including the renewable energy.

- **Turkish Electricity Transmission Corporation (TEİAŞ):** Within the context of the Transmission Licence obtained from EMRA on 13 March 2003 and according to the new market structure, TEİAŞ carries out its activities by central and nationwide units responsible for project, installation, operation, maintenance, and load dispatch.
- **Ministry of Environment Urbanization and Climate Change (MoEUCC)** regulating EIA, environmental and construction permitting, and leasing of seabed.
- **The General Directorate of Environmental Impact Assessment** under the MoEUCC is responsible for regulating, following, and managing activities related to environmental impact assessment.
- **Directorate General of National Property** under the MoEUCC is the competent authority for the leasing of seabed/concession.
- **Ministry of Transport and Infrastructure**, regulating sea and shore activities including maritime affairs, shipyards, coastal structures, and infrastructure investments.
- **Local authorities including governorships, municipalities, port authorities, etc.** (typical in contact with the central ministries)—concerning public consultation and local interests.
- **Turkish Naval Forces, Office of Navigation, Hydrography, and Oceanography** is responsible for providing navigational, hydrographical, and oceanographic services and products, providing national coordination and international activities in this field with the objective of safety of navigation, scientific marine research, and operations of naval forces assets.
- **Ministry of Agriculture and Forestry General Directorate of Fisheries and Aquaculture.** Before the construction of offshore wind farms, necessary permissions must be taken from our Ministry within the scope of Law on Fisheries (Law No 1380).

In addition to the aforementioned, other competent authorities may be involved related to planning at land and sea, aquatics, cultural heritage, oil and gas exploration, tourisms, national security, and transnational coordination and border issues in the sea (Aegean and Mediterranean).

7.3 PROCUREMENT OF OWF—YEKA MODEL AND YEKDEM SUPPORT MECHANISM[XXVI]

This section briefly presents the Turkish procurement scheme relevant for large-scale OWF projects, being the YEKA regime.

7.3.1 Renewable energy resource zones (re-zone/YEKA) model

Three different investment models are in place in the Turkish renewable energy market: the Renewable Energy (RE) Zone (YEKA) model [44], unlicensed, and licensed models. Large-scale offshore wind projects will predominately fall under the YEKA model due to size in terms of MW.[xxvii]

xxvi Please note that the YEKDEM section 7.3.2 is included only for the overview of support mechanisms for renewable energy other than offshore wind, as offshore wind will be managed by YEKA.

xxvii YEKA model is not related to capacity limits.

YEKA projects are targeting large scale renewable projects, and the zones were instituted under the October 2016 Regulation on Renewable Energy Resource Areas [45]. This regulation determines the YEKA areas, allocates connection capacities, establishes tender conditions, prescribes licensing application process for successful tenderers, and outlines the procedures regarding the sale of electricity generated in YEKAs based on a local production component and the creation of research and development (R&D) centers [46].[xxviii]

These areas, or zones, are exclusively allocated to establish generation facilities based on renewable energy resources.[xxix] A public tender is carried out for each renewable energy zone based on a reverse auction, with the ceiling price being the feed-in tariff determined under the Renewable Energy Law [47].

The overall objective of the YEKA investment model is to support the realization of renewable energy projects. To this aim, the main purposes of the YEKA Regulation have been identified as follows [44]: a) to commission renewable energy resources much more efficiently and effectively through identification of renewable energy zones; b) to realize the renewable energy investments much more rapidly; c) to manufacture renewable energy equipment in Türkiye; d) to use locally-manufactured equipment/components; and e) to contribute to research and development activities through technology transfer following one of the two mechanisms [23]:

- **Allocation on the condition of local manufacturing**—in which the legal entity being offered the YEKA, and its connection capacity utilization rights, must establish an equipment manufacturing factory and a Research and Development Centre in Türkiye, according to the standards and the terms of references.
- **Allocation on the condition of using locally manufactured equipment**—the YEKA and its electrical connection capacity utilization rights are given to a legal entity which wins the competition and commits to procure locally manufactured equipment and other related local components.

7.3.2 Renewable Energy Resources Support Mechanism ("YEKDEM")

The Renewable Energy Resources Support Mechanism ("YEKDEM") was first established in 2005 under the Renewable Energy Law (Law No 5346) to increase investments in the field of renewable energy and to prevent investors from avoiding entering the market because of high investment costs.

YEKDEM guarantees the purchase of electricity at predetermined price levels for 10 to 15 years, whereafter the electricity will be sold to spot markets or via direct sales to end users [48].[xxx] Under the scheme, renewable energy plants such as wind, hydropower, geothermal, biomass, and solar can qualify for feed-in tariffs. There are additional incentives if the mechanical and/or electro-mechanical components of the plant are manufactured domestically.

xxviii The tender will be organized by General Directorate of Energy Affairs (GDEA), being the competent authority under MENR. GDEA is expected to communicate with all responsible parties related to YEKA tenders, including guidance required for permitting. Furthermore, on facilitation, the Regulation on RE Zone, Article 5.3.d states that MENR cooperates in good faith with the legal entity that has won the competition for the necessary permission processes in order to make the RE Zone, which will be developed using the connection capacity allocation method, ready for investment.

xxix As explained by government stakeholders, please note two types of YEKA Zone determination: 1) determination of zones by MENR; and 2) determination of zones by the winner of the tender. In the first tender, zones are determined by the MENR. Therefore, all relevant opinions are obtained prior from public institutions, including the military.

xxx Law No 7257 dated 25.11.2020 ("Law No 7257") on Article 6 of Law No 5346 on Usage of Renewable Energy Sources for Electricity Production stipulates that the prices and duration to be applied according to Law No 5346, will be determined by the Turkish President.

YEKDEM supplements the YEKA model, as renewable energy producers may obtain feed-in-tariffs directly. Unlicensed producers (of smaller capacity RE plants) can benefit from the YEKDEM scheme through their officially assigned supply company whereas licensed producers must make an application to the EMRA [48].

It has recently been decided to renew the YEKDEM regime. On 1 May 2023, the Turkish President issued Decision No 7189, which introduces a new feed-in tariff for electricity generation facilities that have renewable energy resource certification in accordance with Turkish Law No. 5346 (Renewable Energy Law) [49]. This applies for operations commencing from 1 July 2021 until 31 December 2030 and states that the feed-in tariff and local content prices are to be applied in Turkish Lira for the RE generation facilities [50]. The prices will be updated[xxxi] monthly starting from 1st June 2023 using a framework of a specific formula considering:

- Producer price index with a 25 percent weight
- Consumer price index with a 15 percent weight
- Monthly average of the daily buying rate of USD as published by the Central Bank of the Republic of Türkiye with a 30 percent weight
- Monthly average of the daily buying rate of EUR as published by the Central Bank of the Republic of Türkiye with a 30 percent weight

There is a differentiation between onshore and offshore wind, in the tariff mechanism. The prices to be applied within the scope of YEKDEM are determined in Law No5346.[xxxii] From 1st May 2023, the tariff mechanism in Turkish Lira for generation plants based on onshore wind and offshore wind is 1.06 TL/kWh and 1.44 TL/kWh, respectively, for 10 years after commencement of their operation. The new YEKDEM regime includes floor price and ceiling price for each type of power plants. These prices are determined as US$0.0495 per kWh and US$0.0605 per kWh for onshore wind and US$0.0675 per kWh and US$0.0825 per kWh respectively.[xxxiii] In addition, a local content price of 0.2880 TL/kWh for onshore wind and 0.3845 TL/kWh for offshore wind will be applied for a term of five years.[xxxiv] As stipulated by Decision No 7189 [50], the Ministry of Energy and Natural Resources will update the procedures and principles on the implementation of local content prices [51].

7.3.3 Experience from the 2018 Offshore Wind YEKA Tender

In 2018, the Turkish Government announced the ambition to construct the world's largest offshore wind park with a capacity of 1.2 GW, built with the latest technologies, with a minimum of 60 points from the local content table (annexed to the YEKA Specifications) related to components locally manufactured, and with 80 percent of personnel being Turkish.

xxxi The PPA prices are typically updated for active tariff contracts being linked to an index.

xxxii Please note that the prices/the tariff is valid as no auction is made for YEKDEM. Auctions are organized for YEKA Tenders.

xxxiii The new YEKDEM scheme shifts the currency of previously USD-denominated feed-in tariff and domestic components incentive premia payments to Turkish Lira (TRY), while still capping the price based on USD.

xxxiv YEKDEM feed-in tariff prices have increased with this decree. The price for wind energy in the new tariff scheme is 25 percent higher as compared to the previous YEKDEM price in USD/kWh (calculated based on the USD-to-TRY exchange rate of USD/TRY: 19.43 (when the tariff was introduced in 1 May 2023). [116]

Unfortunately, the 2018 goal could not be realized via the first Turkish offshore wind tender due to low interest from prospective bidders. Based on the stakeholder consultations held for this study, the reasons behind the low interest appear to be a combination of both tender-specific and macro-economic factors. These factors made the construction and financing too costly for potential developers in competition with other RE projects based on, for instance, onshore wind farms and solar PV. As a result, due to the conditions in the tender, internationally leading offshore wind companies did not participate in the competition, consortiums comprising Turkish companies presented no bids, and the tender was postponed.

It appears that the auction received little interest from developers partly because of limited site preparation (site conditions being undeveloped and uncertain) as well as the combination of a price ceiling (a price cap of US$0.08 per kWh) increasing the need for de-risking, transparency, and preparation of technical studies.

In addition, the requirements for domestic production made the foreseen completion within the set timeframe challenging, thus increasing the risks of delays and loss of deposit guarantee, and compensation by the project developers.

Furthermore, limited resources and credit rating of Turkish state-owned banks to support funding a 3 billion USD project, complemented with depreciation of the Turkish Lira from August 2018, and the volatility and rising interest rates for the currency, implied that obtaining financing was challenging and costly. Even if projects are financed in EUR or USD, revenues would come in Turkish Liras, thus currency fluctuation risk was high (e.g., due to a higher fall in the value of the Lira, compared to inflation levels).

Also, stakeholders conveyed concern that the environmental and social impact assessment process was unable to ensure safeguarding of marine environment and coastal communities. Although Türkiye already has the legal framework in place, it was perceived that this process would not meet the environmental and social standards of international lenders.[xxxv]

Finally, stakeholder feedback highlights that the lack of clarity in the permitting procedures posed a high risk for development. With more than 30 permits to obtain, the current regulatory system gives cause for concerns related to the internal processes, timing, and coordination involved. As such, the processes involved the permitting regime should have more clarity and transparency to reduce development risk.

Based on the stakeholder discussions, we provide a summary of the YEKA experiences gained from the earlier experiences. In our analysis and stakeholder discussions, we have taken account of the detailed evaluation on the experiences based on the 2018 YEKA offshore tender as provided by the Shura Energy Transition Centre [52]. The findings of our regulatory study confirm the main points raised also by Shura, and can be summarized as follows:

- The administrative processes related to offshore YEKA auctions are challenging with regard to the program timing and also licensing requirements and processes involved.

xxxv Please note that the validity of this perception has not been explored further by this study. However, it is reported here as we find value in reporting such feedback for the ongoing dialogue on strengthening the regulatory processes related to OWF. As such, it is recommended as part of the roadmap to look further into this issue to eliminate any such distrust by maintaining best international practice.

- Locations for the proposed OWF are not suitable or adequate in terms of optimal capacity, e.g., in terms of wind resources, water-depth, infrastructure/offshore supply chain, and grid connection.
- The high level of local content requirements constitutes a challenge.
- The price mechanism applied based on FiT and ceiling price has not been optimal in attracting investors.
- As an overall concern, the specific YEKA OWF action must be able to attract international competition among technology providers / international project developers.

As the experiences show, supplemented by stakeholder consultations held during the preparations for this study, the main concerns relate to the regulatory processes in terms of permitting, planning, site preparation, and pricing. Such uncertainty added by the price structures and conditions as applied by the YEKDEM and YEKA may limit the interest for international as well as local lead consortium investor participation.

The processes related to the permitting regime cause some uncertainty. The number of required permits to be obtained amounts to more than 30 different permits, which by itself is not a problem per se as the problem rather relates to the internal coordination among the competent authorities and the timing involved.[xxxvi] Such uncertainty may discourage potential investors from participation in proposed tenders. It shall be noted that the current regulatory framework and the YEKA tender designs intend to facilitate such processes. As such, a further improvement of the current permitting process should be addressed to improve the overall coordination and certainty based on international best practice.

7.4 PERMITTING

The principal permit required to establish an OWF is the **generation license** issued by the Energy Market Regulation Authority (EMRA). Before the main license is issued, investors must obtain a preliminary license. During the preliminary license term, the license holder must secure the necessary permits, approvals, and land/sea use rights over the site/property on which the OWF and related facilities will be installed.[xxxvii] The term of the preliminary license (no more than 36 months) depends on the installed capacity of the planned OWF power plant to be constructed.[xxxviii]

As soon as the required permits have been obtained and the preliminary license is converted to a generation license, the construction can begin. Generation licenses may be issued up to a maximum term of 49 years.

In addition, the **EIA approval** is needed.[xxxix] As required by the Environmental Impact Assessment Regulation (EIA Regulation), the projects listed in Schedule 1 of the regulation must obtain an EIA approval before the construction commences. Large-scale OWF projects fall within the scope of the listed projects in the EIA Regulation and an EIA approval with conditions is required.

xxxvi It shall be noted that YEKA already prescribes that all permission processes will be coordinated by GDEA.

xxxvii The winner is responsible to obtain all permits. It is assumed that preliminary approvals will be obtained by MoENR.

xxxviii The developer must obtain the preliminary license first. Then, the developer will have a maximum of three years to convert it to generation license, however the exact timeline will be the part of YEKA tender. Please also refer to the flowchart.

xxxix The content of EIA is project specific. The content and the format will be given by the MoEUCC after application. Overall content principles are defined in the addendum-3 of the EIA regulation.

Approved EIA, approved zoning plan, and project design and documents should be submitted to the Ministry of Transportation and Infrastructure (MoTI) for project approval. Permits related to Marine traffic and safety at sea and all other permissions including fisheries are expected to be evaluated during MoTI Project approval phase.

A **construction permit** according to the Zoning Law is needed from the relevant municipality or the relevant special provincial administration, and with the involvement of the MoEUCC before the construction of any structure can take place. The Zoning Law prescribes that the construction must be commenced within two years from the date of the construction permit, otherwise it becomes invalid.[xl] For construction and operation, a construction permit exemption letter[xli] can also be issued by the relevant administration [47].

As an example of the challenging permitting regimes attributed to large-scale offshore infrastructure projects, the table presented in chapter 16 (appendices) outlines the permitting requirements involved for the construction of such an offshore infrastructure. This example is applicable for both offshore hydrocarbons and offshore winds projects. Additional permits may be added related to wind power plants by the specific case. As the purpose alone is to illustrate the difficulty and resource demand involved during the permitting of a large-scale offshore project, the table is not an attempt to provide an accurate, complete, or up-to-date overview of the relevant permitting regime for OWF projects. This example is based on recent investigations by GazDay on large-scale offshore infrastructure permit procedures. The durations listed in the table are practical estimates based on experiences by stakeholders. Please note that the permitting outline only involves the construction phase, as additional permitting is needed for operation.

The example indicates the complexity involved in the permitting of large offshore infrastructure projects. This may be manageable by resource strong developers if the project is deemed bankable based on a reasonable rate of return of the investments. However, the overall risk involved in the process for delays and uncertainties may discourage investors and developers from participation, in particular international investors not familiar with the Turkish permitting regime.

Also, the timing related to permitting seems to be in need of adjustment in line with the long-term planning typically attributed to larger OWF projects. The need for converting the preliminary license into a power generation license within three years may cause a significant problem in terms of timing. Similarly, the required commencement within two years after obtaining the construction permit may also cause a significant timing problem. The timing of such permitting should be revisited to allow for adequate project preparation.

In this light, as the international market opportunities for RE and OWF projects are rising, and as the global developers are seeking for best possible business opportunities across the globe, any uncertainty, complexity, and additional costs attributed to a particular market could easily lead to a lower interest from an international investment perspective. However, such potential obstacles may be balanced with the investors' possible long-term interest in the future Turkish OWF market taking advantage of participation from an early stage.

xl The date by which the construction must be complete follows from the YEKA tender. Please also refer to the flowchart.

xli See [47]. In addition, the exemption letter can be issued in some cases by the municipalities. Normally, a construction permit (yapı ruhsatı) under the Zoning Law is needed from the relevant municipality, or from the relevant special provincial administration before the construction of any structure (including house, factory, plant, or workshop) is begun (unless the structure in question is exempt from this requirement). Under the provisions of the Zoning Law, construction must be started within two years from the date of the construction permit, otherwise it becomes invalid. For construction and operation of power plants, a construction permit exemption letter can also be issued by the relevant administration. The legislation on exemption from the requirement to obtain a construction permit for power plants is not very clear and has been interpreted differently by various local administrations. There is yet no experience with offshore project construction license.

More details on the permitting, including project phase, permit/approval name, content of application, regulation, relevant authority, and duration can be found in chapter 16 (Appendix A–Permitting related to construction of offshore infrastructure).

In support of the permitting described within this section, please refer to the flow chart presented in chapter 16 (Appendix B–Flowcharts for the sequence of permitting related to OWF projects).

7.4.1 Strengthened coordination

It follows from the previous section that the applicants and/or preliminary license holders must obtain permits from many separate administrative authorities. This corresponds to the responses obtained from the stakeholder consultation, as it has been voiced that a large number of permits and application files are needed to be obtained in coordinated manners. Stakeholders acknowledge that coordination in permitting is being addressed by regulation and supplemented by the YEKA tenders. However, the stakeholders raise a request for more coordination efforts from the government side in assisting in obtaining the permits and express a need for further clarity in the administrative processes involved [47].

Following international experiences, the permitting of OWF projects is substantially different from the permitting for onshore wind farms. An OWF will often involve different stakeholders as compared to the onshore projects and may have different priorities among the stakeholders. In particular, the sensitive marine environment and the cultural heritage above and below the sea level are likely to have significant influence on the site selection, site preparation, and the specific conditions needed for a particular OWF project. Also, interests related to national security and defense, together with commercial interests related to shipping, fishing, and tourism/recreation industries are likely to have a significant impact on such conditions. The seabed may also cause challenges in terms of crossing pipelines and other infrastructure that the OWF and its shore-based connection points may encounter. In short, maritime spatial planning from the government side is one of the key issues to release the offshore wind potential.

Although many of these challenges also may apply to onshore projects, the uncertainties and the limited experience level in permitting related to large-scale OWF projects, call for attention and integrated efforts among the competent authorities. As the interests involved may be different for offshore projects, the priorities and weighting among the various interests will differ compared to onshore projects. Also, the involvement of offshore-relevant competent authorities will be a difference. A different approach to permitting OWF is needed when preparing for the YEKA tenders as well as for the actual implementation of the YEKA project. In this regard, the timing and processes involved should also allow for a sound public consultation process, and transnational consultation and planning processes if the location of the OWF site and implications hereof so warrant according to Turkish international commitments.

Based on our stakeholder consultations with developers and the private sector, we have noted some concern about the clarity of the regulatory system itself. Although the stakeholders generally recognize that the current legislation supported by the specific YEKA tender designs also can be applied to OWF projects, a wish for improving the legal certainty for OWF has been voiced especially, but not only regarding zoning. The problem is not legal per se as it rather concerns the current lack of certainty related to the offshore specific references, criteria, and particularities, which are necessary for both administrators, developers, and the general public in order to regulate, develop, and address the complexity involved in offshore regulation and conditions. Although a further analysis of this goes beyond this study, we take note of the related 2018 amendment to the Coastal Law article 6 allowing for the installation of renewable energy power plants in areas declared by MENR as Renewable Energy Zones in accordance with maritime zoning plans.

Improved coordination, clarity, and certainty can be achieved by strengthening the processes and institutional competencies directly by the individual YEKA terms and conditions. If such improvements are being soundly addressed by the individual YEKA OWF tenders in near future, a later evaluation of such tenders will allow for an assessment of whether such needed clarity and certainty have been obtained with regard to processes and permitting, or an OWF legal reform is needed. The same YEKA experiences should also allow for a full legal analysis of the need, if any, for introducing a distinct OWF regulatory framework in line with international best practices.

The possibility for an introduction of a "one-stop shop" approach, as seen in other international jurisdictions (i.e., UK, Denmark, Netherlands), where relatively few permits are required compared to the Turkish permitting regime, has not been investigated in detail under this study. It could, however, be considered as a longer-term objective, as it will provide further needed clarity and certainty to the system. Although a well-coordinated system among 30+ permits may work well, it will still be challenging for investors to gain a full and comfortable overview, especially when participating for the first time in a YEKA tender.

7.5 RECOMMENDATIONS

The high-level analysis of the regulatory framework suggests that the following elements could be further addressed for improving the conditions for OWF in Türkiye:

Short-term recommendations

- Address uncertainty and the lack of clarity in the permitting and planning processes by strengthening the processes and institutional competencies directly by the individual YEKA terms and conditions.
- MENR should seek further to facilitate the permitting process with a view to reducing uncertainty for developers. This could be done by providing some permits with the YEKA tender, for example permits to carry out initial environmental and technical surveys, and supporting a developer to coordinate with different government authorities. Furthermore, prior to the next YEKA tender, MENR should publish a list of all the permits that a developer will be required to obtain, including the details of the relevant authorities, a firm plan and timetable, and details of the coordination efforts to be provided by authorities. This should also include guidance on the appropriate processes and standards for ESIA, which should be carried out in accordance with GIIP and based on robust baseline survey evidence.
- To the extent possible, continue to use the current regulatory framework with further improved YEKA conditions in order to strengthen project-based clarity and certainty.

- Engage with the industry during the planning of the next YEKA tender for offshore wind. Experience in established markets has shown that strong communication between the government and industry helps to design and improve competitions and processes. This helps to increase the chance of a successful tender outcome as the industry has visibility of the competition's features and has helped to make its conditions acceptable and attractive.
- Local content requirements constitute a major risk to developers, particularly where local firms have no experience with offshore wind. Local content requirements can cause delays and added costs, which lead to higher tariffs and can be detrimental to the start of a new offshore wind industry (this is an important lesson from the French experience [13]). Not having local content requirements does not mean that there will not be local content. Developers will always seek to minimize costs, and locally sourced materials and labor in Türkiye will be highly competitive with existing European suppliers, for example. Acknowledging that local content is an important driver, reducing the requirement for locally produced parts (e.g., to 25 percent) could be a more achievable target in the short term, until Türkiye develops a more capable and experienced local offshore wind supply chain.
- Allow sufficient time to conduct detailed site surveys in order to establish certainty on site conditions as part of the preparation for YEKA tenders.

Long-term recommendations

- Consider clarity and efficiency in OWF permitting regimes by means of a centralized approach (such as the Danish "one-stop shop" approach).
- Based on the coming experiences of future YEKA OWF tenders, undertaking an overall assessment of the possible need for a regulatory reform introducing an OWF specific permitting regime, and also assessing the possible need for introducing a distinct OWF regulatory framework following international best practices.
- Consider alternatives to FiTs to reduce the amount of offtake support required. This could include the use of support mechanisms that enable generators to sell power on the Turkish electricity markets. These mechanisms should provide generators with certainty of the offtake price, such as a contract for difference (CfD) model. Other options to allow generators to negotiate long-term supply agreements with offtakers (such as corporate power purchase agreements, or C-PPAs), can also be considered.

7.6 INTERNATIONAL REGULATORY EXPERIENCES

To assess OWF market opportunities for Türkiye, it may be useful to draw on relevant OWF international experiences and lessons learned, especially from northern Europe.[xlii] Any comparison between jurisdictions and markets shall be approached with caution as conditions typically vary. However, although it is not the aim of this study to provide a comparison with the Turkish regulatory regime, the lessons from Europe provide inspiration as a well-regulated, integrated, and transnational system, and as the European supply chain for offshore wind farms is mature and competitive, serving not only wind farms in Europe, but also some wind farms in more distant countries.[xliii] Companies from the UK, Denmark, Germany, and the Netherlands are the main participants in the supply chain, since the seas bordering these countries have seen the most growth in OWFs.[xliv]

In Europe, specific OWF national legislation addresses and directly encourages the development of OWF projects. Such legislation provides the needed certainty and stability to attract investments and developers. With this framework as a basis, public regulators prepare and manage the tenders in effective manners and include the public and other stakeholders in facilitating consultation and participation processes. The Danish and Dutch OWF legislation is, for instance, typically available in English and is based on same regulatory concepts.[xlv]

The advanced European OWF market and regulatory framework is useful for three reasons. First, the European market and regulatory regime are products of a learning process. Second, being advanced provides useful benchmarking for global market standards and local regulation. Third, the European OWF market and regulatory framework to a large extent sets the bar for international investors'/developers' expectations and interests when assessing global market opportunities for bankable investments. An investment regime based on regulatory certainty and reliability in terms of market access and during implementation may prove to be a preferred business case. However, these aspects shall be seen in the specific context of each individual project opportunity as local projects may have unique attractiveness for international investors beside the aforementioned.

7.6.1 Planning

The key for any successful OWF is a well-planned process. It is a process being characterized by complexity in managing the many interfaces, risks, and interests involved. This may include securing and sustaining a long-term partnership with a private contractor, ensuring optimal bankability and best competitive prices based on predictability and certainty in risk allocation, risk mitigation, and contract management.

xlii Regulatory lessons for this study are derived primarily from examples of OWF projects (recently in operation or planned), and based on the information provided: Denmark's Energy Islands [123]; Kriegers Flak [124]; Baltic 2 [125]; Hesselø Offshore Wind Farm [126]; Thor offshore wind farm [127]; Nearshore Wind Tender [128] Walney Extension [129]; Horns Rev 3 [130]; Beatrice Offshore Windfarm Ltd [131]; Hohe See [132]; Hornsea Project One [133]

xliii The UK regulatory approach in planning and consenting, as well as in the supply chain related to all project phases is well documented in BVG Associates' 2019 "Guide to an Offshore Wind Farm." The guide lists the authorities, functions, supplier names, costs, key facts, and scope for supply chain items in each project phase from development all the way through decommissioning. Even though the guide is focused on the UK, the information given generally provides a good representation of the European market, since co-operation is common [54].

xliv For the Danish regulatory approach, see Energy Policy Toolkit on Physical Planning of Wind Power Experiences from Denmark, which provides a good overview of OWF planning and consents. As from 2015, the details of the legislation have changed, but the general legislative process is still the same [122].

xlv The Danish regulation provides an example: The conditions for offshore wind farms are defined in the Promotion of Renewable Energy Act. In chapter 3 it is stated that the right to exploit energy from water and wind within the territorial waters and the exclusive economic zone (up to 200 nautical miles) around Denmark belongs to the Danish State [122].

Planning based on long-terms goal

OWF projects are typically addressed in long-term national planning and further detailed by planning and specific legislation providing the legal mandates needed. The planning will also initiate the early consultation processes involving stakeholders and the public in general. These processes are useful in stimulating the needed legitimacy for the projects to come and to alert the market investors of possible new project opportunities.

Integrated national and transnational planning and coordination

OWFs in the North Sea and the Baltic Sea are located in waters being shared by many states and in proximity to some of the busiest shipping routes in the world. As such, in addition to national planning requirements, a significant element of transnational planning and organization takes place.

It is a legal requirement for the planning of offshore wind farms to follow EU and national legislation, and the regional sea conventions (i.e., OSPAR and HELCOM), and national legislation on national and transnational environmental, social, and economic impact assessments, as well as maritime spatial planning, and public consultation.

There is also a market driven cooperation and coordination among TSOs in the region, encouraged by EU legislation and a market approach to optimize/utilize capacity based on economy of scale.[xlvi]

National and EU legislation requires that offshore planning is based on an integrated approach. It follows from EU marine and maritime legislation, and from the Regional Sea Conventions, that EU member states individually and in transnational coordination shall perform planning, taking all activities into account. The planning will prepare for further development of OWF sites and ensure alignment with other planning and area use, such as for national security of military and navy purposes. It is not per se a system that eliminates the secrecy and priorities associated with national security as it is rather a system that ensures coordination among interests.

7.6.2 Integrated permitting

The national permitting for the development of OWF is primarily based on an integrated permitting system among authorities and a one-stop approach. This means that the applicant in most cases may only refer to one entry point, and that permitting will be coordinated as far possible. It should be noted, however, that all competent authorities will be involved and will issue permit conditions to be fulfilled by the developer. However, it is a system that significantly eliminates uncertainties related to the process, timing, and outcome of any system involving many permitting authorities, including authorities safeguarding national security issues.

As an example, in Denmark, three licenses are required to establish an offshore wind farm [53]. The three licenses are granted by the Danish Energy Agency (DEA), which serves as a "one-stop shop" for the project developer. The three licenses are:

1. License to carry out preliminary investigations;
2. License to establish the offshore WTGs (only given if preliminary investigations show that the project is compatible with the relevant interests at sea); and

xlvi The owners of the wind farms Kriegers Flak and Baltic 2, for example, have recently completed a joint 10-year project together with TSOs Tennet and 50Hertz to make the world's first combined grid connection between two wind farms [135].

3. License to exploit wind power for a certain number of years, and an approval for electricity production (given if conditions in license to establish project are kept).

The three licenses are given successively for a specific project. Furthermore, it is necessary to perform an EIA if the project is expected to have an environmental impact. So far, it has been necessary to perform an EIA for all existing Danish offshore wind farms.

An integrated one-stop shop approach is not without several application phases in time and content. Depending on the tender terms, the successful winner may be required to follow-up and/or undertake specific permitting requirements as part of the project preparation and the undertaking of the engineering, procurement, and construction (EPC) contract and possible following O&M contract. The level of involvement of the developer and the degree of risk attributed depends on the specific project. However, in order to eliminate uncertainty, European OWF tenders are typically well prepared in order for the developer to take advantage of already issued permits and/or apply for permits based on well-developed feasibility studies and impact assessment.

Institutional lead agency is typically within the ministry of energy, being the energy agency, such as the Danish Energy Agency (DEA), or an agency within management of natural resources and/or RE infrastructure.

In the UK, the permitting system is also streamlined in five aspects [54]:

1. Before the consenting process can begin, the developer must secure a seabed lease by The Crown Estate (in 2017, a new body, Crown Estate Scotland, was formed to own and manage the seabed in Scottish Territorial Waters and adjacent areas of the United Kingdom Exclusive Economic Zone). The Crown Estate retains responsibility for the seabed in England, Northern Ireland, and Wales.[xlvii]
2. Offshore wind projects of more than 100 MW installed capacity in England and Wales are defined as nationally significant infrastructure projects (NSIP) and are examined by the Planning Inspectorate.
3. The Secretary of State for the Department for Business, Energy, and Industrial Strategy (BEIS) grants or refuses consent based on a recommendation made by the Planning Inspectorate. In England, a Development Consent Order is granted under the Planning Act 2008 (as amended) which incorporates several consents, including a marine license and onshore consents. ESIA is required for these processes.
4. In Scotland, Marine Scotland examines applications for the offshore works and Scottish Ministers grant or refuse consent for a marine licence under the Marine (Scotland) Act of 2010 (up to 12 nm from shore) and the Marine and Coastal Access Act 2009 for projects 12 to 200 nm from shore.
5. A streamlined process incorporates consent under Section 36 of the Electricity Act 1989 in parallel. ESIA is required for these consents.
6. Onshore consent including where the transmission cable landfall is awarded by the relevant local planning authority (LPA), except where a project is handled under an NSIP in England and Wales, in which case the onshore consents are considered within the NSIP process.

xlvii ESIA activities can be carried out without grant of agreement for lease. The agreement for lease allows site investigation, the lease itself is granted after consent to allow construction to commence.

7.6.3 Concession/use of site

The successful developer of an OWF site obtains a legal right for site access and concession of exclusive site exploration based on a long-term contract. The rights following the concession can be based on use, rent, or lease contract terms as an integrated part of the project agreement or the PPA.

The contract will stipulate the terms for site conditions, the construction of the OWF, the use of the site, and the exclusive exploration. It will also include access areas, pipelines, and submarine cables. Depending on the terms of the tender and the contract, the developer may also be responsible for shore-based infrastructure and installation for transporting power to the designated grid connection point(s).

As explained previously, in the United Kingdom the Crown Estate/Crown Estate Scotland provides seabed leasing. In Denmark, this is provided by the Danish Energy Agency.

7.6.4 Market access

Access to the European market is based on well-established procurement processes. Procurement takes place as a result of long-term planning and takes direct advantage of a liberalized and competitive energy market to meet the ambitious RE policy goals and agendas at national and EU levels. As part of the procurement process, the competitive approach among bidders is deliberately being employed in terms of negotiation during procurement with the aim of empowering public and private partnerships to utilize and tap into existing cutting-edge knowledge, expertise, and resources to develop, finance, and to implement OWF projects. An approach that also typically involves a degree of well-balanced local content requirement in terms of stimulating its own industry without jeopardizing the market attractiveness for foreign investors.

De-risking

The public and private partnership allows for early involvement in the process, which again allows for securing an early partner commitment to the project even before award of contract, to mitigate uncertainties and risks identified, and to obtain valuable insight from the bidders to further refine the details of the procurement material, such as technical and commercial details.

The market and the project owner itself need a certain level of project certainty and predictability to assess the attractiveness of the project. This calls for clear risk allocation and work division for both developer and the owner during construction and implementation, and the undertaking hereof must be reflected realistically in the implementation plan of the project. If such is not in place, there may not be any or limited participation/bids or the prices offered will be high to cover the uncertainties. Additionally, there may be a risk of the developer defaulting during implementation if certainty is lacking. This means that projects to the extent possible are being de-risked by well-prepared tenders and risk identification based on impact assessments and feasibility studies. De-risking also takes active part of the procurement negotiation itself, allowing the parties to identify risks, provide for agreed risk allocation within the tender requirements, and establish risk management and risk mitigation schemes.

In addition to certainty concerning site condition, access areas, and connection points/interfaces, certainty is also required by the legal and regulatory framework. The tender must be clear in designating contracting authority and outlining the process required, including permitting. Each bidder must undertake legal due diligence to identify possible regulatory shortcoming and risks, and these shall be addressed during the procurement stage.

Besides certainty in public law, legal certainty also requires certainty in clear contract terms between the parties. Contract format follows internationally recognized formats and regimes based on clear contract structures, such as EPCI (engineering, procurement, construction, and installation); design, build, finance, operate (DBFO); PPAs; or single or multi-contract regimes. A significant risk allocation is typically addressed by the price and payment structure involved. Feed-in-tariffs that were common in the past have been replaced by a structure based on ongoing market prices with de-risking caps for both developer and contractor (e.g., based on CfD).

Contracting and procurement strategy

This calls for a clear procurement strategy as part of the early stages of the planning for the project. As recent European OWF project experiences show, current procurement involves the following major categories which should be considered at an early stage:

- **Market sounding** is used prior to the launch of the official procurement to initiate an investigation into the current appetite/interest among the potential bidders at the international market. This insight is key to target the launch of the procurement and to level/optimize the details of the procurement material and the project conditions.
- **Public tendering**, or auctions based on negotiation with prequalified highly eligible bidders. This allows for securing an early partner commitment to the project even before award of contract, to mitigate uncertainties and risks identified, and to obtain valuable insight from the bidders to further refine the details of the procurement material, such technical and commercial details.
- **Use of internationally recognized procurement processes and contract regimes** (e.g., EPCI/turnkey, single or multi-contract regimes, DBFO, O&M) tailored with specific conditions relevant for the particular project. Use of such recognized regimes enhance certainty and stimulate the interests for the project among international bidders.
- **Price structure based on ongoing market prices with de-risking caps** for both developer and contractor (e.g., based on CfD).
- **Bidders to take more risk and responsibility for connection grid and points** (both in terms of construction and/or operation) towards TSO, even at shore.
- **Site preparations** depending on the actual project. Where such preparation already is provided for by the government (e.g., initial environmental impact assessment (IEIA) to identify fatal flaws (if any) and pre-feasibility studies), it may constitute a de-risking for the private developer (all depending on the tender terms) and procurement time may be shortened and to some extent also allow for certain de-risking for the contractor.

The sound procurement and contracting of a large-scale offshore wind farm has a major influence on the success of the project. The costs involved and potential for making a profit or loss is much higher in comparison to smaller scale onshore wind farm projects. Therefore, the consequences of a poor contracting and procurement strategy can have a serious impact on the project financial performance.

European grid

Market attractiveness is also sustained by a high level of European market access by a well-integrated, well-established, and stabile grid system. Seamless integration among European states and markets, which promotes stability and security are largely based on EU legislation and provides the investor or developer—and also the off-taker—with a high degree of certainty in terms of grid and supply certainty even in peak times and during fall out events. The European energy market is characterized by high demand for RE solutions, several national markets located in relative closeness to the OWF sites, and a public and commercial willingness to support the further development of OWF.[xlviii] The concept of multi-linking is also seen as an efficient way to take best use of resources and can be expanded and enriched with energy storage capabilities or Power-to-X (or P2X) technologies.[xlix]

These facts stimulate the interests among investors, developers, and off-takers to embark on larger OWF projects, which may be costly but also likely to be profitable. These factors also stimulate virtual investments in the European market from the world outside. The tendencies of green investments towards virtual PPAs (VPPAs) based on an increased focus on price structures based on CfD illustrates that the global energy market and related global competition in terms of attracting investors and also in terms of competition among the investors themselves truly are borderless.

Allow for exploration and exclusivity unless reserved by law or planning

As part of the liberalized market for OWF, and to stimulate private development of OWF, the Danish legislation allows for active pre-investigations of possible offshore sites by private developers. Such pre-investigation will address and assess all relevant conditions related to the environmental issues, wind resource, and ocean currents and impact on shipping and other infrastructure. Based on an application from a private developer, exclusivity by the government may be granted for within a set timeframe to undertake such exploration and if positive conditions are found and approved, development and operation of the OWF may be granted under set terms.

This option is only valid for OWF eligible sites not reserved, used, or prohibited by planning, use, or law. This also means in practical terms, that applications will not be granted for OWF sites reserved, or under consideration for being reserved, for public tendering by the government.

xlviii No viable technical solutions allow a large-scale wind farm to run without grid connection. Battery storage solutions are economical for use during a limited time on very small scale (less than 100 MW) wind farm. "Power to x" technologies are promising, but have not yet been applied to OWF and would carry a very high risk in the first few applications

xlix As Europe looks toward 180 GW in the North Sea, such energy storage and distribution technology is seen as a more flexible, faster, and cost-efficient method of using offshore wind power, as well as to reduce transmission needs. These hubs facilitate better linkage of all the power produced and provide opportunities for energy storage, in the form of electricity and hydrogen. This concept is especially interesting because the network connects not only wind farms, but countries: Germany, UK, Norway, Denmark, and the Netherlands [134].

8 FINANCIAL AND ECONOMIC ANALYSES

8.1 PURPOSE

This chapter seeks to shed light on the economic potential of offshore wind in Türkiye and what it would take to release that potential.

8.2 ESTIMATED LCOE OF OFFSHORE WIND IN TÜRKİYE

The LCOE of offshore wind is the most common point of comparison of potential offshore projects both nationally and internationally. The LCOE measures the total cost of producing energy from a specific site per unit of energy produced over the lifetime of the project. To do this, the LCOE discounts all future costs and energy generation to today's value using the Weighted Average Cost of Capital.

Levelized Cost of Energy

I_t : Investment cost in year t.
M_t : O&M costs in year t.
E_t : Energy generation in year t
R: Discount rate
N: project life

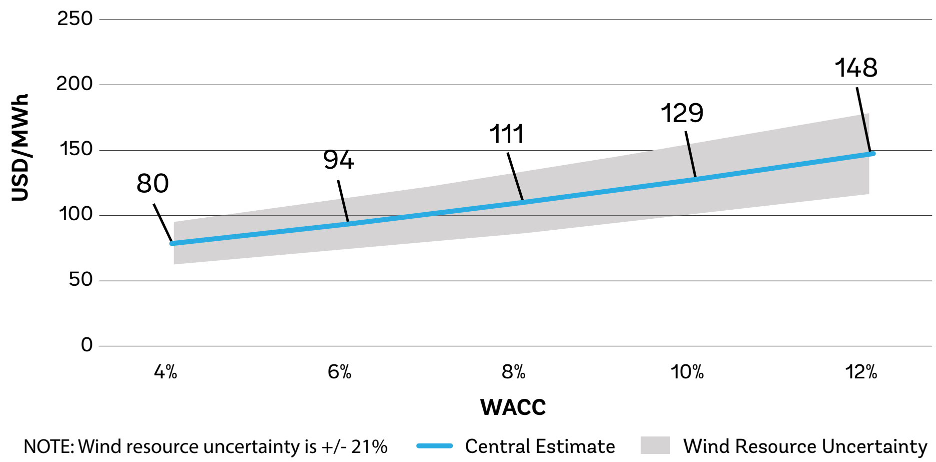
The main inputs for the LCOE estimation are investment costs, O&M costs, energy generation, project duration, and the cost of capital. The cost of capital is important in Türkiye because of the very high interest rates on loans in Turkish Lira (further discussed in section 8.4.5). Hence, the impact of the cost of capital will be examined in a sensitivity analysis. Likewise, the lack of on-site wind measurements results in a considerable uncertainty on the available wind resource (discussed in section 6.3), which will also be addressed by way of sensitivity analysis. The main results and sensitivity analyses concern the 2030 target capacities defined in the low growth and high growth scenarios. Cost trajectories towards 2050 are provided and the main assumptions used are summarized in Table 8.1.

TABLE 8.1 INPUT TO THE LCOE ESTIMATION.

Input	2030- Low growth scenario (0.5 GW)	2030-High growth scenario (2 GW)
CAPEX (USD/MW)	2.4 million	2.4 million
OPEX (USD/MW)	61,500	61,500
Net AEP (GWh/year)	Central: 1,600 High: 1,900 Low: 1,200	Central: 5,000 High: 5,900 Low: 4,000
Technical life (years)	25	25
WACC (%)	4% to 12%	4% to 12%

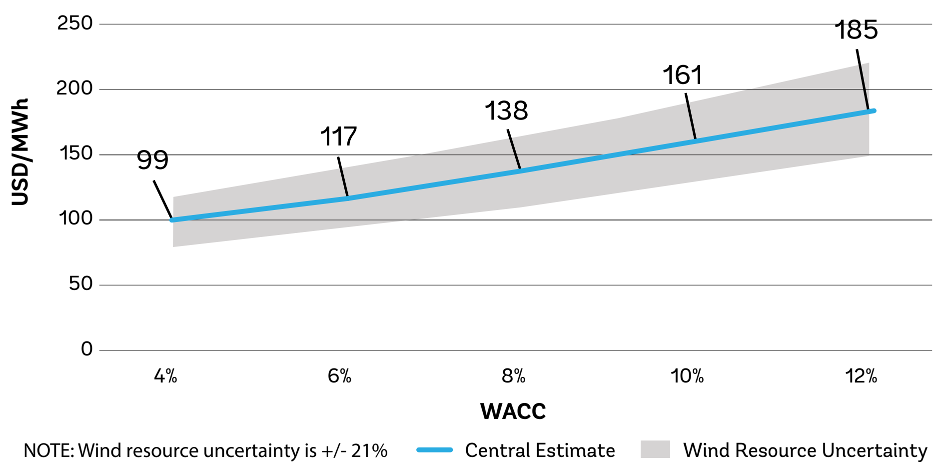
The results of the LCOE estimations are presented in Figure 8.1 and Figure 8.2. The impact of the cost of capital is seen as the LCOE increases as WACC increases. Uncertainty on the wind resource is shown as a grey band around the central estimate.

FIGURE 8.1 LCOE—LOW GROWTH SCENARIO. THE NUMBERS FOR THE CENTRAL ESTIMATE ARE INCLUDED.



The wind resource uncertainty is derived from application of data from Global Wind Atlas and New European Wind Atlas respectively and P50 and P90 estimates based on this data. In the low growth scenario, the LCOE could be as low as US$63 per MWh and as high as US$180 per MWh depending on the cost of capital and the wind resource. Currently, a typical WACC for the first offshore wind projects in Türkiye could be 10 percent or more, due to country and technology risk premiums. To ensure the affordability of the country's first projects, it will be important to consider options to reduce financing costs. These could include blended concessional finance, public sector guarantees, and other de-risking instruments.

FIGURE 8.2 LCOE—HIGH GROWTH SCENARIO. THE NUMBERS FOR THE CENTRAL ESTIMATE ARE INCLUDED.



In the high growth scenario, LCOE is expected to be higher due to two factors: 1) the average wind resources of the high growth scenario are less than the low growth, leading to less average energy production; and 2) the per-MW CAPEX and OPEX costs remain the same between the two scenarios, as 2 GW is not large enough to achieve the economies of scale which typically lower these costs.[l] However, the total of 7 GW installed capacity expected in the mid-term (2030-2040), as per the high growth scenario roadmap, would deliver such economies of scale and lead directly to the growth phase in which even higher volumes continuously drive down LCOE. Accordingly, LCOE values should have always been considered in context of long-term cost and benefit.

The range of LCOE estimates presented in Figure 8.1 and Figure 8.2 clearly demonstrate the need for addressing two significant uncertainties in the development of Turkish offshore wind: the cost of capital and the wind resource.[li] Often the focus of de-costing for offshore wind projects lies on the cost estimates—especially CAPEX—and how to develop a local and supposedly cheaper supply chain. In this case, it is evident that the cost of capital and the lack of wind speed measurements are also significant sources of uncertainty.

8.2.1 Cost trajectories

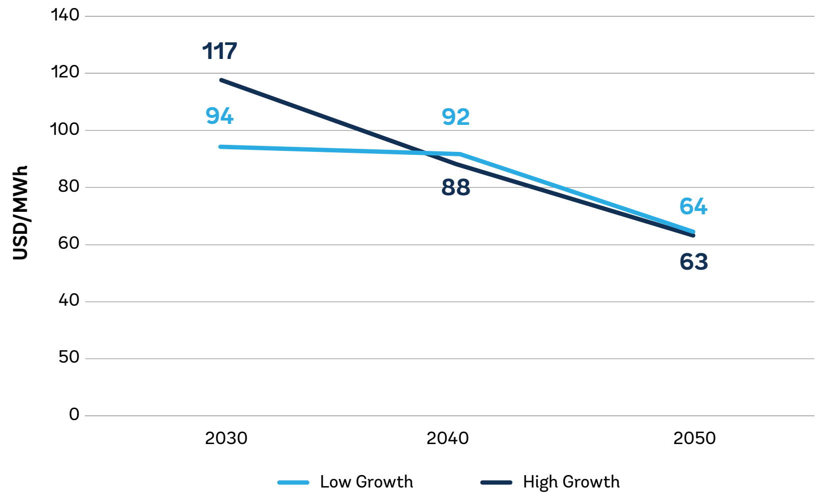
Cost trajectories towards 2050 will be subject to a high degree of uncertainty. There are many factors which will influence the future cost of offshore wind in Türkiye. Global trends in technological development and efficiency gains in installation and operation of offshore wind farms plays a role. In addition, the rate of build out of offshore wind capacity in Türkiye, development of a Turkish supply chain, and market conditions for the independent power producers among others also play a role.

The cost trajectories provided here are based on learning curves. Learning curves is a simple way of relating cost reductions to increases in installed capacity. The International Energy Agency [55] have estimated a learning rate for offshore wind of 15 percent. Every time installed capacity doubles, the cost is reduced by 15 percent. Globally, the 15 percent learning rate corresponds to a 40 percent cost reduction by 2030. However, this is a global average dominated by existing installation. For an emerging market, the 40 percent cost reduction by 2030 is not directly applicable. In an emerging market, the 15 percent learning rate should be applied to the expected pipeline of offshore wind capacity in the country or region. Further, the 15 percent learning rate should not be applied to the very first offshore wind capacity, otherwise doubling capacity will happen at an unlikely pace.
The expected cost trajectories for Türkiye in the low growth and high growth scenarios expressed in terms of the LCOE are provided in Figure 8.3. In both scenarios, it is assumed that the learning rate of 15 percent does not take effect until after installation of the first offshore wind capacity. For one, the cost estimates used for the 2030 targets is based on estimates that take into account the short-term cost developments. Second, the total installed capacities are low enough that a learning rate would result in extreme cost reductions.

l This unusual fact is due primarily to the distribution of wind speeds in Türkiye, which has a modest area of high winds around Çanakkale, which are exploited first in the low growth scenario. For the high growth scenario, wind farms must also be built in areas with lower wind, driving up the average LCOE.

li Installing LIDAR at the most promising offshore wind sites will help to reduce wind resource uncertainty greatly.

FIGURE 8.3 LCOE TRAJECTORIES IN THE LOW GROWTH AND HIGH GROWTH SCENARIOS.



From a level of approximately US$94 per MWh (low growth) and US$117 per MWh (high growth) in 2030, the LCOE of offshore wind in Türkiye is expected to drop to US$92 per MWh (low growth) and US$88 per MWh (high growth) in 2040 and finally 63 for both scenarios in 2050. The LCOE in the low growth scenario starts out lower due to the aforementioned challenges with the wind resource.

These cost trajectories are based on the installed capacities provided in section 5.2. Further, the LCOE estimates are based on a 6 percent WACC and a P50 best case wind resource. These cost trajectories are heavily dependent on the cost of capital and the wind resource. Achieving a WACC of 6 percent would be highly aspirational and would require substantial support from sources of concessional finance, coupled with other de-risking initiatives. If global risk-free financing base-rates reduce in future years, this could make a lower WACC more achievable.

In relative terms, the cost trajectories result in a 40 percent to 50 percent cost reduction by 2050 relative to 2030.

8.3 JOB CREATION AND ECONOMIC EFFECTS

The calculation of the employment effects is based on Leontief multipliers,[lii] total production output, and annual employment data by economic activity [56, 57, 58]. The employment and investment effects can be split into two: direct impact and indirect impact. The direct impact is the increased activity, created by the investment itself. This will include tasks such as development, supervision, installation, and construction work. The indirect employment impact is the increased demand for labor, which occurs because of procuring goods and services, and the effect this has with the supplier. The employment impacts are measured in FTE years, which corresponds to one individual working full time for a year.

The Leontief matrix supplied by OECD splits the Turkish economy into 36 sectors. In order to use the multipliers to assess the impact of an investment, the investment must be linked to a specific sector [56]. Offshore wind projects are large and complex projects typically spanning several key sectors such as construction, manufacturing, and marine transport. This effect is achieved by creating a weighted average of the relevant sectors based on professional international experience, see Table 8.2.

lii Method developed by Wassily Leontief, to estimate the impact of an increase in production in one sector on all other sectors in the economy. The method is based on detailed input output tables from national accounts statistics and estimates a constant factor by which increased activity in one sector impacts the whole economy. These factors or "multipliers" typically have values in the range 1.5 to 2 implying that e.g., a US$1 million investment in a specific sector will increase the total activity in the economy by US$1.5 to 2 million.

TABLE 8.2 WEIGHTED SECTORS FOR THE INVESTMENTS.

Activity	Sector weights
OWF construction	Construction: 60% Transportation and storage: 10% Manufacturing: 30%
OWF O&M	Construction: 70% Transportation and storage: 25% Manufacturing: 5%

The cost estimates for 500 MW of offshore wind and the associated O&M were derived from the COWI's 2019 study, by taking the average CAPEX and OPEX per MW of the wind farm scenarios in the study and multiplying these costs by 500 MW [59]. These estimations have also been made for the 2 GW scenario. The estimates are provided in Table 8.3.

TABLE 8.3 COST ASSUMPTIONS.

Activity	Investment (billion USD)
Construction, O&M of 500 MW of offshore wind (30-year lifetime)	2.1
Construction, O&M of 2 GW of offshore wind (30-year lifetime)	8.5

Türkiye's general industrial capabilities and the onshore wind experience are strong and thus the assumptions of the share of local content in Türkiye are similar to the assumptions of share of local content in Europe. After installing 10.2 GW of offshore wind, the local share of employment is almost 50 percent in the UK [60]. In this study, this calculation assumes that Türkiye is able to achieve a local share of 40 percent for the construction of 500 MW of offshore wind. This is quite an ambitious target for the first offshore installations, but stakeholder engagement has indicated that such a requirement is expected, especially given the high focus on local content in previous YEKA tenders.

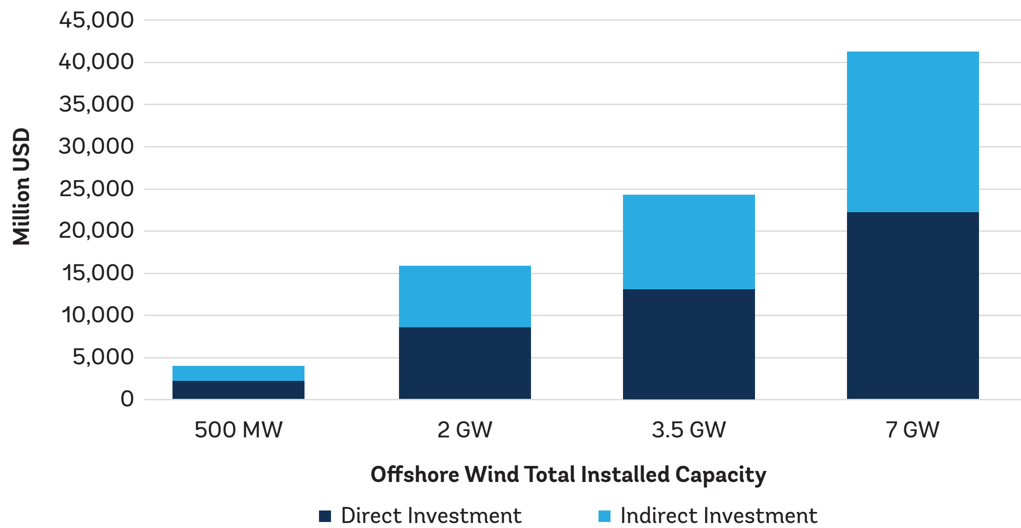
If the 2030 target of 2 GW installed capacity is to be reached, local content requirements must be eased. It is assumed that 25 percent local content is achievable in the 2 GW scenario. As more local knowledge and expertise is accumulated beyond 2030, there will be less need for international support for the development and construction projects (see Table 8.4). Nevertheless, it must be noted that the high growth scenario would be expected to deliver more local content in absolute terms (25 percent of US$8.5 billion is approximately 2.5 times greater than 40 percent of US$2.1 billion).

TABLE 8.4 LOCAL CONTENT SHARE FOR PARTS AND EMPLOYMENT.

Activity	Local content share
500 MW installed capacity	40%
2 GW installed capacity	25%
3.5 GW installed capacity	35%
7+ GW installed capacity	40%
O&M	90%

The impact on GVA from investments in offshore wind are illustrated in Figure 8.4.

FIGURE 8.4 EFFECT ON GVA FROM OFFSHORE WIND INVESTMENT.



The total impact on GDP from 500 MW of offshore wind and O&M is expected to be almost US$4 billion, of which US$2.1 billion is the direct investment and US$1.8 billion is the expected indirect investment[liii] (see Table 8.5). The application of Leontief multipliers implies a linear relation between installed capacity and GDP impact. This linear connection is a reasonable approximation of the short term. In the long term, cost reductions, learning curves, and productivity gains will likely result in a declining marginal GDP impact per MW installed capacity. Simply put, each MW of additional capacity becomes cheaper than the previous MW, reducing the impact on GDP and employment. Table 8.5 shows the impact on Turkish GDP for each wind farm phase.

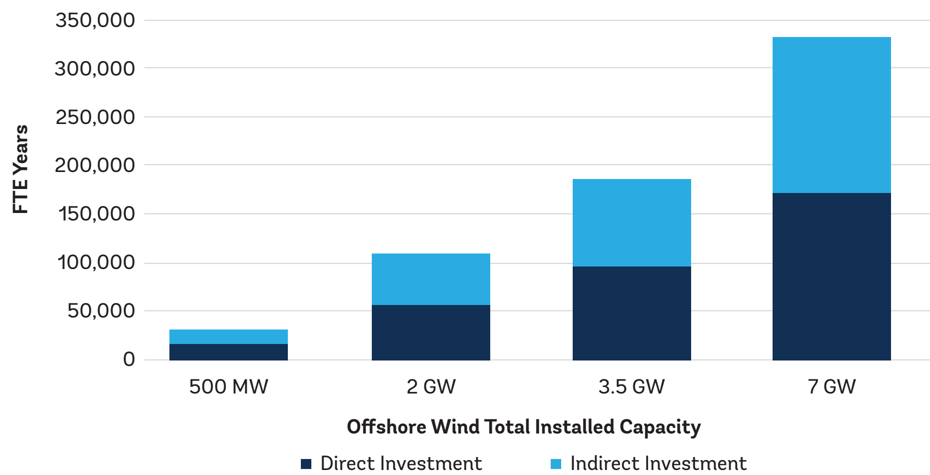
TABLE 8.5 IMPACT ON DOMESTIC GDP IN 2030.

	Direct investment (mUSD)	Indirect investment (mUSD)	Total impact on GDP (mUSD)
Low growth scenario (500 MW)	2.1	1.8	4.0
High growth scenario (2 GW)	8.5	7.3	15.8

The total local employment effect from investing in and operating and maintaining a 500 MW OWF is estimated to almost 32,000 FTE. This includes both direct and indirect effects (see Figure 8.5).

liii The indirect effect is the increased demand for goods and labor, which occurs as a result of procuring goods and services, and the effect this has with the supplier.

FIGURE 8.5 LOCAL EMPLOYMENT EFFECTS FROM OFFSHORE WIND INVESTMENT.



In terms of local value creation, there is a big difference between CAPEX and OPEX. While the construction of the OWF is assumed to achieve at most 40 percent local content, the O&M is assumed to achieve 90 percent local content. The results on local jobs[liv] and GDP impact are summarized in Table 8.6.

TABLE 8.6 LOCAL EMPLOYMENT EFFECT FROM OFFSHORE WIND INVESTMENT.

	Direct FTE	Indirect FTE	Total FTE
Low growth scenario (500 MW)	16,500	15,500	32,000
High growth scenario (2 GW)	57,000	53,000	110,000

Offshore wind requires a considerable input of labor. Installing the first 500 MW offshore wind in Türkiye will require approximately 32,000 FTE years of labor input. How this equates to jobs depends on the timeframe of the project. Assuming the first offshore wind farm is ready by 2030 and that the main body of construction, manufacturing, and installation work is delivered from 2025 to 2030, than the 32,000 FTE equates to almost 6,500 full time jobs.

8.3.1 Looking toward 2050

Beyond 2030 offshore wind in Türkiye is expected to continue to grow and accelerate. By 2050 the installed capacity is expected to be 16 GW and 26 GW respectively in the low growth and high growth scenarios. Although the cost of offshore wind is expected to decrease (see section 8.2.1), the amount of offshore wind that needs to be installed will lead to increased economic activity and job creation because the local content of the total activity will increase as the local Turkish supply chain develops. Local content shares are presented in Table 8.4.

liv The Institute for Sustainable Futures, which conducted a study on behalf of Greenpeace, estimates the direct employment effect in offshore wind to 23.6 FTE per MW for construction and 0.2 FTE per MW per year for O&M [100], which corresponds to 11,800 FTE in the construction phase and 2,500 FTE during O&M over a 25-year lifespan. This is in line with the direct effect found in this study. According to the study the indirect effects are estimated to account for 50 percent to 100 percent FTE, and which results in a total employment effect of 21,000 to 28,000 FTE.
In another study from 2020, QBIS estimated the direct and indirect employment effect for planned OWF in Denmark to 9,500 FTE per GW. The study assumes an aggressive development in the FTE/CAPEX, and that technological development will result in increased efficiency, and thus the need for fewer hands for the construction of OWF. These assumptions can have substantial impact on the estimates [101]. The expected effects in Denmark are lower relative to the expected effects in Türkiye as the two countries have different levels in salary and expected local share of employment. In addition, the two countries have different assumptions on the development in automation in the production, and installation of parts are also different.

The impact on employment of investments in offshore wind over time is summarized in Figure 3.9. The FTE impact in each 10-year period corresponds to the necessary additional investments needed to meet the target installed capacities at the end of that period. This takes into consideration that some of the capacity was installed in a previous 10-year period.

In the period 2040 to 2050, meeting the 2050 target for installed capacity will require installing as much as 20 GW additional capacity in the high growth scenario. This will require almost 500,000 FTE years delivered by Turkish labor, or almost 50,000 full time jobs for ten years.

Furthermore, it must be noted that in addition to the aforementioned, development of floating offshore wind across the Mediterranean region and potential exports within this area can create increased job opportunities within Türkiye.

8.4 BANKABILITY AND INTERNATIONAL FINANCING

Offshore projects represent massive capital investments with a long payback time. This puts emphasis on the financing of the projects and the ability of the project to not only attract investors but also to secure lending on reasonable terms. The typical debt/equity split on offshore projects is in the range of 65/35 to 80/20 depending on the track record of the developer, the experience of the banks, and the overall risk profile of the project.[lv]

For many emerging offshore markets, the first offshore project will seek a mix of local and international lending. The local banks provide local knowledge, bridge language barriers, and manage cash flows in the local currency. The international banks provide knowledge of offshore wind projects, provide risk mitigation, and offer lending at favorable rates.

The bankability of offshore wind projects (i.e., the willingness of banks to provide the necessary lending) depends on many factors. Banks have to assess the track record of the developer, environmental and social risk, the political and regulatory stability over the lifetime of the project, risk allocation and risk management, and the business case of the project.

8.4.1 Developer track record

Offshore wind is a massive undertaking. The complexity and scale of offshore wind projects is not comparable to onshore wind. Stakeholder feedback suggests that Turkish onshore developers are not ready to make the leap into offshore on their own. It will be necessary to bring in experienced international developers for the first demonstration and pilot projects. Over time, a collaboration between international and national developers will hopefully transfer the necessary knowledge and experience to the local developers, as discussed in chapter 12.

International offshore developers are in scarce supply today, as many countries, like Türkiye, seek to kickstart offshore wind. Therefore, Türkiye will be in competition with many other offshore markets for the attention of the international developers. Türkiye has to establish itself as an attractive alternative by providing attractive financial incentives, promising future potentials, and a stable and credible regulatory setup.

lv It is assumed, that offshore wind projects in Türkiye will use project financing.

The track record of the developer may also have a direct impact on the cost of capital. The cost of capital—most notably the interest on loans—will depend on the lenders' assessment of the risk of the project. The developer's ability to manage the risks and carry the project to success is a major evaluation criterion for the lenders.

8.4.2 Political and regulatory stability

The tenor on loans for offshore wind are typically more than 10 years and often upwards of 15 years or more. This kind of long-term exposure demands a careful examination of the political and regulatory stability in Türkiye.

According to feedback from stakeholders, there is a great deal of uncertainty regarding commitment of the Government of Türkiye to offshore wind. Highly ambitious targets for installed capacity have been communicated, but there is a lack of backing for the targets in terms of regulatory reforms, planning, and funding, as discussed in chapter 7.[lvi]

The lack of public funding has a direct impact on the business case of the offshore projects. It must be expected that the first offshore wind projects in Türkiye will require a substantial public subsidy to provide the necessary returns to attract financing. The lack of a clear political commitment to a reasonable funding scheme can halt the development of offshore wind at a very early stage.

The risk of major reversals of policy must also be considered for projects spanning decades. It is reasonable for investors and lenders to do an in-depth assessment of the stability and commitment of the Turkish Government to offshore wind. Not only in terms of funding, but also in terms of permitting and licenses.

8.4.3 International lenders' E&S requirements

Before committing to an investment, both concessionary finance providers and commercial project finance lenders will carry out due diligence on a project's compliance with environmental and social performance standards. The IFC's performance standards (PS) require projects to meet minimum requirements in respect of biodiversity protection (PS6) and cultural heritage (PS8). IFC PS1 requires the assessment of these and other issues through ESIA to GIIP and community engagement. Similar provisions apply to most private sector providers of finance, either through proprietary standards or through the application of the Equator principles.

Failure to meet these standards may leave projects with fewer financing options or preclude investment altogether. Building these performance standards into the regulatory framework for offshore wind is therefore likely to improve the bankability of projects, as well as delivering increased environmental and social benefits while avoiding significant harm.

lvi It is important to note that stakeholder perception is not fact. Often stakeholders may have outdated knowledge or misinterpretations of the current conditions. If this is the case, the remedy is information rather than reform, which should be easier to accomplish.

8.4.4 Risk allocation and risk management

Stakeholder feedback[lvii] has pointed to some of the critical risks limiting the bankability of offshore wind projects in Türkiye.

- Undefined permitting process leading to uncertainty of the development time and the projects' ability to reach commercial operation date (COD).
- Very ambitious local content requirements that will be an additional cost driver as well as limit the projects' ability to reach COD for lack of qualified local offshore wind industry.

Stakeholder feedback suggests that there is confidence in the prospect of formulating a PPA which will provide a fair risk allocation. Risks associated directly with the variable nature of wind power and delivery of electricity to the grid are perceived to be manageable. Likewise, any risks associated with force majeure, decommissioning, and performance guarantees are expected to be managed in a fair and reasonable manner.

Feedback from stakeholders related to the 2018 tender suggests that the risks during the development stages of the offshore project were deemed to be too great and to be unilaterally allocated to the developer, as discussed in section 7.3.3.

8.4.5 Business case

The main driver for bankability on a specific project will always be the business case. A well-documented feasibility study that demonstrates sufficient cash flow to service debt and provide dividends to equity is a must. Among the many unknowns in a 25- to 30-year business case, a few stand out: the wind resource, the cost of capital and exchange rate risk.

The wind resource in Türkiye has lower mean wind speeds and lower extreme wind speeds than in the North Sea, for example, as discussed in section 6.3. This drives up the LCOE of Turkish offshore sites. To keep the LCOE within reasonable levels, it will be necessary to develop WTGs specifically designed for Turkish conditions. This could also drive up costs in the short run depending on the market potential for similar WTGs globally. The lack of existing WTGs designed for Turkish conditions contribute significantly to the uncertainty of CAPEX estimates.

The cost of capital in Türkiye is very high. Stakeholder feedback suggests that interest rates on loans in Turkish Lira could run as high as 12 percent. Although the Turkish banks have the financial strength to provide multi-billion-dollar loans, the cost of these loans will likely be a barrier for most offshore wind projects. The alternative is financing in USD or EUR through international financial institutions. This could provide a significantly lower cost of capital, but at the same time increase the project's exposure to exchange rate risk.

Managing the exchange rate risk will be central to any offshore wind project in Türkiye in the foreseeable future. The exchange rate risk is often split between off-taker and developer through a combination of several strategies. Strategies including indexing of the PPA tariff or developing CfD options will alleviate some of the developer's/IPP's exposure to the local currency.

lvii It is important to note that stakeholdeer perception is not fact. Often stakeholders may have outdated knowledge or misinterpretations of the current conditions. If this is the case, the remedy is information rather than reform, which should be easier to accomplish.

9 HEALTH AND SAFETY

9.1 PURPOSE

Since the beginning, the offshore wind industry had to deal with various H&S challenges. The supply chain of the offshore wind industry, which includes manufacturing, siting, transport, construction, and maintenance, is different from those of other industries in each step. Challenges in manufacturing and transport arise from the enormous weight and size of the different components. During siting, transport, and construction, the remote location of the sites at open sea with extreme and rapidly changing weather conditions is the main difference to other industries. The enormity of the plants and the unique environmental conditions on the one hand, and the recent formation of the offshore wind industry on the other hand are among the reasons for the ongoing development of specific offshore wind H&S guidelines.

Offshore wind farm construction and operations pose significant H&S risks for (contractor) personnel and should always be handled with great care to create a safe working environment.

9.2 HEALTH AND SAFETY RISKS

H&S risks comprise hazards and activities/operations with potential for dangerous situations. A hazard is a situation or an activity with the potential to harm people, environment, or property. Regarding offshore wind projects, the most relevant hazards and dangerous activities/operations are listed in Table 9.1.

TABLE 9.1 HAZARDS AND DANGEROUS ACTIVITIES IN OFFSHORE WIND PROJECTS [61].

Hazards	Activities and operations
Working at heights	Aviation
Lifting operations	Cable laying and entry
Electrical systems	Lifting
Access/egress	Marine co-ordination
Routine maintenance	Navigation
Transfer from/to vessel	Piling and grouting
Climbing/rope access	Ports and mobilization
Vessel operation	Remote working
Transit by vessel	Subsea operations
Communications	Vessel operations

The activities undertaken during the construction and operational phases of an OWF will subject the work force to a range of risks which will differ depending on each individuals' role. As a result, it is important to understand what these risks are, and assess each one so that they can be minimized or ideally, completely eliminated. Risks are typically assessed in two dimensions: firstly, the **probability** of occurrence and secondly, the **severity** of the associated hazard. The probability quantifies the likelihood of a hazard occurring whereas the severity is a measure of the amount of damage or harm a hazard could create.

Risk assessment involves a sequence of actions to trace and evaluate the risks associated with the execution of a task. It requires the awareness of all possible events and the detailed knowledge of each step of the process. The result of the risk assessment is usually divided into three risk categories: low, medium, and high. A low risk, does not require immediate action. However, a high risk should not be accepted by the employer and should result in the implementation of an alternative method to reduce the risk to an acceptable level.

Risk assessment is an instrument that helps to identify hazards and indicates how to deal with those. An example of a simplified Task Risk Assessment is presented in Table 9.2.

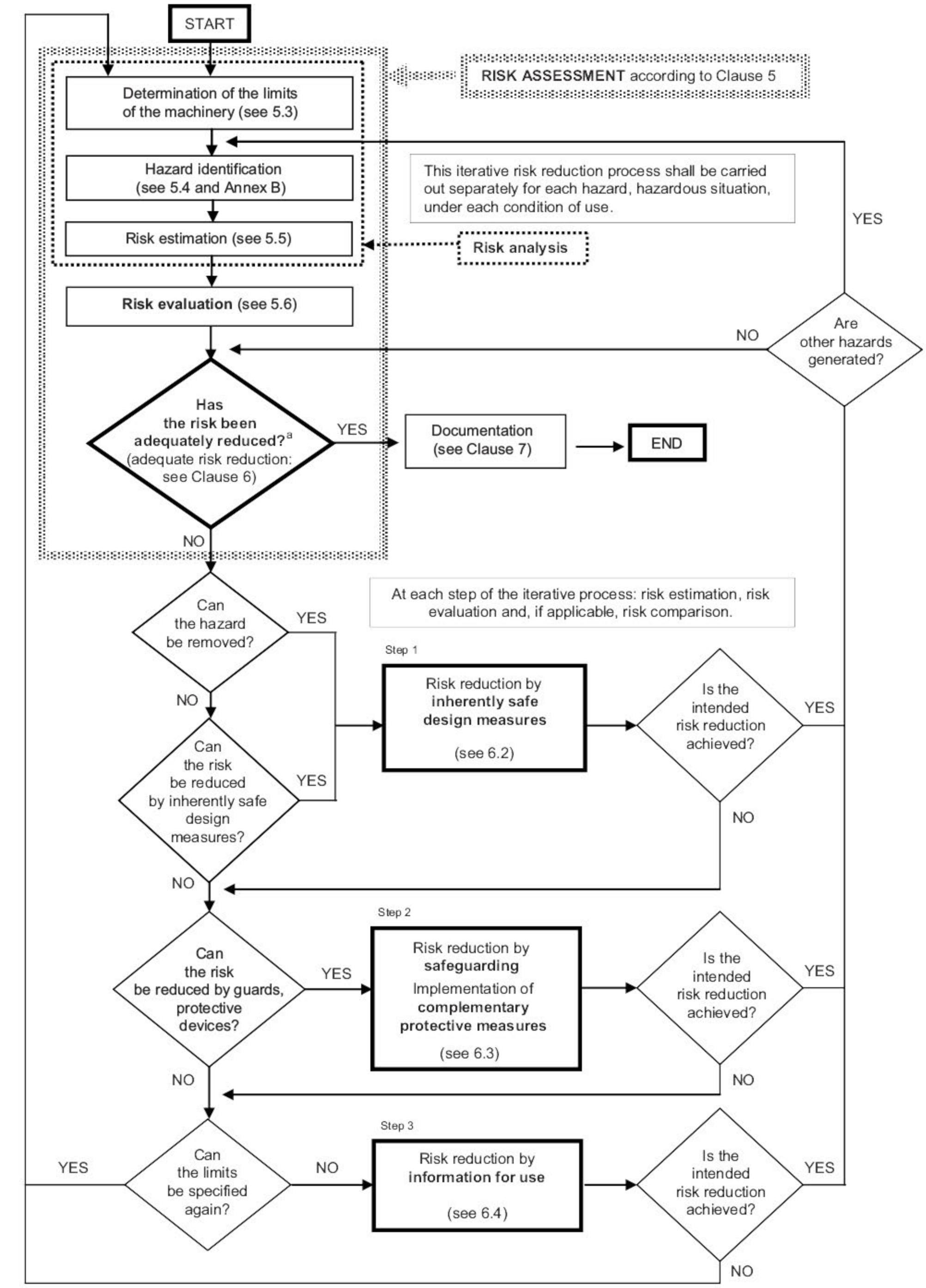
TABLE 9.2 TASK RISK ASSESSMENT.

Severity \ Probability of occurrence	A	B	C	D	E
1	LOW	LOW	LOW	LOW	MED
2	LOW	LOW	LOW	MED	HIGH
3	LOW	LOW	MED	HIGH	HIGH
4	LOW	MED	HIGH	HIGH	HIGH
5	MED	HIGH	HIGH	HIGH	HIGH

Probability of occurrence		Severity		Risk	
A	Very unlikely to occur	1	Negligible	Low	No immediate action required, proceed with care
B	Unlikely to occur	2	Moderate		
C	Might occur	3	Serious	Medium	Review and implement preventive measures
D	Likely to occur	4	Major	High	Unacceptable; find alternative method
E	Will probably occur	5	Catastrophic		

The risk assessment process is usually followed by a risk reduction process, in which protective measures can be implemented to minimize or completely eliminate the identified hazards. The assessment and reduction processes can be iterative, depending on the time and effort needed to set up an appropriate system to adequately mitigate specific risks. An example of this process is illustrated in Figure 9.1.

FIGURE 9.1 EXAMPLE OF RISK ASSESSMENT AND RISK REDUCTION PROCESS [62].



a The first time the question is asked, it is answered by the result of the initial risk assessment.

9.3 INTERNATIONAL GUIDANCE

The following table provides an overview of international organizations that provide H&S guidelines for the offshore wind sector. It includes links to the most relevant online resources.

TABLE 9.3 OVERVIEW OF INTERNATIONAL GUIDANCE ON H&S IN OFFSHORE WIND.

Organization	Description	Online resources
The Energy Institute	The Energy Institute does not work on H&S guidelines itself but provides an extensive database of all kinds of resources in the field of H&S in offshore wind projects. The institute is based in the UK and collaborates with The Crown Estate.	The offshore wind collection provides more than 100 guidance documents [63].
European Agency for Safety and Health at Work (EU-OSHA)	EU-OSHA is the European Union information agency for occupational safety and health. Their work contributes to the European Commission's Strategic Framework for Safety and Health at work 2014-2020 and other relevant EU strategies and programs, such as Europe 2020.	EU-OSHA has published a few reports, including guidelines for the wind sector, such as: • E-fact 79: Occupational safety and health in the wind energy sector [64] • Occupational safety and health in the wind energy sector [65] • E-Fact 80: Hazard Identification Checklist: Occupational Safety and Health (OSH) risks in the wind energy sector [66]
Global Offshore Wind H&S Organization (G+)	(G+) is an international association based in the UK with the aim of creating and delivering world class H&S guidelines for the offshore wind industry. The association has 11 members which are all European utilities.	The G+ has developed a few good practice guidelines and has published these through the Energy Institute. These guidelines provide recommendations for working at height in the offshore wind industry, the management of small service vessels, offshore wind transfer, and offshore emergency response [67].
IFC—part of the World Bank Group	IFC, a member of the World Bank Group, is the largest global development institution focused exclusively on the private sector in developing countries.	The General EHS Guidelines contain information on cross-cutting environmental, health, and safety issues potentially applicable to all industry sectors [68]. This document should be used together with the relevant Wind Industry Sector Guidelines [69].
International Marine Contractors Association (IMCA)	An influential trade association with more than 900 members from the offshore marine construction industry worldwide. The organization provides one of the most extensive collections of H&S guidelines for offshore projects in general, including offshore wind but also offshore oil and gas projects.	HSSE Guidance and Technical Reports can be obtained from the IMCA website [70].
Wind Europe	Formerly known as the European Wind Energy Association, which actively promotes wind power in Europe and worldwide. It has over 450 members, active in over 40 countries.	Wind Europe has a H&S Working Group which aims to promote and share H&S activities, best practices, and lessons learned. They occasionally publish guidelines on topics such as emergency arrangements including first aid [71].

A list of some international standards is also provided in the following:

/EN 50308/	EN 50308:2005 Wind Turbines—Protective Measures—Requirements for design, operation and maintenance
/EN ISO 12100/	EN ISO 12100:2018 Safety of machinery—General principles for design—Risk Assessment and risk reduction
/ISO 31000/	ISO 31000:2018 Risk Management—Guidelines
/EN ISO 14122-1/	EN ISO 14122-1:2016 Safety of machinery—Permanent means of access to machinery—Part I: Choice of fixed means and general requirements of access
/EN ISO 14122-2/	EN ISO 14122-2:2016 Safety of machinery—Permanent means of access to machinery—Part 2: Working platforms and walkways
/EN ISO 14122-3/	EN ISO 14122-3:2016 Safety of machinery—Permanent means of access to machinery—Part 3: Stairs, stepladders, and guardrails
/EN ISO 14122-4/	EN ISO 14122-4:2016 Safety of machinery—Permanent means of access to machinery—Part 4: Fixed ladders

A brief description of the most common H&S guideline categories is provided in the following:

- **Guidance on the investigation and reporting of incidents** defines the procedures and formal requirements in a case of an incident. It includes recommendations on interviewing the personnel, inspecting the site, and filing and managing the collected information. It also gives examples for an incident classification scheme and insurance reporting.
- **Marine roles for small workboats** aims to provide guidance for the staff of the offshore wind industry operating on small workboats less than 200 gross tonnes. The guidance considers the special requirements and areas of competence of the operation of those small-sized vessels. It must be understood as a framework which should be applied with regards to local requirements.
- **Risk assessment** provides recommendations for the continuous mitigation and controlling of risks in the offshore work environment. It highlights the importance of communicating information about hazards to reduce injuries of workers or damages of the equipment. The assessment can be conducted via a written document or with the help of a toolbox meeting and covers a wide variety of areas within the offshore operation.
- **Safe lifting** sets the guidelines for lifting jobs in the marine environment. As they are a crucial part of offshore operations the document lays out rules for equipment, maintenance, and safe operation. Besides the theoretical background, a safe proceeding also requires experience and practice.
- **Toolbox talks** is a guideline that gives recommendations for the phase right before the actual job at the offshore wind park. A group talking with focus on the tasks of each team member maximizes the effectiveness and reduces the risk of accidents or delays during the operation. They can take place on a regular basis or at shift change and should follow the four basic requirements of timing, attendance, observation, and knowledge.

- **Working at height** is a guideline initially developed for the offshore oil and gas industry to reduce the number of work-at-height accidents. Besides the discussion of hazards and recommendations for working on a ladder, working on scaffolds, working on platforms, or working near an open hole, the specific aspects of working in the offshore wind industry were added in the guideline of the G+ as, for example, access and egress, and transfer between vessels.

9.4 BEHAVIORAL SAFETY

As stated in [55] and [61], behavioral safety covers all non-technical aspects of safety and determines how work is actually undertaken, which sometimes differs from how work is expected to be undertaken.

Analysis of incident data shows that behavioral failures are the most common immediate cause for incidents. This understanding has served as basis for focussing on safe behavior in different industries.

Safe behavior by individuals is defined by the safety culture in an organization. Some of the key factors impacting the safety culture are:

- Management support and involvement in safety;
- Management style;
- Visible management;
- Good communication at all levels of an organization; and
- Striking the balance between different types of goals—e.g., safety goals and production goals.

The management plays a key role in defining and leading the safety culture within an organization.

Working with behavioral safety will require a mapping of the present state in an organization and how employees act at all levels in relation to safety. The mapping can include evaluation of routines, procedures, and attitudes towards safety. Depending on the result of the mapping, specific mitigating actions can be taken to change the behavior if needed. The focus in changing behavior should be on the desired safe behavior and working with barriers to get there. It must be stressed that changing behavior requires involvement from all levels of the organization, as well as strong H&S leadership.

9.5 GWO TRAINING

GWO has introduced a set of training standards for working with offshore wind. GWO training standards are courses that teach to understand and reduce the risk associated with safety hazards in the WTG industry. The training standards comprise the following:

- Basic safety training standard
- Lift user training standard
- Basic technical training standard
- Advanced rescue training standard

- Enhanced first aid training standard
- Blade repair training standard
- Slinger signaller/rigger person training standard

A full overview of the standards and the content is available at the GWO webpage, globalwindsafety.org.

Upon completion of the GWO Basic Safety Training (BST) Sea Survival, people will be trained to work on offshore wind installations, e.g., WTGs, construction vessels, accommodation platforms, transformer stations, etc. They will learn Personal Survival Techniques and methods of safe transfer between vessels and installations.

There are several companies offering GWO courses in Türkiye.

9.6 OFFSHORE H&S IN TÜRKİYE

As the offshore wind sector has not taken off yet in Türkiye, there is not specific regulation in place for such activities.

Companies in Türkiye prepare H&S procedures pursuant to ISO 18001. For offshore activities, further reference can be made to MARPOL. MARPOL, The International Convention for the Prevention of Pollution from Ships, is the main international convention covering prevention of pollution of the marine environment by ships from operational or accidental causes. MARPOL works under the International Marine Organization (IMO) and although focused on pollution, it also contains guidance on H&S offshore.

Finally, the Turkish occupational H&S law (Law No 6331–20/06/2012) provides some outline and regulation for H&S requirements such as requirements to H&S organization, risk assessment, control, measurement and documentation, and inspections. Most importantly, it states that employers must ensure the safety of their employees and take the required measures to protect the environment.

10 GRID INFRASTRUCTURE

10.1 PURPOSE

Connection to the electrical transmission grid is mandatory for any offshore wind farms; however, this connection can present some challenges. This chapter reviews the general capacity of the Turkish grid to absorb electricity from offshore wind farms and suggests the necessary measures to enable their grid connection.

Generally, integrating a growing proportion of renewable energy sources into the electrical transmission system may be challenging for a variety of reasons. Most renewable energy sources such as wind are variable, and the energy output depends on the resource quality determined by weather conditions and the time of day and year. The increasing share of VRE in the power system can, therefore, make system balancing and control more challenging unless additional system flexibility is introduced.

The electrical generation/transmission system of Türkiye is the third largest in Europe after France and Germany. It has a complex mix of primary energy sources (gas, hydro, coal, onshore wind, and solar) located over the entire span of the country.

Currently, renewable energy generation capacity is at approximately 55 GW including approximately 31.5 GW hydro power. The VRE sources (wind and solar) make up approximately 21.5 GW of the total generation capacity in Türkiye.

10.2 EXISTING POWER SYSTEM

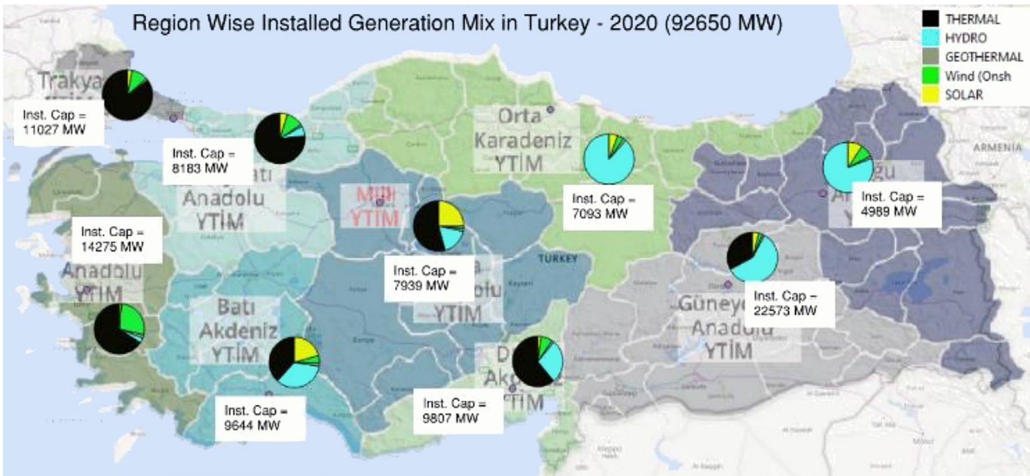
The installed power generating capacity in Türkiye is approximately 104.5 GW, as of May 2023 [72], which is distributed on approximately 45.4 percent thermal, 30.2 percent hydro, and 20.5 percent VRE [72]. It should be noted that the VRE portion is increasing rapidly as wind and solar projects experience strong development.

10.2.1 Generation

The largest concentration of onshore wind is seen in the western part of Türkiye, from the Black Sea coast, around the Marmara Sea and on the Aegean coast. These regions coincide well with those which have offshore wind potential areas. In this western region, the other power sources are thermal, primarily coal and gas. This large thermal fleet may enable the connection of large quantities of offshore wind generation in this area by providing possibilities to regulate power generation in the event of fluctuating wind conditions.

As per Figure 10.1, it can be seen that a very large percentage of onshore wind farms are in the western part of Türkiye. According to the spread of primary sources, the generation mix in the respective RCC controlled areas look as follows:

FIGURE 10.1 REGION-WISE INSTALLED GENERATION MIX–2020[LVIII] [72].



10.2.2 Transmission

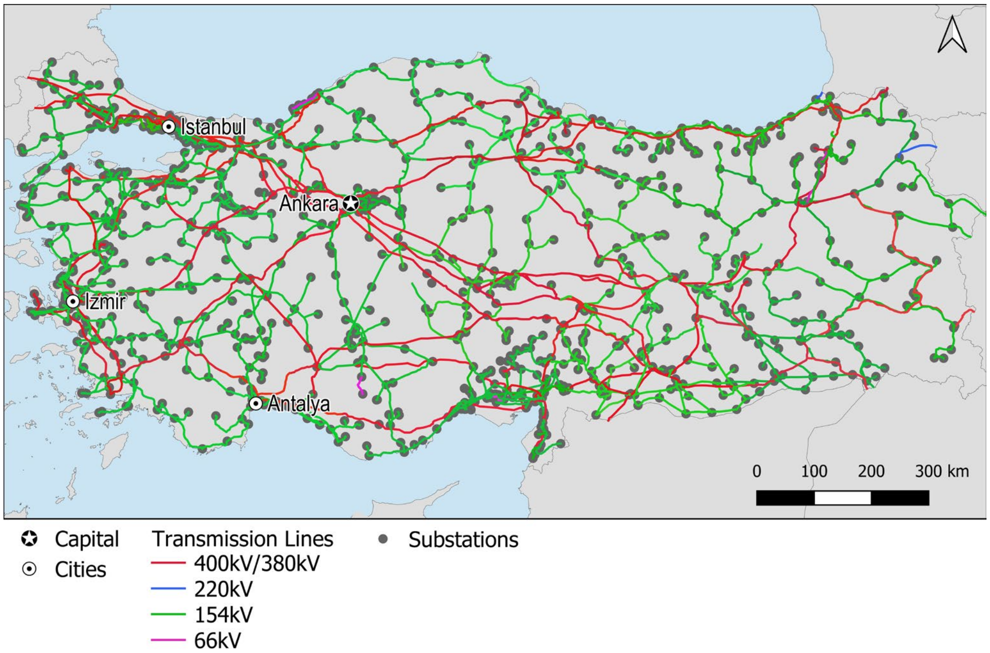
Türkiye's transmission system is operated by Türkiye Elektrik Iletim A.S (TEIAS). The transmission system comprises 73,788 km of transmission lines and 790 high voltage substations [72]. Of the total length, the major part is at 154 kV (approximately 65 percent), whereas 380 kV and 220 kV represent the remaining approximately 35 percent.

For the transmission network, shape files for the Turkish transmission grid have been processed on a QGIS platform for better overview and presentation of results. The shape file clearly shows the location and distribution of transmission lines at various voltage levels (380 kV, 154 kV, 220 kV, and 66 kV).

Figure 10.2 shows the transmission grid of Türkiye as of today based on publicly available data.

lviii It shall be noted that this region-wise generation mix is only based on the extent of information available. Since not all power plants could be mapped, the values for some regions have been extrapolated.

FIGURE 10.2 EXISTING TURKISH TRANSMISSION NETWORK [72].



The figure clearly presents a transmission network that is strong and covering the country well. However, with the ever-increasing demand for electricity and the introduction of more renewable energy in the system, Türkiye needs more installed capacity and flexibility options such as interconnections with neighboring countries for supply/demand balancing and frequency control.

The Turkish transmission system is interconnected with seven neighboring countries through 11 interconnections. The system is at present synchronously connected with the European system via links to Greece and Bulgaria. Moreover, it has used and unused connections on its eastern borders with Georgia, Iraq, Iran, Armenia, and Azerbaijan.

The Adequacy Forecast Studies (Mid-Term Adequacy Forecast–MAF) until 2030, recently published by both ENTSO-E and MED-TSO shows that Türkiye may face some shortages of supply and the results have been quantified in terms of loss of load expected (LOLE), loss of load duration (LLD), energy not served (ENS), and expected energy not served (EENS) in 2025 and 2030. The methodology used to carry out such calculations is very comprehensive and requires:

- Very detailed network models;
- Element availability;
- Planned network expansion;
- Power plant decommissioning plans;
- Demand and consumption patterns; and
- RE sources variability forecasting, etc.

This work is basically carried out by TSOs. TEIAS already has advanced experience within this field and the expected approach to be used by TEIAS will be the same as that used by ENTSO-E. In this method, probabilistic modelling of loads, RE generators and element availability indices are used to assess the transmission system most accurately in future.

10.3 PLANNED UPGRADES AND EXTENSIONS

According to the annual report from TEIAS on transmission system reinforcement plans, the following focus points are most important for keeping the Turkish power grid in a reliable and secure mode of operation at all time:

1. Implementation of three major transmission system projects, two in the Marmara region and one in the Çanakkale area financed by the World Bank. These projects are in continuation with other TEIAS projects.
2. Keeping the national LOLE at a minimum level.
3. Keeping high availability of network elements at distribution level and work towards achieving the N-1 safety criterion.
4. Increasing the transmission line current carrying capacities by changing the conductor type. This solution is cheaper, and the network uses the existing transmission towers better and economically.

10.3.1 Major identified transmission projects

The first point, as mentioned earlier in this report, encompasses the three transmission system projects as financed by the World Bank Group which are expected to be operational within the timeframe of 2030. The project characteristics are summarized in Table 10.1.

TABLE 10.1 EXISTING IDENTIFIED MAJOR TRANSMISSION PROJECTS UNDER PROGRESS IN THE MARMARA REGION AND ÇANAKKALE AREA [73].

Project Name	Project Description
380 kV Çiftlikköy substation	The new substation is planned to be constructed under WBG loan in Yalova province, Çiftlikköy district. This substation will serve for transmitting the energy of wind energy plants in southern Marmara Region to the consumers in Bursa, Istanbul, and Kocaeli.

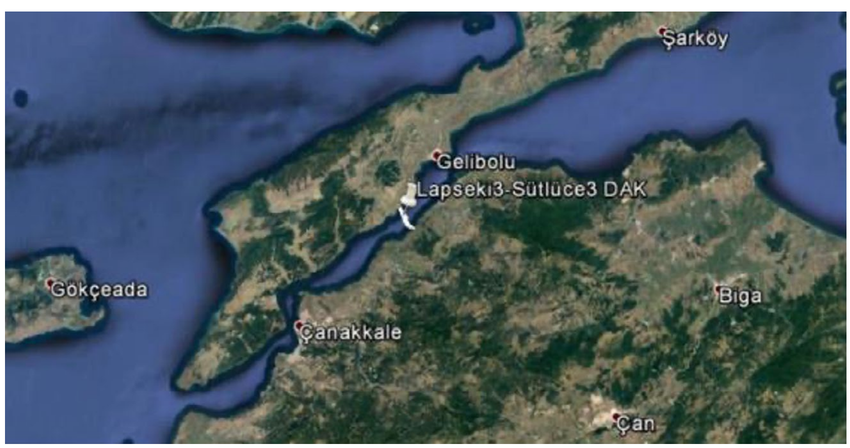
<table>
<tr><th>Project Name</th><th>Project Description</th></tr>
<tr><td>380 kV Hersek Interface Point</td><td>
A strong interface point for receipt of future windfarms is planned under WBG financing in Yalova province, Altinova district, Hersek Village.

Southern Marmara and Western Anatolia of Türkiye have high wind energy potential. It is expected that some of the new wind energy plants will enter into operation soon in Çanakkale and Balıkesir (around 1,600 MW in total), and Izmir and Manisa (around 1,250 MW in total). The regional grid reinforcement also involves a new Izmit 380 kV submarine power cable for upgrade of the transfer capacity of wind energy to Kocaeli and Istanbul.

</td></tr>
<tr><td>380 kV Lapseki-Sultuce-3 Submarine Cable Interface Points</td><td>
The reinforcement project is planned to counteract a potential energy shortage problem in Çanakkale and Istanbul in the near future by increasing energy transmission capacity that serves the region via the back-bone transmission corridor located more west.

A new 380 kV strung point Lapseki 3 and complemented with a new 380 kV submarine cable project is planned to be constructed within the scope of a WBG loan in Çanakkale province.

The total submarine cable capacity along the Dardanelles together with the first and second submarine cables under APL-6 and REIP projects will be increased with the addition of wind energy to the substations in southern Marmara and Western Anatolia. Consequently, the whole 380 kV transmission network to Istanbul will be formed along the Istanbul and Dardanelles straits, and a secure and strong loop network will be formed around the sea of Marmara.



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</table>

The aforementioned projects are financed in continuation with other onshore projects of TEIAS for strengthening the transmission system.

10.3.2 Network planning until 2050

Based on available information, the plans regarding expansion of the transmission system in Türkiye beyond the year 2030 are mainly based on:

- Inter-country capacities;
- Load complementarity (time difference and, hence, demand shift) among the member states of MED-TSO; and
- Need to interconnect countries to share all the existing infrastructures most efficiently between different Mediterranean and European stakeholders .

This approach at an overall level is certainly conducive to integrating RE to the greatest extent possible in the Turkish system. The national energy plan brings new challenges for TSO since the plan includes ambitious targets to reach net-zero emission in 2053. The TSO should take into account all circumstances that the new plan materializes.

10.3.3 Planned new interconnections with neighboring countries

There is currently emphasis on two major interconnection projects between Türkiye-Bulgaria and Türkiye-Greece. These projects are listed in ENTSO-E's TYNDP 2020 as project No 1066 and No 1067. These projects are expected to be operational by 2036. The details of these projects are as follows:

TABLE 10.2 400 KV INTERCONNECTION PROJECTS WITH BULGARIA AND GREECE [74].

TYNDP 2020 ID	Project name	Project description
1066	Türkiye -Bulgaria	The project concerns the construction of a new AC 400 kV interconnection between Türkiye and Bulgaria. The proposed interconnection line with a total length of 150 km will connect Maritsa East 2 SS in Bulgaria and Vize Havza SS in Türkiye.
1067	Türkiye - Greece	The project concerns the construction of a new AC 400 kV interconnection between Türkiye and Greece. The proposed interconnection line with a total length of 130 km will connect Nea Santa SS in Greece and Babaeski SS in Türkiye.

The two projects make up the East Balkan Corridor which will contribute to increasing the cross-border transfer capacities between ENTSO-E countries and Türkiye and address a system need, identified in ENTSO-E's System Needs Study. The construction of the two interconnections will also improve the stability of the connection of a large electricity system, such as the Turkish system, to the unified electricity system of the countries of continental Europe. Furthermore, the project will allow integration of more renewables into the grid, support the convergence of market price between the neighboring countries, and thus will help the realization of clean energy package targets.

For more detailed needs of these projects, please refer to the ENTSO-E's TYNDP 2020.

Other possible major interconnection projects on the agenda of MED-TSO are:

- Türkiye-Egypt 2x1500 MW HVDC 700 km submarine connection; and
- Türkiye- Israel 2x1000 MW HVDC 600 km submarine connection.

10.4 CONSEQUENCES OF ADDING OFFSHORE WIND

Adding offshore wind to the Turkish power system will increase the portion of renewable energy with significant amounts in one step, given typical 500 to 1,000 MW generating capacity of an offshore wind farm. Consequently, an offshore wind farm does not only affect the overall system as such, but also requires specific investigations and most likely upgrades/strengthening at the grid connection point and the immediate back-bone system behind.

The OWF grid interconnection can be designed either with 220 to 275 kV AC export cable systems for 0.5 to 1 GW size or 325 to 525 kV DC point-to-point HVDC systems with AC/DC converter systems in each end for > 1 GW and with large distance between the OWF and the grid connection point. Only a focused design on an actual OWF project can determine the most feasible topology. This grid interconnection often is a direct connection between the OWF and the power grid.[lix] Consequently, it is vital to decide who will be the owner and operator of this HV interconnector. In mature markets, major offshore wind developers have shown a preference to take the design and construction of these grid interconnectors to the Point of Connection (PoC) into their scope, as it allows the developer to better control cost and risk. However, this approach is not used in all markets. Different approaches prevail worldwide if the OWF developer shall maintain the ownership and operation of this transmission asset or if it shall be transferred to the TSO or a third party. The legal framework and mechanism for this shall be settled before a massive outbuild of offshore wind power is commenced.

Doubling the current plan of solar and wind capacity to 40 GW will not have a major impact on system planning and operation. It would be achievable without any additional costs and the impact on redispatch and curtailment would be negligible. The total investment needed to expand the transmission grid and add transformer stations is estimated at around 390 million EUR (US$475 million) per year [75].

Tripling wind and solar capacity is achievable with efficient implementation of grid integration strategies. These include the selection of wind and solar generation sites based not only on resource quality but also on local demand, grid capacity, and increased system flexibility. A moderate increase of investment in the transmission grid to 430 million EUR (US$520 million) annually can create a system that operates just as efficiently with limited redispatch and less than 1 percent of curtailment of solar and wind electricity [75].

lix It does not form part of the back-bone transmission grid.

11 PORT INFRASTRUCTURE

11.1 PURPOSE

Like grid infrastructure, port infrastructure is an essential enabler of offshore wind which must be fulfilled locally. In this chapter, Türkiye's infrastructure capacity regarding offshore wind is assessed. Although inland infrastructure such as roads plays a role in serving offshore wind farms, the most critical infrastructure is the ports used for installation. This chapter focuses on the analysis of construction ports for offshore wind farms mainly with fixed-bottom foundations for several reasons:

- **Construction ports** for fixed-bottom foundations are an essential enabler for wind farm construction and can act as a key constraint.
- **Manufacturing ports** are much more flexible, both in terms of technical requirements and location. Some manufacturing facilities are successfully located inland, while other manufacturing facilities or ports are in other countries. Depending upon the component manufactured, they can have much lower requirements than the construction port. The availability of manufacturing ports does not typically constrain the installation of offshore wind farms.
- **O&M ports**, like manufacturing ports, have much lower technical requirements than construction ports. Their location should be as close to the wind farm they serve as possible, but this is not usually a bottleneck, as small regional or even local ports can be used.
- The port requirements for offshore wind farms using floating foundations vary greatly according to the technology used, but there are still several design types in use and the industry has not yet converged to one or two commonly used designs. The wide variety of floating technology under consideration at this time does not allow for a quantitative analysis in this study.

11.2 INLAND INFRASTRUCTURE

Depending on the offshore wind project, large components may be delivered to the staging port via ship from other ports or via land routes. In 2019, Türkiye's road infrastructure was ranked 5 out of 7 in the World Economic Forum's survey, putting it at rank 32 out of 141 countries [35]. This indicates that no significant constraints are expected due to the road network. In addition to this good ranking, Türkiye's ports in the Marmara and Aegean seas are very well connected via highway systems and routinely receive large deliveries.

Especially the Izmir region already has significant experience with transporting oversize components of onshore WTGs. A 2020 Wind Europe report ranked Türkiye as the fifth leading producer of strategic WTG components in Europe. Izmir is home to more than 40 facilities producing wind energy components, including blades and towers [73].

It is not commonly seen that freight trains are used for transport of components to installation ports.

The proximity to other modes of transport such as airports could also be an advantage if crew rotation is planned out of the installation base. However, this infrastructure is not a driving factor.

11.3 PORT REQUIREMENTS FOR OFFSHORE WIND

The driving infrastructure for offshore wind farms are the ports used for installation of the wind farms.

11.3.1 Installation port requirements for bottom-fixed wind farms

The following port requirements have been developed with a view to the continually increasing sizes of WTG components in the 8 to 15 MW range and of the vessels needed to transport and install them. For requirements to which volume is important, such as yard area, the requirements are defined with a 500 MW wind farm in mind.

- Distance to wind farm
    - A short distance between the wind farm and the installation port allows for efficient use of costly charter vessels and better use of short windows of good weather. Based on a sample of 40 European offshore wind farms, the median distance between the installation port and the wind farm is between 50 to 100 km. Of the 40 wind farms, 36 were within 250 km of the installation port. Some outliers, such as Northwind (Belgium) and Westermost Rough (England), where installation was carried out from Esbjerg despite a distance of close to 600 km, shows that other factors can take precedence.
    - Maximum: 400 km
    - Recommended: less than 200 km

- Depth at channel entrance
    - The water depth at the entrance, in the channel, or along the fairway should be deep enough to allow access to all vessels at all tides. Having less available depth still allows operations but can pose a limit to larger cargo and installation vessels. Similarly, if a harbor can only be accessed and departed from during high tides, this adds additional constraints to a critical activity, which is the efficient charter of installation vessels.
    - Minimum: 9 m
    - Recommended: 12.5 m

- Harbor entrance width
    - Harbor entry width must be sufficient to allow easy navigation in a range of weather conditions. The most constraining vessels are the WTG installation vessels, which often carry blades of over 100 m stacked, across, and protruding from the deck.
    - Minimum: 200 m
    - Recommended: 300 m

FIGURE 11.1 WTG INSTALLATION VESSEL AT SAIL AWAY FROM HARBOR [76].

- Lock/gate
  - Locks are incompatible with cargo that extends over the deck of a vessel, such as is commonly the case with blades on WTG installation vessels.
  - Minimum: No lock or gate present

FIGURE 11.2 BLADES EXTENDING OVER THE DECK OF THE WTG INSTALLATION VESSEL [77].

- Vertical clearance
  - The need for vertical clearance is driven by WTG installation vessels, on which both pre-assembled towers and retracted jack-up legs can extend 100 meters above the deck of the vessel.
  - Minimum: 120 m
  - Recommended: No restriction

- Berth length
  - Berth length is a function of the number and length of vessels expected to simultaneously use the berth. Marginal berths (parallel to the shoreline, as opposed to perpendicular) are preferable for offshore wind. Ideally, the berth is marginal (parallel to shore) and two vessels can be moored simultaneously because this gives flexibility in scheduling the inbound and outbound vessels.
  - Minimum: 200 m
  - Recommended: 400 m

- Depth at berth
  - Similar to the depth requirement at the channel entrance, the water depth at the berth must be deep enough to accommodate the common vessels used in offshore wind farms. The slightly lower requirement at the berth is due to smaller under keel clearance.
  - Minimum: 8 m
  - Recommended: 12 m

FIGURE 11.3 MONOPILES AND TRANSITION PIECES SAIL AWAY FROM HARBOR (SOURCE: COWI).

- Load capacity

  - Load capacity describes how heavy a load a certain area can support. The requirement depends heavily on use and type of transport within the staging area. These requirements are driven by the high (and increasing) weights of components such as monopiles, jacket foundations, towers, and nacelles. These components are likely to range from 650 to 1,200 tons for 10 to 12 MW WTGs. Increasing the load capacity is one of the most common upgrades required for offshore wind ports. However, this high load capacity does not necessarily need to be present over the whole port area. On a case-by-case basis, it may be possible to have the maximum bearing capacity only in certain areas.
  - In general, having an overall general uniformly distributed load (UDL) of 50 kN/m^2 is enough to allow both transport and storage of elements such as nacelles, blades, and tower segments.
  - Having a UDL of 100 kN/m^2 allows unhindered running of all components (including monopiles and transition pieces) using self-propelled modular transporters and staging transition pieces on quay side.

- Yard area

  - To make the most efficient possible use of charter vessels, components are staged in the ports yard area, further away from the quay, and transported in batches to quayside to be loaded as soon as vessels are ready.
  - Minimum: 15 hectares
  - Recommended: 20 hectares

FIGURE 11.4 BELFAST HARBOUR UK OUTLINE OF YARD AREA [78].

The aforementioned requirements are summarized in Table 11.1

TABLE 11.1 SUMMARY OF PORT REQUIREMENTS.

Property	Requirement range (minimum to recommended)
Distance to wind farm	<200 to <400 km
Depth at channel entrance	9 to 12.5 m
Harbor entrance width	200 to 300 m
Presence of lock/gate	Not acceptable
Vertical clearance	120 m to no restriction
Berth length	200 to 400 m
Depth at berth	8 to 12 m
Load capacity	50 to 100 kN/m2 (UDL)
Yard area	15 to 20 hectares

11.3.2 Installation port requirements for floating wind farms

Currently, the formulation of a port requirements benchmark for floating foundations is quite an uncertain exercise, as the technology used is still highly varied. The six demonstrator floating wind farms coming online in Europe until 2023, for example, use four different concepts: semi-submersible, barge, tension leg platform, and spar [19]. In time, some of these concepts will emerge as the most popular and then global port requirements can be formulated for them.

Compared to the bottom-fixed foundations, the most important distinction is absence of the WTG installation vessel with its requirements for an uninterrupted installation schedule. This would result in smaller entrance width and potentially shorter berth requirements.

The key driver of the process would be the production cycle of the floaters which would need to be explored in a detailed planning process. Based on sizes of current demonstration projects, indicative requirements for port properties are described in the following paragraphs.

The size of storage yard area is unclear as joining of WTG and floater is a continuous process governed mostly by the rate of floater production. In that sense, the size of the yard can be as low as to allow for one shipload of components to be available for installation (approximately 5 hectares) but also as high as for fixed foundations (15 to 20 hectares).

Load capacity allowance is governed by the heaviest component storage on quay and tracked cranes required for lifting (possibly dual lift). It is therefore likely that requirements are like those for bottom-fixed foundations.

The required depth at berth and entrance may need to be larger than for bottom-fixed foundations, as the foundations are floated directly at quay. While barge-type floaters have comparable draught to vessels used for offshore wind, semi-submersible foundations require larger draught (probably around 20 m) for maximal stability.

FIGURE 11.5 WTG MOUNTED ON A SEMI-SUBMERSIBLE FOUNDATION FLOATED DIRECTLY AT QUAYSIDE [79].

11.3.3 Operation and maintenance port

Requirements of ports used for O&M of offshore wind farms are far less demanding than the requirements on ports used for installation. The vessels commonly used for O&M are crew transfer vessels (CTV) and service operation vessels (SOV).

CTVs are small vessels with an overall length of 15-30 m and a shallow draft. They are used to reach wind farms which are relatively close to shore and are used for day trips, with the crew returning to shore at the end of the day. To accommodate CTVs, ports need about 4 m depth at the channel entrance and berth, a harbor entrance width of approximately 12 m and a vertical clearance of only 10 m, as CTVs do not transport large components. When using CTVs, only spare parts and equipment are stored at the port, consequently, a high load capacity is no longer required. An O&M port should ideally have 0.75 to 1.5 ha of available area, adjacent to the berthing to allow for the footprint of the onshore facilities, such as offices, storage, accommodation, and workshops. For wind farms served by CTVs, the O&M port is typically located 50 to 100 km from the wind farm.

SOVs are larger vessels with crew lodging and warehousing areas on deck. They can stay at sea for longer periods of time (up to two weeks), making them useful for wind farms that are further from shore or very large. Compared to CTVs, SOVs require deeper (approximately 7 m) and longer berth, as well as higher vertical clearance (approximately 40 m). As the vessels return to port less frequently, the berth can be shared with other vessels and as some functions are available on the vessel, less yard area could be needed onshore. With an SOV service concept, the O&M port is typically located 100 to 200 km from the wind farm being served.

For large component exchanges or repairs, WTG installation or other specialized vessels may need to be used. However, as these events are infrequent, these vessels can use another port, such as the one used for installation.

11.4 ANALYSIS OF POTENTIAL INSTALLATION PORTS IN TÜRKİYE

The 1915 Çanakkale bridge, connecting these two seas was finished in March 2022. The bridge has a 70 m clearance, which does not meet the minimum 120 m clearance, which is required by typical WTG installation vessels [77]. While some workaround solutions, such as the use of feeder vessels, exist for WTG installation vessels which cannot move freely, these are not ideal.

The 1915 Çanakkale bridge effectively splits the Marmara Sea and the Aegean Sea into two separate areas, as seen in Figure 11.6. As the offshore wind volumes expected in Türkiye are moderate, it is likely that one major offshore wind installation port in each area would suffice. Due to the anticipated moderate volume of offshore wind expected, it is also important that any upgrades made to the ports for offshore wind are also designed with a multi-functional use. The upgrades should not serve only offshore wind alone, but also give an added value to the port between offshore wind installation cycles.

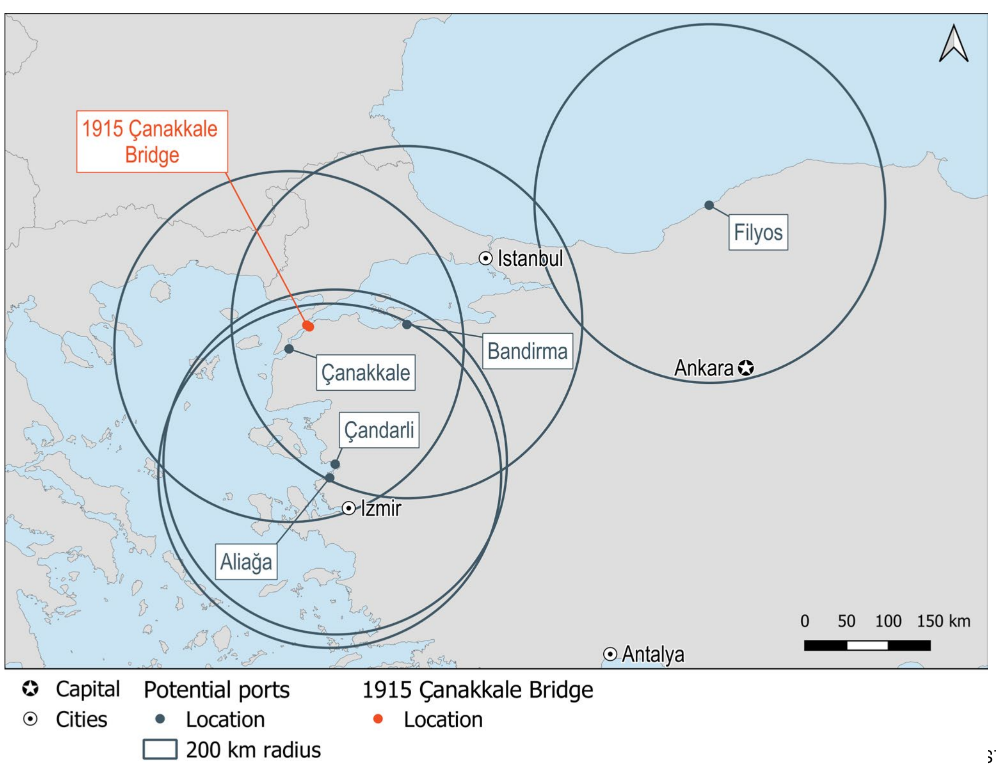
Potential ports have been discussed with the Turkish authorities and are identified as follows:

- Çanakkale
- Aliağa
- Çandarli (under construction)
- Bandırma

In addition to the aforementioned ports, it should be noted that the Filyos port is under construction near the city of Zonguldak on the southern coast of the Black Sea.

Figure 11.6 shows the location of the candidate ports and the bridge.

FIGURE 11.6 LOCATION OF POTENTIAL PORTS IN AEGEAN AND MARMARA SEAS, INCLUDING 200 KM RADIUS, AND 1915 ÇANAKKALE BRIDGE.



Though the planned layout of the Fylios port is likely to support offshore wind farm activities, the port is at a distance of over 300 km from the wind farm areas in the Marmara Sea. In comparison, the distance from the port of Bandırma to the wind farm areas in the Marmara Sea is 30 to 70 km and therefore preferable. However, if wind farms are constructed in the Black Sea, Filyos port would likely be a good candidate for an installation port.

11.4.1 Bandırma

The port of Bandırma is in the Bandırma Bay on the southern coast of the Sea of Marmara. The Bandırma region is highly industrialized and concentrates a great number of Türkiye's imports and exports. The port currently serves import-export activities for the onshore wind sector (See Figure 11.7).

FIGURE 11.7 OVERVIEW OF PORT OF BANDIRMA [80].

For bottom-fixed offshore wind farms in the Marmara Sea, Bandırma is the logical choice. However, the port is surrounded by residential areas which restrict any potential expansion inland. The local topography with steep slopes is also an obstacle for any of the area's expansion as earthworks would be considerable. Some solutions, such as reclaiming land, combining yard areas, and/or using smaller vessels may be possible to enable the use of the port for offshore wind for relatively small investment costs.

Table 11.2 shows the gaps at Bandırma port compared to the baseline set out in section 11.3.1.

TABLE 11.2 GAP ANALYSIS OF BANDIRMA PORT.

Property	Requirement range (minimum to recommended)	Port gap analysis
Distance to OWF	<200 to <400 km	All possible wind farms in Marmara Sea are within 200 km
Depth at channel entrance	9 to 12.5 m	OK
Harbor entrance width	200 to 300 m	OK
Presence of lock/gate	Not acceptable	OK
Vertical clearance	120 m to no restriction	OK, within Marmara Sea
Berth length	200 to 400 m	Less than minimum
Depth at berth	8 to 12 m	OK
Load capacity	50 to 100 kN/m2 (UDL)	Varies
Yard area	15 to 20 hectares	Less than minimum

11.4.2 Çanakkale

The Port of Çanakkale was built in 2005 and it is operated by private sector under the management of Çanakkale Liman Isletmesi San. With its location, Çanakkale can serve the northern half of the Aegean Sea within a 200 km radius up to the 1915 Çanakkale bridge. The main activities in the Port of Çanakkale are roll-on/roll-off, general cargo, chemical, liquid bulk, container, dry bulk, and cruises. The port is also the leading ship generated waste reception service in Türkiye with a dedicated plant and is used as well for onshore wind components export-import activities (see Figure 11.8).

FIGURE 11.8 PORT OF ÇANAKKALE OVERVIEW [80]

There is a single terminal on a pier which is perpendicular to shore and is about half the recommended quay width (50 m) for tower assembly and loading onto installation vessel. This leads either to the need to double the size of the pier or to significantly restrict activities. The available yard area is too small to support offshore wind installation and would need to be expanded. However, possibilities for such expansion seem limited, especially if the additional area should be directly adjacent to the pier. Yard areas which are separated by even a few kilometres from the port will cause costly double handling.

Table 11.3 shows the gaps at Çanakkale port compared to the baseline set out in section 11.3.1.

TABLE 11.3 GAP ANALYSIS OF ÇANAKKALE PORT.

Property	Requirement range (minimum to recommended)	Port gap analysis
Distance to wind farm	<200 to <400 km	Moderately good; about half of the Aegean Sea is within 200 km radius
Depth at channel entrance	9 to 12.5 m	OK
Harbor entrance width	200 to 300 m	Not applicable
Presence of lock/gate	Not acceptable	Not applicable
Vertical clearance	120 m to no restriction	OK
Berth length	200 to 400 m	OK length, perpendicular quay may be too narrow
Depth at berth	8 to 12 m	OK
Load capacity	50 to 100 kN/m2 (UDL)	OK
Yard area	15 to 20 hectares	Less than minimum

11.4.3 Çandarli

The Çandarli port was envisioned as a container port which would serve the North Aegean region with a capacity of 12M TEU[lx]/year once fully developed. The construction of the breakwater was completed in 2014 (see Figure 11.9).

FIGURE 11.9 ÇANDARLI PORT OVERVIEW [80].

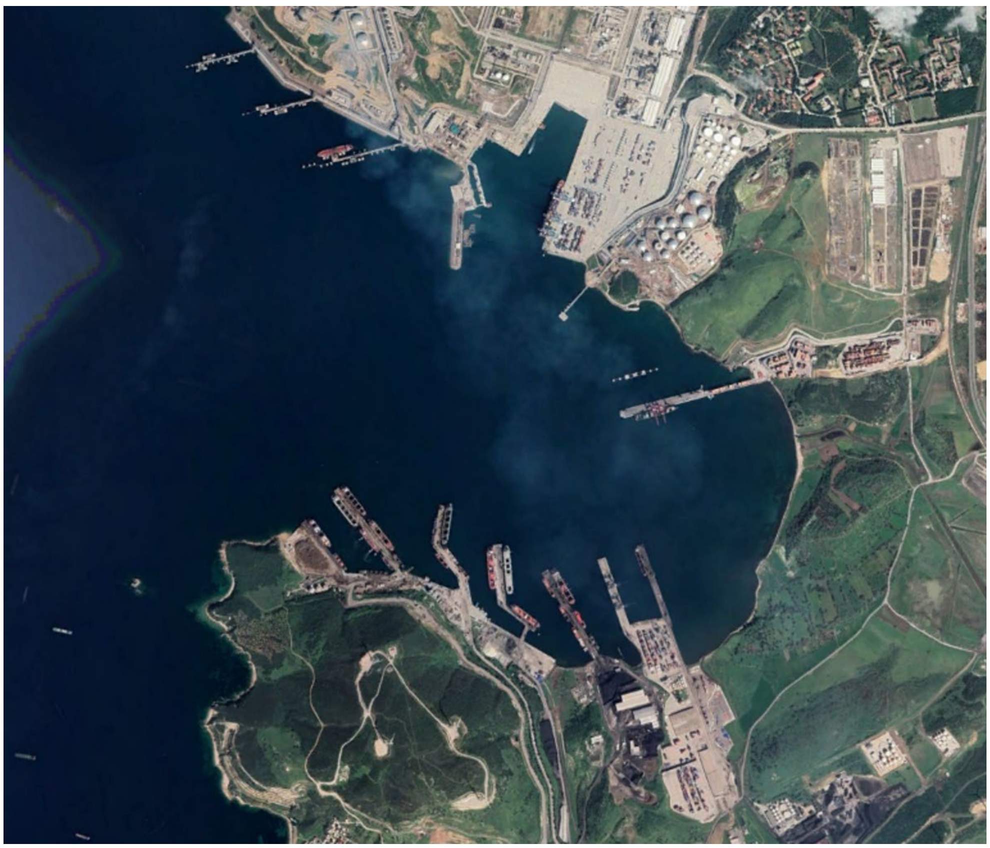
lx TEU—a TEU (twenty-foot equivalent unit) is a measure of cargo capacity in units of twenty-foot-long containers.

The construction of the remaining port infrastructure and equipment procurement was planned to be awarded as a Build-Operate-Transfer contract to a private company but is now paused as this tender was not successful. Currently, the planning process for Çandarli has been stopped. As the port is being constructed in an internationally important wetland (Bakırçay Delta KBA), Çandarli is not recommended to be developed to support offshore wind.

11.4.4 Aliağa

The ports considered at Aliağa are in the Nemrut Bay in the eastern part of the Aegean Sea. The area is a congested industrial center with oil refineries, plastic production, iron/steel production, and wind power plants. The ports are owned and operated by private companies and the main activities carried out are bulk liquid, dry bulk, and general cargo (see Figure 11.10).

FIGURE 11.10 OVERVIEW OF ALIAĞA PORTS IN THE NEMRUT BAY [80].



Most terminals at Aliağa are incompatible with the offshore wind installation port requirements due to high utilization, narrow wharves, and insufficient backup areas.

Table 11.4 shows the gaps at Aliağa port compared to the baseline set out in section 11.3.1.

TABLE 11.4 GAP ANALYSIS OF ALIAĞA PORTS.

Property	Requirement range (minimum to recommended)	Port gap analysis
Distance to wind farm	<200 to <400 km	Good, can serve entire Aegean Sea
Depth at channel entrance	9 to 12.5 m	OK
Harbor entrance width	200 to 300 m	OK
Presence of lock/gate	Not acceptable	Not applicable
Vertical clearance	120m to no restriction	OK
Berth length	200 to 400 m	Between minimum and recommended values
Depth at berth	8 to 12 m	OK
Load capacity	50 to 100 kN/m2 (UDL)	OK
Yard area	15 to 20 hectares	Less than minimum

Key recommendations for the Turkish offshore wind industry in terms of grid and port infrastructure are presented in chapter 5.

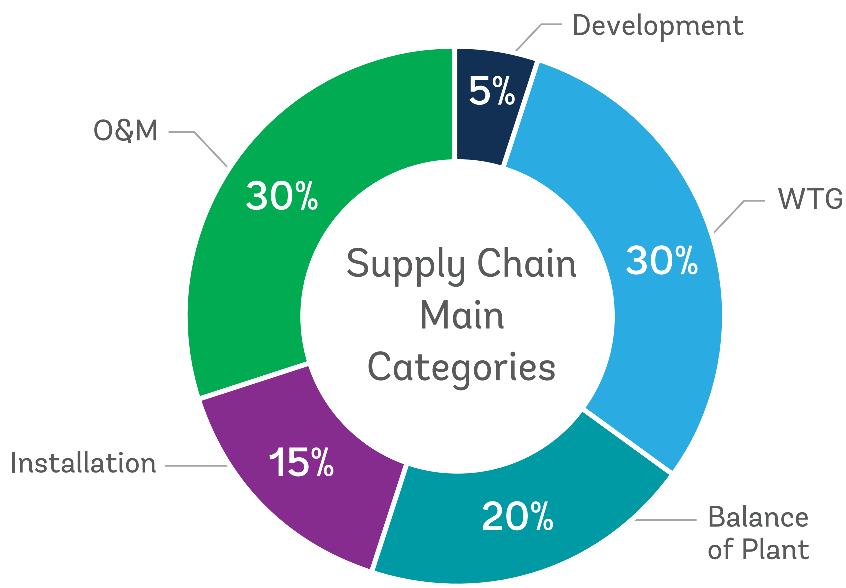
12 SUPPLY CHAIN

12.1 PURPOSE

Building an offshore wind farm is a major endeavor and the supply chain required to deliver the material and workforce is a huge undertaking. The procurement list for an offshore wind farm is extensive, making use of elements from both the onshore wind industry and the marine industry. It applies highly specialized technologies like underwater high voltage cablings, as well as simpler engineering elements such as concrete structures and steel frames.

The offshore wind supply chain comprises five main categories as presented in Figure 12.1.

FIGURE 12.1 DISTRIBUTION OF SUPPLY CHAIN MAIN CATEGORIES ON OVERALL COSTS (SOURCE: COWI, ADAPTED FROM INFORMATION PROVIDED BY BVG ASSOCIATES [54]).



This section presents an overview of the possibilities related to the offshore wind supply chain in a Turkish context. The different supply chain categories are described and then possibilities for Türkiye to tap into the supply chain are assessed. The development of a vast local supply chain, however, is a long-term effort and will occur simultaneously with skill building and knowledge transfer over many years. Accordingly, the supply chain items described in the following sections will only gradually migrate to Türkiye over time, increasing in scope depending on the expansion of the Turkish offshore wind industry and to some extent, also the broader development of offshore wind in the Mediterranean.

12.2 SUPPLY CHAIN CATEGORIES

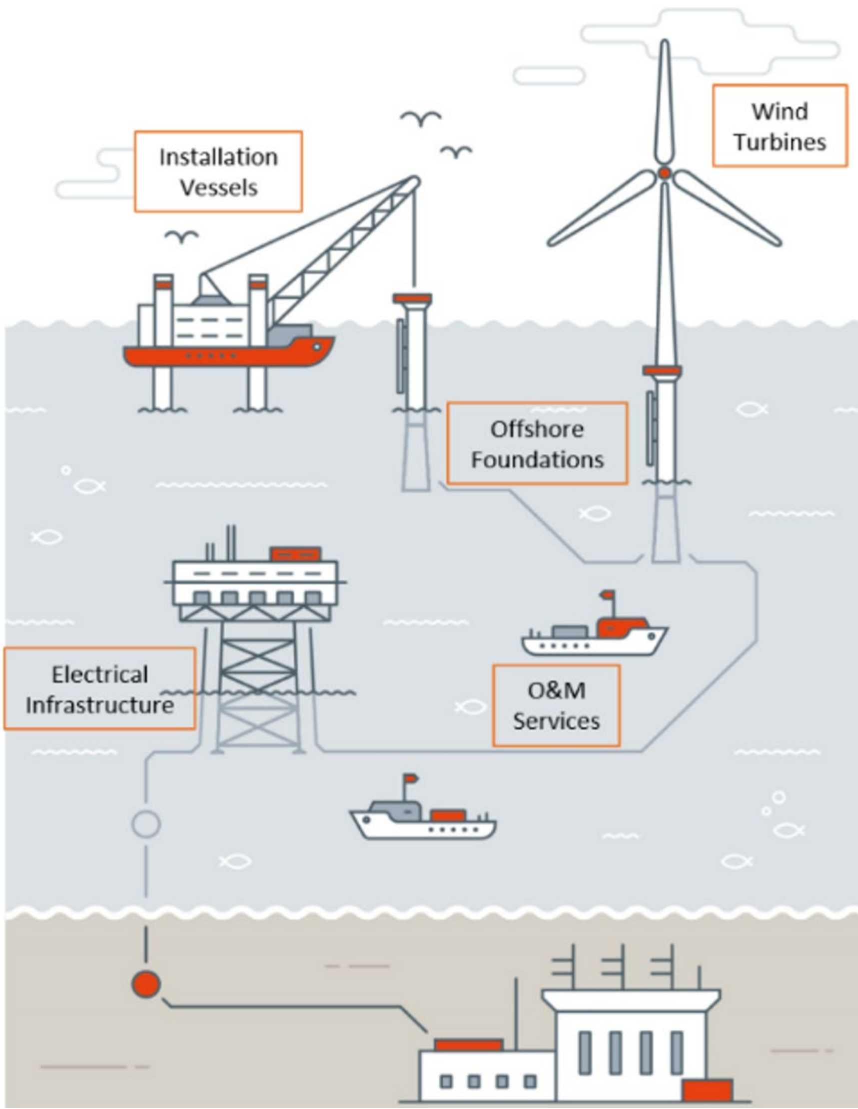
The following section explores the key elements and components required for developing a future offshore industry in Türkiye. Each category of the needed supply chain is presented. In addition, some key subcomponents and relevant international and local providers are listed. The current market state-of-play is also described along with expected upcoming developments.

While project development tasks and survey activities are paramount for establishing a robust wind farm design and realizing a low LCOE, development costs account only for around 5 percent of the total project costs. Hence, capturing most of the project value in Türkiye relies on capturing the other aspects of the project, such as manufacturing, installation, and O&M constituting 95 percent of the overall costs.

The following component categories have been examined in this study:

- Development
- WTG
  - Blades
  - Nacelles, hubs, and assembly
  - Towers
- Balance of plant
  - Foundation supply
  - Array and export cables
  - Offshore substation supply
  - Onshore infrastructure
- Installation
- O&M

FIGURE 12.2 KEY ELEMENTS OF THE OFFSHORE WIND SUPPLY CHAIN (SOURCE: COWI).



12.3 DEVELOPMENT

As there have been no offshore projects in Türkiye, there is little experience in the country with the development and permitting issues related to the design, construction, and installation of offshore wind farms. These issues are generally front and center on developers' minds when entering a new country. Significant resources are dedicated to understanding and navigating local approval processes, permits, and environmental, maritime, and safety regulations.

International developers are very cautious towards unclear and untested procedures, as there is a significant risk that a developer might misunderstand requirements and authorities may refuse a construction or operation permit. In this regard, Turkish consultants and advisers will have an important role to play in supporting international developers in navigating the development process. Alternatively, this may also be an opportunity for creating consortiums between international developers and local Turkish contractors.

12.4 WIND TURBINE GENERATORS

Initially driven by significantly higher investment costs and followed by recent market consolidation developments in the last five years, the number of original equipment manufacturers (OEM) for offshore WTGs is considerably smaller than the number of onshore OEMs. Three major western players dominate the global market: the Danish supplier Vestas, the German-Spanish group Siemens Gamesa (SGRE), and American supplier GE Renewable Energy. Within the Chinese offshore sector, there are four significant suppliers: Goldwind, SEwind, MingYang, and Envision, jointly controlling over 90 percent of the Chinese market. However, these companies have not established significant market shares outside of China. SGRE and MVOW are expected to control around 60 percent of the global market share by 2023 [81].

Table 12.1 lists the three leading manufacturers who are supplying the international offshore market, including the current WTG types and their size and capacity, as well as the types announced to be available soon.

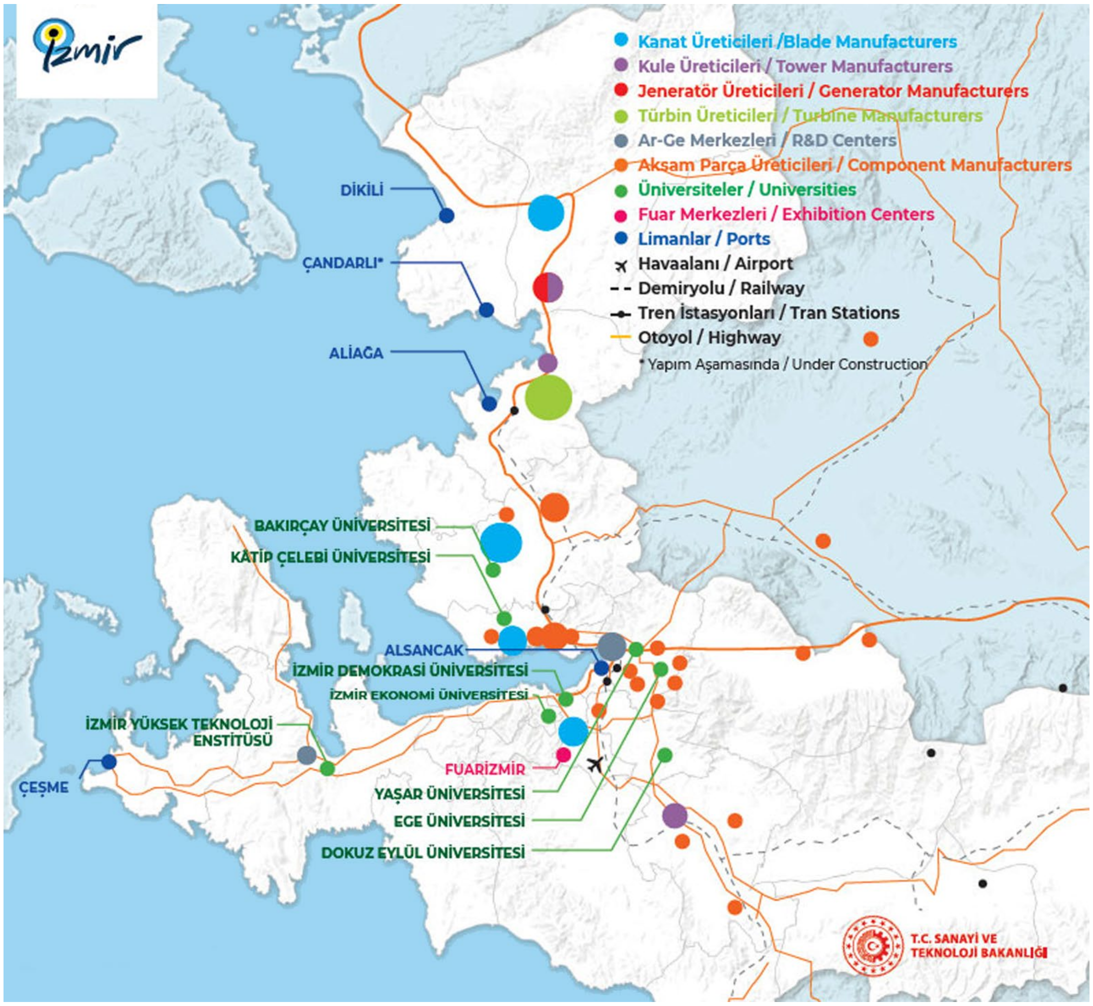
TABLE 12.1 OVERVIEW OF CURRENT AND FUTURE OFFSHORE WTG MODELS.

Manufacturer	WTG type	Capacity	Rotor size	Availability
Siemens Gamesa [82]	SG 14-222 DD SG 11.0-200 DD SG 8.0-167 DD	14 MW 10 MW 8 MW MW	222 m 200 m 167 m	2024 2022 Available
Vestas [83]	V236-15 MW V174-9.5 MW V164-9.5 MW V164-10 MW	15 MW 9.5 MW 9.5 MW 10 MW MW	236 m 174 m 164 m 164 m	2024 Available Available Available
GE [84]	Haliade-X	12 MW 13 MW 14 MW MW	220 m 220 m 220 m m	2021 2023 2024

While none of the offshore WTGs in Table 12.1 have yet been manufactured or installed in Türkiye, the country has already built a strong production market for onshore WTGs and ranks fifth in Europe for WTG component production, covering towers, blades, castings, and nacelles [85]. Türkiye currently holds 12 operational production facilities, four within blades, two within casting, and six within tower production. All three leading offshore OEM have established manufacturing facilities in the country for their onshore WTG portfolio or work with local production partners to produce components.

However, while the production for onshore WTG is already well established in the country, it is not straightforward to apply these manufacturing facilities for offshore purposes. If there is no significant pipeline of offshore projects in Türkiye or the wider region, the investment risk may be too substantial. Further, as illustrated in Figure 12.3, many manufacturing facilities are located inland, which is not conducive to mass production and transportation of the larger offshore WTG components. However, there could be a significant benefit to local content production in Türkiye if smaller WTGs are used offshore, as this increases the likelihood that components can be produced locally in existing onshore factories. Given the wind regime in Türkiye with moderate wind speeds, there could be an opportunity for local production of onshore WTG adapted to offshore conditions.

FIGURE 12.3 LOCATIONS OF ONSHORE WTG PRODUCTION FACILITIES IN IZMIR [86].



12.4.1 Blades

In recent years, the offshore wind market has seen an astonishing increase in blade span. While in 2017, a 5 MW WTG presented blade lengths of around 60 to 70 m and had rotor diameters of approximately 130 m, modern WTG models have increased their blade lengths up to 107 meters [87]. The huge blade size not only requires the highest technical design and fabrication capabilities, but it also imposes constraints for transportation and installation (see Figure 12.4).

FIGURE 12.4 LM WINDPOWER'S 107 M LONG BLADE IS THE LONGEST DEPLOYED TO DATE [87].

While SGRE and Vestas have established in-house capabilities for blade production, GE has purchased the blade manufacturing capacities through its acquisition of LM Windpower.

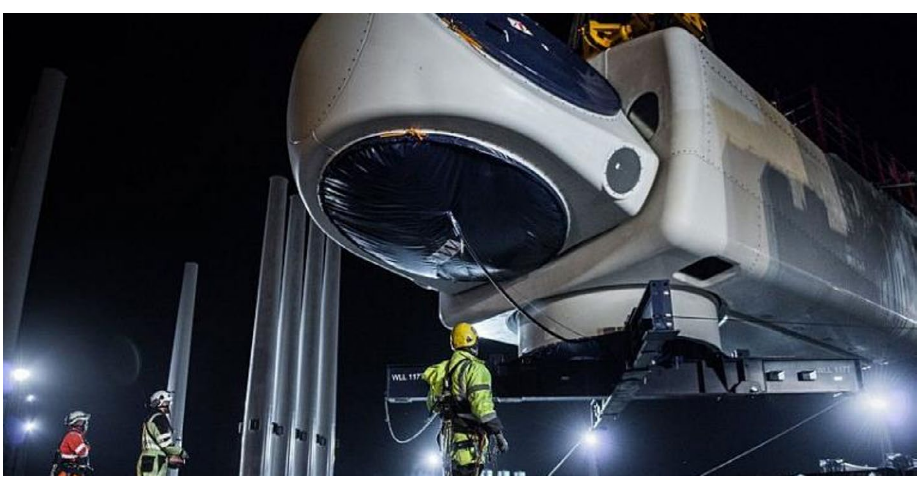
In Türkiye, LM has established a production site in Bergama [88] and Siemens Gamesa is constructing a facility in Aliağa [89]. The company TPI Composites is present in Izmir. TPI is a supplier within the manufacturing of WTG blades and related precision moulding and assembly systems. The company forms long-term supply agreements with manufacturers and offers a dedicated supplier model to them.

12.4.2 Nacelles, hub, and assembly

Major WTG components such as the nacelle, hub, gearbox, and bearing housing require large steel castings, while gear wheels, bearing rings, bearings, shafts, and tower flanges require steel forgings. Only a limited number of European foundries can cope with the required size to cast these components. Examples of established suppliers include Brueck, Euskal, Fonderia Vigevanese, Siempelkamp, Torgelow, and VTC.

However, several Turkish companies already present the potential to move into the sector. Siemens Gamesa has a nacelle factory in Izmir [90], and in addition, Hattat Holdings, Dirinler Igrek Makina, and Alpar Metal present potential to support cast component production.

FIGURE 12.5 THE MASSIVE ROTOR HUB AND NACELLE OF A VESTAS 164-9.5 MW BEING LIFTED TO A VESSEL [91].



Compared to the three-speed gearbox variants commonly found in the onshore wind industry, offshore WTGs have turned into mid-speed and direct drive options, a trend that is likely to continue. Most recently, digital hydraulic drive train options are also being tested. In the offshore wind industry, gearless, direct drive solutions and drivetrains consisting of gearboxes with permanent magnet generators have proven to be the most cost-effective and technically reliable option. As a result of the different technical approaches to drive train solutions, this component has become increasingly product-specific, leading to implications for supply availability as the establishment of a new supplier for such subcomponent requires significant lead time. As the size of future generation gearboxes and mid-speed or direct drive generators continues to increase, developers will prefer coastal sites located close to nacelle assembly facilities.

Suppliers like Winergy, Bosch Rexroth, and ZF Wind currently serve the European market for gearboxes. However, Vestas is the only European manufacturer that uses a gearbox for their offshore WTGs, limiting the potential for offshore gearbox suppliers in Türkiye.

The situation may be different for providers of generators and transformers like ABB who have already long been present in Türkiye with a manufacturing facility in Vadodara which could also start serving the offshore market.

12.4.3 Towers

The towers for offshore WTGs are very similar in composition to those for onshore sites. However, due to the harsh environment offshore, the towers have higher quality requirements (e.g., anti-corrosion coating) than towers for onshore WTGs. Accordingly, potential suppliers must undergo a higher qualification process during selection by the OEM.

Like the blades, the towers for offshore WTGs have particular logistical requirements. For example, the wider base diameter of the towers might easily exceed the traffic underpass requirements. WTG types, such as the V164 to 8.0 MW from Vestas, use a tower base diameter of 6.5 m. Therefore, the manufacturing facilities are expected to be located near the coast and near the sail-out port to tackle logistical constraints.

As WTG sizes continue to increase, the increase in wind farm size has not translated proportionally into an increase in tower demand. When using a 15 MW WTG, a 1,000 MW wind farm installation will require 67 towers instead of 160 needed for a smaller 6 MW WTG. With the trend towards larger structures, smaller numbers of towers will be produced and may pose challenges for developing an offshore tower facility without a sufficiently large pipeline. As a guideline, manufacturers might require an output level of 100 to 200 towers per year over a period of five years to justify investment in a new factory. Accordingly, tower suppliers should expect to supply two or more WTG manufacturers to support the investments they will need to make. However, the high transferability of offshore WTG manufacturing might mitigate this risk, and new coastal facilities could also serve onshore wind tower demand.

The offshore production might well be served by current onshore tower manufacturers Ateş Çelik, CS Wind, Çiltug, Çimtaş, Gesbey, and Temsan who could expand in order to also serve a Turkish offshore market.

12.5 BALANCE OF PLANT

12.5.1 Foundations

The foundations on which offshore WTGs are installed have historically been fixed to the seabed. Lately, the development of floating foundations has taken off, but the technology is still in the early development stage, and only a few pilot projects have been deployed on a worldwide basis.

Within the group of fixed foundations, three main types exist: gravity-based concrete foundations for shallow waters, steel monopiles for water depths of 20 to 50 m, and steel jackets for deeper sites up to 60 m. Given the lower cost and simple design, the vast majority of the installed European offshore wind projects rely on steel monopiles and jacket structures, with some near-shore projects utilizing gravity-based concrete foundations.

Gravity-based foundations

Gravity-based foundations are large, reinforced concrete structures that do not require piling. Instead, they have a significant footprint (>30 m in diameter) and rely on their weight to resist overturning (see Figure 12.6). Turkish construction companies such as STFA could be a potential supplier of these foundations for the Turkish market. However, in Türkiye, it is likely that the use of gravity-based foundation technologies would require significant port upgrades, as storage will likely exceed the bearing capacity at Turkish ports due to the enormous dimensions and weights of these structures. Given that there is next to no potential in shallow waters, it is not foreseen that a supply chain within gravity-based foundations will be viable in Türkiye.

FIGURE 12.6 GRAVITY-BASED FOUNDATIONS FOR THORNTON BANK (SOURCE: COWI).

Monopiles

Monopiles are large tubular steel structures, which are currently up to 80 m length. They consist of tubular sections rolled out of steel plate and then welded together. Once transported to the site, the installation crew typically drives the monopiles into the seabed with a hydraulic pile hammer or pre-drills the pile before hammering, if soil conditions are challenging. Many projects subsequently add a transition piece (TP), which is mounted on top of the monopile and grouted into position. The WTG tower is then bolted to the transition piece, which helps to level the tower and acts as an attachment point for boat landings, access ladders, and work decks.

Monopiles have long proven themselves in the industry as the most cost-effective solution for offshore wind. The technology is tried and tested for even giant WTGs, and currently projects with water depths of up to 50 m are using monopile foundations. The success of the monopile foundation is primarily due to its simplicity, which has allowed for fast evolution as the ability of manufacturers to retool factories to handle increased steel thickness and diameter has increased. In 2012, a diameter of 6 m was considered the maximum, which increased to 9 m by 2015. In recent years however, the industry has pushed this boundary even further and now diameters of up to 11 m with a thickness of 150 mm and achieving total weights of up to 2,000 tons have been possible (see Figure 12.7). Major player SIF has been able to provide these capabilities since 2017 and in 2019 also German manufacturer Steelwind Nordenham finalized the supply of 40 monopiles with this diameter for the Taiwanese Offshore wind farm Yunlin. Further established market suppliers are Bladt, EEW SPC, and Bilfinger (now part of the VTC Group).

FIGURE 12.7 MONOPILES AND TRANSITION PIECES AT SAIL AWAY FOR LONDON ARRAY (SOURCE: COWI).

Currently, the largest monopiles being designed in the EU will not immediately be provided by Turkish suppliers. However, major fabricators in Türkiye, like Cimtas, may well be prepared to roll steel in these large diameters and thicknesses in the mid-term future. To boost local content, especially at the initial development stage of the Turkish offshore wind industry, focusing on a more conservative approach with smaller WTGs in shallow waters could be the most reasonable short-term approach.

Jackets

Jacket structures are the most common option for a non-monopile steel foundation, a cross-braced and welded structure using steel tubes, and where each leg is fixed to the bottom using steel piles typically 2 to 3 m in diameter. This type of foundation has been extensively utilized in the offshore oil and gas industry and is often used to support offshore electrical infrastructure. It is commonly used where water depths exceed the limits of applicability for monopiles (i.e., 50 to 60 m water depth) or where challenging soil conditions exist (see Figure 12.8). Jackets have been applied on numerous European offshore wind projects, including Thornton Bank, Wikinger, Nordsee Ost, Baltic 2, and East Anglia 1, and are planned on further sites like Scottish Neart Na Gaoithe, as well as on many Asian projects, including Taiwan and China.

FIGURE 12.8 JACKET STRUCTURE AT WIKINGER (SOURCE: COWI).

One of the established suppliers of jackets is UK-based BiFab, which delivered jackets for the Beatrice and Alpha Ventus pilot projects and the Ormonde commercial project. Other leading players are OWEC Tower, German supplier EEW, Danish Bladt, Spanish Navantia, and Belgium companies SIF and Smulders. The market could be attractive for Turkish shipyards like Cimtas. Companies with shipbuilding or offshore oil platform experience may have an opportunity to participate in this emerging market for offshore WTG jackets and towers as well. However, they need to consider that while the production of jackets for O&G focuses on few but expensive units, the supply for offshore wind concentrates on large production volume at a low cost. Therefore, their manufacturing facilities will require a high level of standardization and process optimization.

From an economic point of view, potential domestic suppliers will need to diversify the significant investment risk to enter the offshore wind market by relying on other similar markets (O&G or onshore wind) and gradually ramp up their capacity. If they can tackle the investment risk, these companies can find a favorable short-term opportunity by combining their marine-specific expertise with the logistical advantage of a domestic supply.

12.5.2 Inter-array and export cables

Another major category in the balance of the plant is the supply of the electrical infrastructure needed to discharge the electrical power from the offshore WTGs to the grid onshore. The first piece of electrical infrastructure is the system of several strings of medium voltage subsea cables, or inter-array cabling (IAC), which connects the WTGs and subsequently feeds into a local offshore substation. The second piece, the offshore substation, then steps up the voltage for transfer to the shore using high voltage export cables. Export cables then transfer power from the substation to a substation onshore.

The topology of the electrical infrastructure depends highly on the distance to the shore and the size of the wind farm. At distances beyond 80 to 100 km from shore or on power islands where several wind farms feed into a central hub, a high voltage direct current (HVDC) approach is also an option. This poses the advantage of reducing electrical losses on the cabling, but the investment for such AC/DC converter systems is significant and a long lead time of five to seven years is likely. To date, only a handful of sites in Germany have applied HVDC setups, and for Türkiye, the most likely scenario for the short-term are sites within reach for HVAC cables. Once the first projects have been established and a significant pipeline of projects is established, HVDC may become a possibility for Türkiye.

Inter-array cabling

The inter-array cabling connects the WTGs to an offshore substation but can also be applied to connect AC collector substations to a direct current (DC) grid connection. The vast majority of IAC are medium voltage alternate current connections (MVAC) rated at 33kV and made from cross-linked polyethylene (XLPE). The recent developments in WTG size have also led to potential designs using 66 kV cabling as a basis for inter-array cabling, which has the advantage of reducing electrical losses. This progress would also allow keeping the relative number of WTGs currently allocated to a single string (between six to eight per string), despite increasing power per WTG. While the array cable supply has historically been separated from the installation contract, this trend is beginning to change as developers strive towards a combined contract to minimize interface risks. For such integrated cases, it is most likely that the main contractor will remain the cable supplier.

Export cabling

The interconnection of the offshore station to the land-based grid is performed by means of high voltage export cables. These are considerably heavier and longer than the inter-array cables. As mentioned earlier in this report, this study focuses on an electrical layout using alternate current (AC), which to date has been the most common setup. For this, the according HVAC setup reaches maximum voltage rates of up to 275 kV.

Türkiye has several experienced cable producers, including HES Kablo, Hasçelik Kablo San. Tic. A.Ş., ZTT Cable, Üntel Kablo, Prysmian Kablo, and Vatan Kablo who should be able to develop production capacity to help meet supply demands for Turkish offshore wind projects.

12.5.3 Offshore substation

The offshore substation (OSS) collects the power generated from the WTGs and converts it to a higher voltage level to export it over subsea cables to a land-based transformer, which subsequently injects it into the transmission grid. The substation comprises transformers, switchgear, controls, and fire protection systems and generally all relevant switching and protection systems necessary to respond to faults. Any other necessary power electronics and auxiliary low voltage systems are installed at the OSS as well.

The overall OSS foundation supports the electrical substation itself and all components for access and temporary accommodation facilities (together called topside), covering an area of around 30 m x 30 m and can reach several stories in size (see Figure 12.9). The total weight of the OSS topside can vary between 1,000 and 2,000 tons or more and, similarly to WTG foundations, is usually installed on jacket foundations and in single cases, on monopiles or concrete gravity foundations.

FIGURE 12.9 OSS OF OWF WALNEY EXTENSION (LEFT) ON JACKET FOUNDATION AND OSS OF OWF KRIEGERS FLAK ON MONOPILE (SOURCE: COWI).

The OSS is a complex system, hosting a vast amount of equipment and numerous interfaces, but supply can roughly be divided into the three following categories:

- Providers of the support structures (jackets, monopiles, or gravity foundations);
- Supply of topsides; and
- Supply of electrical equipment.

The support structures can be provided by the same companies providing the foundations for the WTGs. Topsides are commonly produced by large yards like Bladt, Bilfinger, Hereema, and Harlan & Wolf. As with jackets, companies like Cimtas could expand into this sector.

Only a limited number of crucial players supply the electrical equipment for the offshore wind market. The key players holding most of the global market share are ABB, Siemens, Alstom, and CG Power. However, companies like BEST and Eltaş could support some electrical infrastructure needs on offshore substations as well as their onshore counterparts.

12.5.4 Onshore infrastructure and substations

Once the voltage is stepped up by the OSS and transported to land utilizing the export cables, the power is received at coastal onshore substations, which clean[lxi] the power and convert it to be integrated into the onshore transmission grid.

There is almost no difference between onshore substations for wind farms and any other land-based power facilities, enabling a wide range of domestic players and manufacturers to supply this wind farm component.

12.6 INSTALLATION AND VESSELS

The installation of an offshore wind farm requires a wide variety of vessels, each with a specific design and purpose, and roughly split into the following vessel types:

- Heavy-lift vessels;
- Derrick barges;
- Transportation barges;
- Jack-up barges without propulsion;
- Self-propelled jack-up vessels;
- Cable laying barges (anchor driven);
- Cable laying vessels; and
- Rock dumping vessels (if offshore cable crossings occur).

These vessels serve to install the WTG foundations, the WTGs, the IAC, the export cabling, and the offshore substation. However, given the low growth and high growth development scenarios presented in this roadmap, it is unlikely new vessel construction will make financial sense to serve the Turkish offshore wind market alone. A larger, regional pipeline would likely be required.

lxi The substation will contain various equipment/plant ensuring an acceptable voltage quality and harmonic distortion imposed by the windfarm.

12.6.1 Foundation vessels

The foundation installation vessels first transport the foundations to the site and then execute the specific installation process depending on the foundation type, such as piling for monopiles. These tasks are usually performed by either floating heavy lift vessels and sheerleg crane vessels (in combination with an additional component feeding vessel) or by jack-up vessels, mainly used for WTG installation.

A variety of vessels have performed monopile installation, such as heavy lift vessels like Seaways Stanislav Yudin, crane vessels like Van Oord's Svanen, or jack-up vessels like Aeolus. The Turkish industry would need to make further investments to bring foundation installation vessels to the Turkish offshore wind market. However, Turkish shipyards, which already support the production of O&M vessels for western developers, could potentially construct larger vessels for the installation of foundations. But again, such investment would rely on a significant domestic pipeline of projects to realize shipbuilding for domestic use.

12.6.2 Wind turbine installation vessels

WTG installation vessels also cover transportation to the site and installation of towers and WTGs. Because of the precision and stability needed to install the nacelle and blades, all commercial projects have solely applied jack-up vessels as a basis for WTG installation. The early years of the European industry were still able to rely on the application of general-purpose jack-up barges from the oil and gas sector, and at that time, these vessels were scarce in the market. However, because of sites with increasing water depths beyond 25 m, in the last ten years, many of the leading suppliers like the UK-based MPI Offshore and Seajacks or Norway's Fred. Olsen Windcarrier started investing in jack-up vessels designed to the specific needs of the industry.

Further examples of established players able to provide these vessels include Belgian Jan de Nul and DEME (who acquired Danish A2Sea), German SAL Heavy Lift, Danish Swire Blue Ocean, and Dutch Van Oord. Many of these actors are currently also ordering new cranes to cope with the increasing lifting heights and weights of the next generation WTGs. Accordingly, these purpose-built vessels are now widely available in the market, especially those able to operate with smaller WTGs. For the European suppliers, the opening of the Turkish offshore market would be a welcome opportunity to leverage the risk of the current surplus of capacity. Hence, it may turn out to be difficult for Turkish companies to compete and build a supply chain in the market for WTG installation vessels.

12.6.3 Cable laying vessels

There are two different methods when using installation vessels for offshore cables. The first method performs a simultaneous lay and burial process with the aid of a plough, while the second method splits the tasks performing the surface lay first and subsequently applies the burial using a jetting tool controlled by a remotely operated vehicle (ROV). The site conditions determine the approach for a particular site. This same process is performed for the IAC and the export cabling and requires two different kinds of vessels for each task. Export cables are preferably installed in one single length and need bigger ships with a larger cable carousel. Vessels for IAC are smaller than for export cables, but due to the high number of cable-pulls and terminations at each foundation, the IAC installation is considered the more difficult task.

While in the past, the technically challenging process of cable installation has led to significant problems and was long a weak point of the industry, the sector has matured and specialized companies with purpose-built vessels have developed in the market. One of the leading suppliers is Subsea 7, which acquired cable installer SIEM Offshore in 2018. Large cable manufacturers like Prysmian, NKT Cables, Hellenic, or Nexans and major EPC contractors like Van Oord have also invested in dedicated vessels for their portfolio. Still, the task requires experienced staff and well-trained vessel crews and remains technically challenging. Even though cable installation providers act globally, local investors will remain hesitant to build domestic purpose-built vessels without strong policy support and commitment to a large pipeline from the government.

12.7 OPERATION AND MAINTENANCE

As presented earlier in this report, O&M activities make up approximately 30 percent of the overall costs of an offshore wind farm and most of it will be locally sourced. Hence, O&M activities represent an important item of the Turkish supply chain that will attract significant investment.

12.7.1 Wind farm operation

The daily operation of an offshore wind farm requires a wind farm control center for monitoring the production and performance of offshore WTGs, which, depending on its capabilities, a developer or owner may choose to build and operate or subcontract to an asset management company. The operations center will work closely with storage facilities, vessel operators, and the maintenance organization. Wind farm operation is a balancing act between optimum electricity production and the logistics of servicing offshore structures and machinery. Because of this, the operation typically requires a dedicated CTV and a dedicated maintenance team that may service one or more wind farms. The work could consist of coordinating simple, annual, or scheduled maintenance and inspection tasks, monitoring the service provider, and handling warranty claims.

12.7.2 Turbine maintenance and service

The maintenance organization is responsible for spare parts inventory, ensuring the availability of trained technicians and adequate vessel capability to service the WTGs. Balancing these constraints is a challenging task. The day-to-day maintenance of WTGs and replacement of minor parts may be rather easily accomplished; however, partial or complete replacement of major components such as gearboxes, bearings, blades, and electrical equipment may require items that have extended lead times to source. Generally, major repairs also require special vessels to install, which are subject to market availability and pricing.

Suitably qualified and experienced personnel are crucial to undertaking effective O&M. Technicians typically travel out to the site every day by boat (see Figure 12.10) transfer across to the WTG (see Figure 12.11), climb the WTG, undertake the maintenance work, and then repeat, as appropriate.

FIGURE 12.10 CREW TRANSFER VESSEL AT A WTG (SOURCE: COWI).

It is quite physical work in a hostile environment and some special certificates and accreditations are required to perform the job safely offshore and at heights. WTG manufacturers can use specific equipment that differs from each other, and technicians may require multiple certifications to work on different WTG types. Many training providers have opened to meet the demand and now include courses provided by WTG manufacturers, higher education courses, and commercial training courses. Roughly, the sector needs between 0.5 and 1.5 FTE jobs per operational WTG.

FIGURE 12.11 OFFSHORE WTG TECHNICIAN ACCESSING A WTG (SOURCE: COWI).

WTGs typically come with a five-year warranty and a service and maintenance agreement from the manufacturer. During this period, the manufacturer will normally employ most technicians on site. After the warranty period, the owner/operator can opt to extend the service and maintenance agreement or take over responsibility for the plant and directly employ the technicians. Some more hands-on owners take responsibility earlier and have jointly employed technicians working on the wind farm during the warranty period.

12.7.3 Balance of plant maintenance

The maintenance organization is also responsible for maintaining the foundations and electrical infrastructure, performing periodic inspections on the foundations, substations on- and offshore, and carrying out seabed surveys to ensure the subsea cables remain buried. These works are often separate from the WTG maintenance and can quickly be addressed by specialist companies in the local market. These activities require specialized vessels and equipment, such as service operation vessels (SOVs) and remotely operated vehicles (ROVs), both specially equipped for the tasks. Further, technicians with special training in certain areas such as diving, welding, and other tasks are required.

13 PREPARATORY STUDIES

13.1 PURPOSE

Studies like this roadmap are performed at a high level in order to get an overview of the situation regarding offshore wind in Türkiye. Preparatory studies comprise the further studies required to mature an offshore wind power project for design and construction. Several studies are required including the following:

- Soil conditions;
- Metocean;
- Wind resource;
- ESIA; and
- Grid integration.

13.2 SOIL CONDITIONS

Soil conditions cover the nature and characteristics of the seabed and the ground beneath. These conditions are driving and determining the design of WTG foundations and offshore substation foundation, as well as cable design and routing.

Establishing soil conditions for design of an offshore wind farm comprise several surveys and investigations. The two major categories are geophysical and geotechnical studies.

13.2.1 Geophysical investigations

Surface investigations that map the seabed (depth, bathymetry, structure, objects, and hazards, such as Unexploded Ordnance (UXO)) often include a scan of the top layers of the seabed. The investigation is carried out by equipment hanging from the rear end of a vessel into the water column. The vessel then scans the seabed by moving in a grid of 200 m, for example. Such investigations provide a significant amount of data and information, and would cost in the region of US$1 to 3 million for a typical 500 MW project.

13.2.2 Geotechnical investigations

Geotechnical investigations comprise drilling, bore samples, and cone penetrating testing (CPT). These investigations determine the strength parameters of soil at specific locations. Geotechnical investigations can be made from a ship or a jack-up vessel, and consequently carry higher cost. However, such investigations are crucial for preparing the design of the offshore structures.

The cost of a full soil condition assessment including surveys is around US$10 to 15 million, depending upon many factors such as site size and vessel availability.

13.3 METOCEAN CONDITIONS

Metocean conditions refer to the combined wind, wave, and climate conditions found at a specific location. Metocean conditions are important for the WTG locations but also for the transmission system design.

The purpose of a metocean study is to provide information and data at a level of detail that will sufficiently enable developers to submit qualified financial bids for design and construction of an offshore wind farm. It is recommended that the metocean study is prepared in accordance with IEC 61400-3-1 International Standard—wind turbines—Part 3: Design requirements for fixed offshore wind turbines. A thorough and certified metocean study significantly reduces risk for developers.

A metocean study for an offshore wind farm in Türkiye should include the following data:

- Location (coordinates) and general site description
- Bathymetry and tidal data
- Wind data
- Wave data
- Current data

Based on the site-specific data, hydrodynamic modelling, wave transformation, and hindcast simulations can be conducted for use towards the design of the offshore structures.

The full cost of a metocean desktop study is around US$75,000 for a typical 500 MW project. The cost of the long-term measurements is detailed in the following section as part of the wind study by means of a Light Detection and Ranging (LIDAR) buoy.

13.4 WIND STUDY

In order to properly estimate the annual energy production (AEP) and the structural requirements to the WTGs, it is necessary to conduct a thorough wind study based on site specific measurements.

The Global Wind Atlas, although a highly advanced tool, relies on mesoscale data and not site-specific data. For Türkiye, it will be necessary to conduct specific measurements on site with a floating LIDAR buoy.

A site-specific wind study should include the following topics:

- Site boundaries (coordinates)
- LIDAR data (position, measuring period, and calibration)
- Mesoscale data

- Validation of data
- Wind speed and distribution
- Seasonal, monthly, and daily variation
- Wind shear
- Long-term variation and correlation
- WTG suitability and site-specific requirements
- Layout optimization
- AEP calculations (gross and net)
- Loss estimation (wake, power curve, electrical, availability, etc.)
- Uncertainty estimation (P50, P70, or P90)

The full cost of a wind study for a for a typical 500 MW project offshore wind farm is approximately US$20,000 excluding LIDAR measurements.

The relating floating LIDAR measurement spanning over a length of 12 months carries a cost of around US$1,000,000.

13.5 ENVIRONMENTAL AND SOCIAL IMPACT ASSESSMENT

An environmental and social impact statement for an offshore wind farm is a very extensive document that must cover several different topics. The assessment falls into two main categories:

- Environmental impact
- Human-related impact

The IFC performance standard *Environmental, Health, and Safety Guidelines for Wind Energy* may be used as guidance for what should be covered in an ESIA. However, it is important that local rules and regulations are respected and incorporated in the analysis.

13.5.1 Environmental (biodiversity) impact

Offshore wind farms have the potential for direct and indirect adverse impacts on both onshore and offshore biodiversity during construction, O&M, and decommissioning. Examples of impacts include bird collision-related fatalities; displacement of wildlife; habitat conversion/degradation; and noise to marine mammals. In offshore environments, benthic disturbance and new structures may also impact existing habitats and attract new habitat-forming species, such as shellfish, corals, and underwater vegetation. Adverse impacts can also result from associated infrastructure, particularly overhead transmission lines, substations, underwater cables, and vessel traffic.

Following a scoping and desktop study, appropriate site-specific baseline biodiversity information may be needed for the ESIA. Baseline biodiversity surveys, where required, should occur as early as possible and should consider seasonality.

Surveys should consider the following:

- Site-specific issues: consideration of habitats, geographical location, topography, and vicinity of the wind energy facility to sites of high biodiversity value.
- Species-specific issues: surveys should be targeted to species of flora and fauna of high biodiversity value, those with a special international or national conservation status, endemic species, and species that are at elevated risk of impact from wind energy facilities. These impacts and potential mitigation options should be assessed on a species-by-species basis.
- Season-specific issues: surveys should take into consideration certain periods during the year when the project site may have a greater or different ecological function or value (e.g., migration or breeding season). Surveys should usually be conducted for at least one year when at-risk wildlife is identified. Longer surveys may sometimes be necessary in areas with exceptional aggregations of at-risk migratory birds and where existing biodiversity data are limited.

Human-related impact

Human-related impact covers several different topics of public, commercial, and governmental interest. The main topics to be covered under this heading are:

- Fisheries and aquaculture
- Shipping
- Impact on recreation and tourism activities
- Visual impact
- Cultural heritage
- Military
- Aviation
- Telecommunication
- Oil and gas exploration
- Underground cables and pipelines
- Dredging

All these topics require site-specific information and data from relevant authorities and stakeholders. Consequently, it is beneficial to the process to engage with relevant stakeholders early on. It is recommended to initiate the ESIA process with public engagement as an early consultation already during the scoping phase of the ESIA. With an early consultation, the public will be allowed to provide ideas and input feeding into the ESIA.

13.6 GRID INTEGRATION

The electrical grid integration studies shall involve both the OWF and the TSO.

It is important to distinguish between the:

- Reinforcement of the back-bone transmission systems; and
- Planning of the OWF grid interconnection.

The interface is the PoC where the TSO allocate HV connection line bays in one of their substations.

13.6.1 Reinforcement of the back-bone transmission systems

The TSO shall plan, construct, and maintain a power grid with sufficient capacity and availability to secure the transmission between the generating units and the load demand centers. This is a non-stop process where the TSO issues a yearly updated master plan for the next 1, 5, 10, or 15 years, for example, for their concession area. Since the power grid is cross-country integrated (to secure stability) the TSO also will plan for eventual heavy interconnectors to neighboring countries (sea-cables or overhead lines either with an AC or HVDC approach). Upgrading of the back-bone system will involve both new substations and overhead lines/cable that will require a long planning horizon of three to five years before. Environmental issues and securing the rights of way for the line corridors often are key factors for such plants. Consequently, it is vital for the TSO having an updated plan for new-builds and dismantling of the generation plants, and a good understanding of the power load demand. In respect to the OWF integration to the grid, they will be considered like a thermal, hydro, or other VRE generation plan.[lxii] The impact of the new generation plants might trigger the need for new lines or substations that will be identified by the TSO's electrical system studies "load-flow, transient/dynamic" and that will reveal the need and timing for the construction/reinforcement.

Since the back-bone power grid is of national importance, the TSO often are reluctant to share necessary details for external advisors, thus these studies for Türkiye are assumed to be implemented solely by the TSO.

However, if international investment banks are involved in the financing of such grid reinforcement initiatives, it is assumed that an external international advisor/consultant will contribute with a high-level assessment and quality assurance on the planning process and eventually assist with drafting feasibility studies for the individual projects. Depending on the number of reinforcement projects, an initial budget could be in the range of US$600,000 to 2,400,000.

lxii The power balancing challenge will be addressed in the design of the dispatch centers.

13.6.2 OWF grid integration

The OWF developer will often be granted a certain lease area and then it will be their own duty to establish a sound power infrastructure system between the WTG and the PoC.

The development of the electrical infrastructure for an OWF aims at identifying the optimal topology and most cost-efficient technology available for the investor. The planning will take basis in the prevailing grid code requirement set out by the TSO where the conditions and requirements in respect to voltage quality and electrical interaction between the OWF and the grid at the connection point are detailed.

The OWF grid interconnection planning will involve the determination of the following:

- PoC location(s) and voltage level made available by the TSO;
- Number of export cables to the PoC and selection of either AC or HVDC technology;
- Number and location of offshore substations within the OWF; and
- Location of landfall and corridor for the onshore export cable.

Detailing the aforementioned will be the result of sequential electrical studies (with detailed level of insight) and the technical/cost optimization of the power infrastructure where the OPEX (energy loss assessment) will also be factored in.

The TSO often will identify a range and details of the electrical system studies requested to verify grid code compliance.

The electrical studies can be

- Initial load flow and short circuit studies. These will constitute the basis for determining the power system topology and give rating of the main components within the OWF and at the onshore substation (OnSS) nearby the TSO PoC. High-level route plans and general arrangement of the OSS and OnSS will be established.
  - These studies are typically implemented in the early developing process and form part of the developers' bid process. Initial dialog with the TSO to identify suitable PoC(s) shall be made.
  - Indicative budget: US$250,000 to 500,000.
- Basic electrical studies (after concession is obtained). A more detailed assessment of the request for components in the OnSS in respect to fulfilment of the grid compliance code will be required. Different WTG type and sizes might be considered. Final sizing of HV components/plants[lxiii] targeting the voltage quality shall be implemented and will constitute the basis for the design and procurement of the BoP components. Initial assessment on harmonic filter in the OnSS will also be implemented. The basis studies will consider initial WTG sizes and a tentative OWF layout where the array cables interconnecting the WTG are incorporated.
  - Indicative budget: US$350,000 to 700,000.

lxiii Reactive power and power factor control maintained by proper sizing/selection of shunt reactors, capacitor banks, static synchronous compensators, or similar.

- Detailed electrical studies (after WTG contract award). The final detailed studies will rely on the final selection of WTG size and location. The detailed electrical model of the WTG agreed will form the basis for a final fine-tuning of the OnSS HV component ratings and also give basis to identify the size/rating of the harmonic filter banks.[lxiv]
    - These studies will also involve transient and dynamic simulations that only can be implemented by use of very specialized software tools.
    - The target is obtaining preliminary agreement with the TSO prior to commencement of the manufacturing of main electrical components.
    - Indicative budget: US$350,000 to 700,000.
- As-build grid compliance studies (after construction). During the test and commissioning of the OWF, several measurements of the electrical plant characteristics and overall performance will be executed. Final electrical studies will complement the verification of the OWF grid code compliance and constitute the final acceptance from the TSO for OWF grid connection and operation. Indicative budget: US$250,000 to 500,000.

lxiv These will be required by TSO to minimize/eliminate harmonic distortion injected into the power grid by the OWF.

14 STAKEHOLDERS

The key stakeholders that have been identified are listed in Table 14.1 under four main groups:

- Government: Government departments, regulators, and institutions at the national and regional level.
- International NGOs: International NGOs with an interest in offshore wind in Türkiye.
- National NGOs: National NGOs with an interest in offshore wind in Türkiye.
- Academia and civil society: National and international academic institutions and civil society organizations with an interest in offshore wind in Türkiye.

TABLE 14.1 LIST OF KEY STAKEHOLDERS FOR OFFSHORE WIND DEVELOPMENT IN TÜRKİYE.

Name	Notes and website
Governmental	
MENR	enerji.gov.tr
TEIAS	www.teias.gov.tr
GDEA	The main policy-making body within the MENR https://enerji.gov.tr/eigm
EMRA	www.epdk.gov.tr
MoEUCC	csb.gov.tr
The General Directorate of Environmental Impact Assessment	ced.csb.gov.tr
Directorate General of National Property	milliemlak.gov.tr
Ministry of Transport and Infrastructure	www.uab.gov.tr
Local authorities including governorships, municipalities, and port authorities	n/a
Turkish Naval Forces, Office of Navigation, Hydrography, and Oceanography	www.shodb.gov.tr
Directorate of Central Fisheries Research Institute, Ministry of Agriculture, and Forestry	https://arastirma.tarimorman.gov.tr/sumae/Sayfalar/EN/AnaSayfa.aspx
General Directorate for Protection of Natural Assets, Ministry of Environment Urbanization and Climate Change	https://tvk.csb.gov.tr/en

Name	Notes and website
General Directorate of Nature Conservation and National Parks, Ministry of Agriculture and Forestry	https://www.tarimorman.gov.tr/DKMP/Sayfalar/EN/AnaSayfa.aspx
TUBITAK, Marmara Research Center Earth and Marine Sciences Institute	https://ydbe.mam.tubitak.gov.tr/en
Food and Agriculture Organization (FAO) Türkiye	https://www.fao.org/turkiye/en/
United Nations Development Programme, Türkiye	https://www.undp.org/turkiye
International NGOs	
Agreement on the Conservation of Cetaceans of the Black Sea, Mediterranean Sea, and contiguous Atlantic area (ACCOBAMS)	https://accobams.org/
BirdLife International	https://www.birdlife.org/
Flora and Fauna International	http://https://www.fauna-flora.org/
Global Ocean Biodiversity Initiative	http://gobi.org/
State of the World's Sea Turtles (SWOT)	https://www.seaturtlestatus.org/
Tethys	https://www.tethys.org/
The Marine Mammal Protected Areas Task Force (MMPATF)	https://www.marinemammalhabitat.org/mmpatf/
Local NGOs	
DenizTemiz Dernegi (TURMEPA)	info@turmepa.org.tr
Doga Arastirmalari Dernegi	http://www.dogaarastirmalari.org.tr/
Doga Dernegi (local BirdLife International Partner)	https://www.dogadernegi.org/en/
Doga ve Surdurulebilirlik Dernegi (DOSDER)	bilgi@dosder.org.tr
Ecological Research Society (EKAD)	https://ekad.org.tr/en/about-us/
Greenpeace Türkiye	https://www.greenpeace.org/turkey/
Ichthyological Research Society	n/a
Kadin Balikcilar Dernegi (Fisherwomen Society)	https://kadinbalikcilardernegi.org/about-us/
Marine Mammals Research Association (DMAD)	http://www.dmad.org.tr/
Mediterranean Association to Save the Sea Turtles (MEDASSET)	https://www.medasset.org/
Mediterranean Conservation Society	https://www.akdenizkoruma.org.tr/en/
Nature Conservation Center (DKM)	https://www.dkm.org.tr/en
Sea Turtle Research, Rescue, and Rehabilitation Center (DEKAMER)	https://www.dekamer.org.tr/index-eng.html
Sustainable Fishing and Environmental Research Society (SUBACAD)	https://www.subacad.org/
Turkish Marine Research Foundation (TUDAV)	https://tudav.org/

Name	Notes and website
Underwater Research Society Mediterranean Seal Research Group (SAD-AFAG)	https://sadafag.org/
WWF Türkiye	https://www.wwf.org.tr/
Yelkouan Shearwater Project	https://yelkouanshearwater.org/en/
Academia and civil society	
Eurasia Institute of Earth Sciences, Istanbul Technical University	https://eies.itu.edu.tr/en/homepage
Faculty of Marine Sciences and Technology, Canakkale Onsekiz Mart University	https://denbiltek.comu.edu.tr/
Institute of Marine Sciences and Management, Istanbul University	https://denizbilimleri.istanbul.edu.tr/tr/_
Institute of Marine Sciences and Technology, Karadeniz Technical University	https://www.ktu.edu.tr/dbe
Institute of Marine Sciences, Middle East Technical University	https://ims.metu.edu.tr/
Marine Sciences and Technology Institute, Dokuz Eylul University	http://imst.deu.edu.tr/tr/deniz-jeolojisi-ve-jeofizigi/derin-deniz-arast-rmalar/
Ornithological Research Center, Ondokuz Mayis University	https://ornitolojiarmer.omu.edu.tr/
Research and Application Center of Underwater, Ege University	https://saum.ege.edu.tr/eng-/Homepage.html
Central Association of Aquaculture Cooperations	https://www.sur.coop/
Karadeniz Doga Koruma Federasyonu (KarDoga)	http://www.kardoga.org
Union of Chambers of Turkish Engineers and Architects (TMMOB)	https://www.tmmob.org.tr/en

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APPENDICES

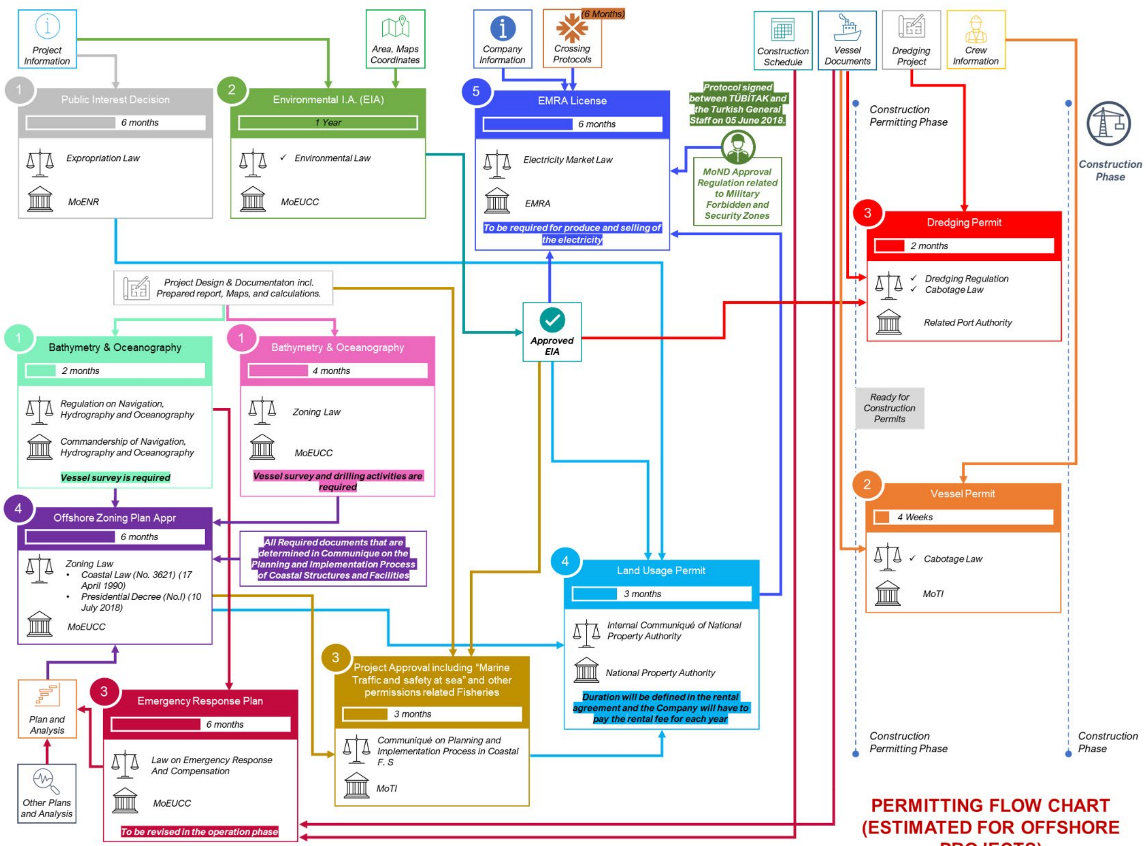
APPENDIX A —PERMITTING RELATED TO CONSTRUCTION OF OFFSHORE INFRASTRUCTURE

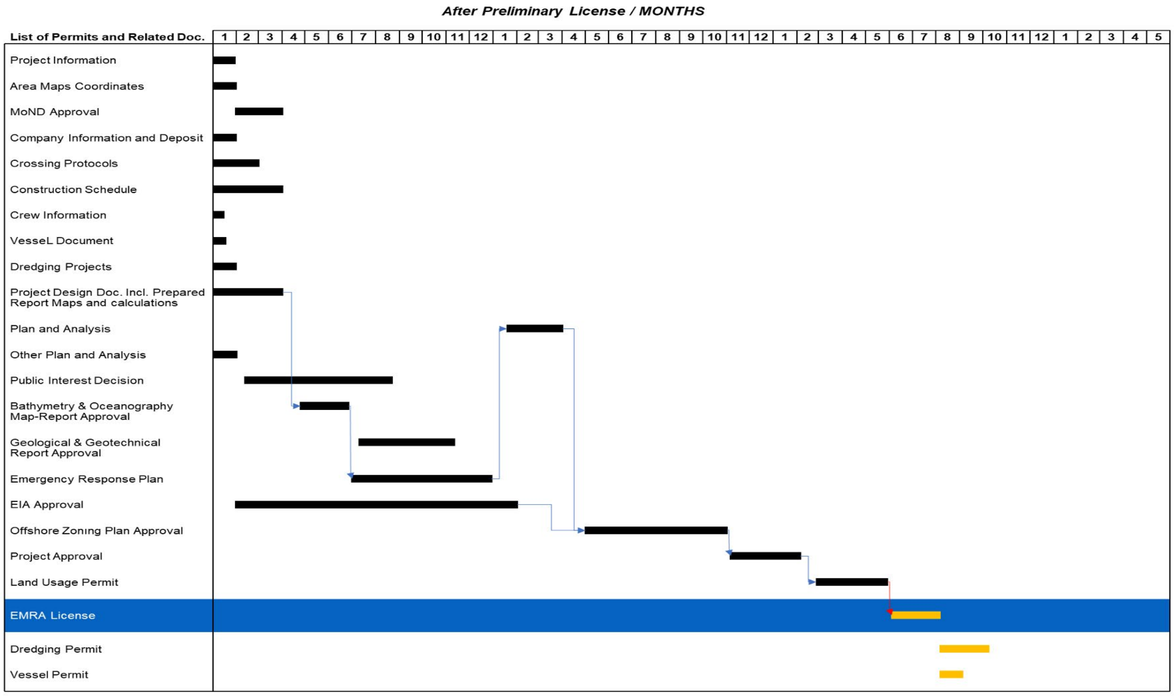
Project phase	Permit/ approval name	Content of application file	Regulation	Authority	Duration	Notes
General	EPDK Licenses	Land Usage permit Approved EIA Company information and deposit	Electricity Market Law	EPDK	2 Months—Revised from 6 to 2 months	To be required for produce and selling of the electricity
	Public Interest Decision	General project documents	Expropriation Law	MENR	5-6 Months	To be required for the land acquisition works of the offshore facilities (if required)
	Obtaining Positive Opinion of Military for the Project Area	Project area maps and coordinates Project information	Military forbidden and security zones regulation issued by the decision of Council of Ministers, dated 17/1/1983 and decision no: 83/5949. The requirement of such approval is stated in the EMRA License Regulation	MoND	2 Months	To be required for the license In accordance with a protocol signed between TÜBİTAK (The Scientific and Technological Research Council of Türkiye) and the Turkish General Staff on 05 June 2018.
Engineering	Environmental Impact Assessment (EIA)	Project area maps and coordinates Project information	Environmental Law	MoEUCC	1 Year	
	Geological & Geotechnical Report Approval	Prepared report and maps and calculations	Zoning Law	MoEUCC	3-4 Months	Vessel survey and drilling activities are required
	Bathymetry & Oceanography Map-Report Approval	Prepared maps and report	Regulation on Navigation, Hydrography, and Oceanography	Commandership of Navigation, Hydrography and Oceanography	1-2 Months	A vessel survey is required
	Offshore Zoning Plan Approval	All required documents that are determined in communique on the planning and implementation process of coastal structures and facilities such as: Approved EIA Approved geotechnical and bathymetry reports Prepared plans and analysis, etc.	Zoning Law Coastal Law (No 3621) (17 April 1990) Presidential Decree (No I) (10 July 2018)	MoEUCC	4-6 Months	

Project phase	Permit/ approval name	Content of application file	Regulation	Authority	Duration	Notes
Engineering	Project Approvals of the Facilities including "Marine Traffic and safety at sea" and other permissions related Fisheries	Approved EIA Approved zoning plan Project design and documents	Communiqué on planning and implementation process in coastal structures and facilities	MoTI	2-3 Months	Site inspection required with the Ministry team
	Land Usage Permit	Approved EIA Approved zoning plan Approved project	Internal Communiqué of National Property Authority	National Property Authority	2-3 Months	Duration will be defined in the rental agreement and the company will have to pay the rental fee for each year
	Emergency Response Plan	Approved bathymetry and oceanography report Vessel information and detail Construction activity details and schedule	Law on emergency response and compensation of damages in pollution of the marine environment with oil and other harmful substances	MoEUCC	5-6 Months	To be revised in the operation phase
	Crossing Protocols with Existing Infrastructures	Crossing projects	N/A	Related company and authority	5-6 Months	The investor is obliged to make crossing protocols with existing infrastructure owners
Construction	Dredging Permit	Approved EIA Vessel documents Crew information	Dredging Regulation Cabotage Law	Related Port Authority	1-2 Months	
	Vessel Permits		Cabotage Law	MoTI	3-4 Weeks	

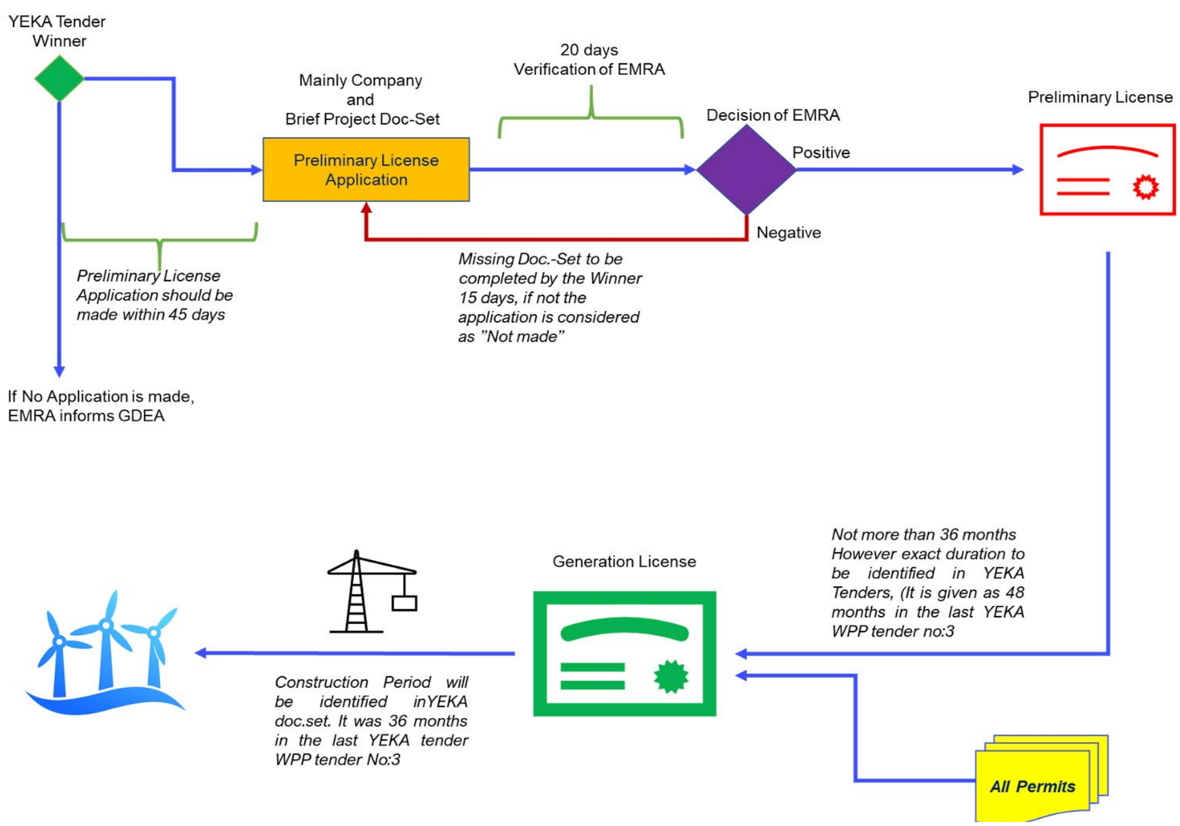
APPENDIX B — FLOWCHARTS FOR THE SEQUENCE OF PERMITTING RELATED TO OWF PROJECTS

Flowcharts for the sequence of permitting related to OWF projects





FLOW CHART FOR PRELIMINARY LICENSE and GENERATION LICENSE



APPENDIX C — PRIORITY BIODIVERSITY VALUES

1 INTRODUCTION

The World Bank Group (WBG) commissioned The Biodiversity Consultancy to provide environmental support for the WBG Offshore Wind Development Program. This support includes the completion of early-stage identification of priority biodiversity values to inform the offshore wind country road map for Türkiye. Incorporating important biodiversity considerations in the assessment of 'practical potential' for offshore wind development is essential to avoid adverse impacts from inappropriate development and provide a foundation for a pipeline of bankable projects eligible for funding by International Finance Institutions.

The WBG and International Finance Corporation (IFC) environment and social requirements are integral to the Offshore Wind Development Program, and the production of individual country roadmaps. They enable WBG, IFC and client countries to better manage the environmental and social risks of projects, and to improve development outcomes. The WBG Environmental and Social Framework, and the IFC Sustainability Framework promote sound environmental and social practices, transparency and accountability. These Frameworks define client responsibilities for managing risks and ensure that offshore wind sector preparatory work is aligned with good international industry practice (GIIP). Of particular relevance to this study are:

- WBG Environmental and Social Standards 6 (ESS6) Biodiversity Conservation and Sustainable Management of Living Natural Resources (2018); and
- IFC Environmental and Social Performance Standard 6 (PS6): Biodiversity Conservation and Sustainable Management of Living Natural Resources (2012) and Guidance Notes

The objective of this study is to identify priority biodiversity values and areas that support these values that should either be excluded from offshore wind development (i.e., no-go areas), or require additional assessment through subsequent Marine Spatial Planning (MSP), site selection and Environmental and Social Impact Assessment (ESIA) processes. To meet GIIP, wind developments in areas supporting priority biodiversity values would likely be subject to restrictions in the form of greater requirements for baseline studies, as well more intensive mitigation measures to avoid, minimise and restore adverse environmental impacts. According to IFC PS6, projects with priority biodiversity values situated within Critical Habitat are required to demonstrate that:

- No other viable alternatives within the region exist for development of the project on modified or natural habitats that are not critical;
- The project does not lead to measurable adverse impacts on those biodiversity values for which the critical habitat was designated, and on the ecological processes supporting those biodiversity values;

- The project does not lead to a net reduction in the global and/or national/regional population of any Critically Endangered or Endangered species over a reasonable period of time; and
- A robust, appropriately designed, and long-term biodiversity monitoring and evaluation program is integrated into the client's management program.

In addition, the project needs to achieve net gains of those biodiversity values for which the Critical Habitat was designated.

This study has focussed on the following key groups of priority biodiversity values, which have been identified through a review of the scientific literature and on experiences in well-developed offshore wind markets:

- Protected Areas (PAs) and Internationally Recognized Areas (IRAs)
- Natural Habitats[lxv]
- Marine Mammals (cetaceans and pinnipeds)
- Birds (seabirds and non-marine large migratory bird species)
- Sea Turtles
- Fish

2 METHODOLOGY

For each group of priority biodiversity values, available global and regional spatial datasets were identified and screened for inclusion in one of two spatial data layers for use in the country roadmap:

1. Exclusion Zone (i.e., areas of the highest biodiversity sensitivity to exclude from the technical assessment of offshore wind resource); and
2. Restriction Zone (i.e., high risk areas requiring further assessment of risk during MSP, site selection and/or ESIA).

Numerous global and regional biodiversity datasets exist (primarily produced by academic, scientific and government and non-governmental organisations) and are useful and important resources. Broadly, these datasets provide an indication of the distribution of given biodiversity values. For example, datasets show:

- Verified point records of species occurrence;
- Species range maps;
- The extent of a particular habitat or ecosystem type, or location of key habitat features;
- Modelled indicative habitat suitability;
- The boundaries of globally important PAs and IRAs that represent areas of high biodiversity conservation value.

lxv For the purposes of this study marine benthic invertebrates are included as integral components of marine Natural Habitats.

Threatened and range-restricted species are the focus of criteria 1 and 2 for the determination of Critical Habitat, as defined by IFC PS6 and therefore represent priority biodiversity values. As a foundational stage, the IUCN Red List was screened to identify all threatened and all range-restricted[lxvi] marine species with global ranges that overlap with Türkiye's Exclusive Economic Zone (EEZ). A detailed literature search was completed to identify spatial data and additional contextual information on these species. In addition to identifying digitised spatial data, supplementary data sources were identified and is summarised in the following subsections. In addition to informing this country roadmap, the available secondary data is vitally important to inform future MSP, site selection and ESIA stages of offshore wind development.

3 PROTECTED AREAS AND INTERNATIONALLY RECOGNIZED AREAS

PAs and IRAs represent high value areas designated for various biodiversity conservation objectives, and some should be excluded from consideration for offshore wind development because of this. For example, development in KBAs should be avoided because these sites represent the most important places in the world for species and their habitats[lxvii]. In UNESCO Natural and Mixed World Heritage Sites[lxviii], and Alliance for Zero Extinction (AZE) sites, WBG/IFC standards prohibit development (IFC 2012b). Other types of designated area, such as Ecologically or Biologically Significant Marine Areas (EBSAs), maybe much larger spatial designations and offshore wind development may be feasible if sufficient research is undertaken and if it is carefully managed, with development activities being coordinated to avoid key sensitive periods for biodiversity.

3.1 Nationally protected areas

A protected area is a clearly defined geographical space, recognised, dedicated and managed, through legal or other effective means, to achieve the long-term conservation of nature with associated ecosystem services and cultural values. (IUCN Definition 2008). They are afforded varying levels of legal protection in different national jurisdictions—however they are often underpinned by commitments made under international conventions. The PA system is Türkiye is aligned with the IUCN management categories[lxix], and include the following:

- National Parks[lxx]
- Nature Parks[lxxi]
- Nature Reserves
- Special Protection Areas
- Natural Protected Areas (three types)
  - Strict Protection
  - Protected Natural Ecosystems
  - Sustainable Use

lxvi Range-restricted marine species are defined by IFC PS6 as having an Extent of occurrence less than 100,000 km2

lxvii Keybiodiversityareas.org

lxviii There are no UNESCO Natural and Mixed World Heritage Sites designated in Türkiye with marine components.

lxix https://www.iucn.org/theme/protected-areas/about/protected-area-categories

lxx https://www.tarimorman.gov.tr/DKMP/Belgeler/Korunan%20Alanlar%20Listesi/1-%20Milli%20Parklar.pdf

lxxi https://www.tarimorman.gov.tr/DKMP/Belgeler/Korunan%20Alanlar%20Listesi/2-%20Tabiat%20Parklar%C4%B1.pdf

Most of the Turkish PA network cover terrestrial areas, although eleven of the 18 designated Special Protect Areas (SPA) include marine components (Figure 1): Saros Korfezi, Foca, Karaburun-Ildir Korfezi, Gokova Datca-Bozburun, Koycegiz-Dalyan, Fethiye Gocek, Patara, Kas Kekova, Belek and Goksu Deltasi. SPAs in Türkiye are areas that are legally protected in compliance with the provisions of the Convention for the Protection of the Marine Environment and the Coastal Region of the Mediterranean (Barcelona Convention), under the Protocol Concerning Specially Protected Areas and Biological Diversity in the Mediterranean. These eleven SPAs have been included within the Exclusion Zone layer.

FIGURE 1: SPAS IN TÜRKİYE (SOURCE HTTPS://OCKB.CSB.GOV.TR/OCK-BOLGELERI-HARITA-I-55)

3.1.1 Ramsar Sites

Ramsar sites are wetlands of international importance that have been designated under the criteria of the Ramsar Convention on Wetlands for containing representative, rare or unique wetland types or for their importance in conserving biological diversity. Contracting Parties are expected to manage their Ramsar Sites to maintain their ecological character and retain their essential functions and values for future generations. There are fourteen Ramsar Sites designated in Türkiye, of which five have marine components (Table 1)[lxxii]. It is unlikely that offshore wind development is compatible with maintaining these sites' ecological character and function and therefore all five Ramsar Sites have been included within the Exclusion Zone layer.

lxxii https://rsis.ramsar.org/sites/default/files/rsiswp_search/exports/Ramsar-Sites-annotated-summary-Turkey.pdf?1616674343

TABLE 1: RAMSAR SITES IN TÜRKİYE WITH MARINE COMPONENTS

Ramsar Site	Important biodiversity features
Göksu Delta	An important wetland delta located on a bird migration route. Sands and saline steppe cover large areas. The site supports reedbeds, marshes, swamps, meadows and, in the surrounding area, agricultural fields. It is a refuge for internationally important numbers of wintering ducks. Up to 327 bird species occur, including *Phalacrocorax pygmeus* and *Pelecanus crispus*. Three species of threatened marine turtles nest in the area.
Gediz Delta	An extensive coastal wetland with bays, salt and freshwater marshes, large saltpans, and four highly saline lagoons located at the mouth of the Gediz River near Izmir. The site supports dry grasslands, arable land, and some woodlands. The globally Near Threatened *Pelecanus crispus* breeds at the site. An important area for breeding, feeding, wintering, and sheltering internationally important numbers of numerous species of waterbirds.
Akyatan Lagoon	A coastal lagoon surrounded by brackish marshes, sandy shores, freshwater pools, wet meadows, and dunes. Among the dunes are pits extending below sea level that fill with freshwater in the rainy season. The site provides habitat for several globally threatened species, including breeding marine turtles, and regularly supports internationally important numbers of numerous species of migrating, wintering and breeding waterbirds
Yumurtalik Lagoon	Comprises the whole of the alluvial delta formed by several rivers in the eastern Mediterranean Sea, with a broad array of freshwater and coastal habitat types which support sand dune vegetation, salt marsh vegetation, stream bank vegetation, and ruderal vegetation of roadsides and field margins. The threatened sea turtles *Caretta caretta* and *Chelonia mydas* are supported, and the site is one of the key points where migratory birds on the Palaearctic-Africa route meet, using the site as both a stopover and a wintering site. It is also a key area for fish reproduction.
Kızılırmak Delta	The site includes dunes, beaches, shallow lakes, seasonal marshes, and wooded areas. Dominant vegetation includes vast reedbeds and seasonally flooded forest. Numerous species of waterbirds breed at the site, several of which are globally threatened. Over 92,000 waterbirds of various species winter at the site.

3.2 KBAs

Key Biodiversity Areas (KBA) have been designated to cover the most important places in the world for species and their habitats. KBAs are identified using a global standard that include criteria that were developed through a multi-stakeholder process. These criteria include quantitative thresholds that mean that sites are globally important for the long-term survival of biodiversity. KBA identification is rigorous, transparent and consistent in different countries and over time.

Sites qualify as global KBAs if they meet one or more of 11 criteria, clustered into five higher level categories: threatened biodiversity, geographically restricted biodiversity, ecological integrity, biological processes, and irreplaceability[lxxiii]. The KBA criteria are broadly aligned with IFC PS6 criteria for Critical Habitat, although they include a wider set of criteria and therefore not all KBAs will qualify as Critical Habitat. All existing BirdLife International Important Bird Areas (IBA) qualify as KBAs (see section 3.2.1). All existing Alliance for Zero Extinction (AZE) sites are also KBAs.

Designation as a KBA does not confer legal protection. However, the IUCN recommends that environmentally damaging industrial activities and infrastructure should be avoided within KBAs[lxxiv] and therefore all KBAs have been included within the Exclusion Zone layer.

lxxiii http://www.keybiodiversityareas.org/working-with-kbas/proposing-updating/criteria

lxxiv https://portals.iucn.org/library/sites/library/files/resrecfiles/wcc_2016_rec_102_en.pdf

3.2.1 Important Bird Areas (IBA)

The BirdLife Global Seabird Programme has identified Marine IBAs that include seabird breeding colonies, foraging areas around breeding colonies, non-breeding (usually coastal) concentrations, migratory bottlenecks and feeding areas for pelagic species. The methodology for the designation of marine IBAs is described in the marine IBA tookit (BirdLife International 2010). Türkiye has 19 marine IBAs, including known breeding colonies of Audouin's Gull (*Larus audouinii*, Vulnerable) and European Shag (*Gulosus aristotelis*, Least Concern) (Table 2).

Currently, the breeding population of Audouin's Gull in Türkiye is estimated between 70 and 150 pairs distributed between seven known breeding sites (Onmuş & Gönülal 2019):

- Aydıncık Islets in Mersin province (17 pairs in 2001)
- Palamutbükü Islet in Datça Peninsula (20–30 pairs in 2000–2002)
- Bodrum Islets in Bodrum Peninsula (2–10 pairs);
- Güllük Islets in Güllük Bay (3–5 pairs),
- Büyükada in Karaburun Peninsula (23 pairs in 2003),
- Alaçatı Islet in Çeşme (20 pairs in 1995); and
- Gökçeada (Imbros) Island (28 pairs in 2018).

With the possible exception of Gökçeada (Imbros) Island, which was only identified in 2018, these breeding colonies appear to be included within marine IBAs. All IBAs have been included within the Exclusion Zone layer.

Marine IBAs do not cover all of the known breeding sites for European Shag. Doğa Derneği identified 45 confirmed breeding sites along the Black Sea coastline, with the highest number of breeding pairs at Zonguldak (152), followed by Haydarpaşa (88) and Şile (53) (Pérez-Ortega & İsfendiyaroğlu 2017). However, no digitized spatial datasets were identified for seabird colonies, except those contained within IBAs.

TABLE 2: MARINE IBAS IN TÜRKİYE

Marine IBA	IBA Criteria[lxxv]	Marine bird trigger species
Akkuş Island	B3	European Shag *Gulosus aristotelis*—IUCN LC
Alaçatı	A1, A3, B2	Audouin's Gull *Larus audouinii*—IUCN VU
Aydıncık and Ovacık Coast	A1, B2	Audouin's Gull *Larus audouinii*—IUCN VU
Ayvalık	B1i, B3	European Shag *Gulosus aristotelis*—IUCN LC Yellow-legged Gull *Larus michahellis*—IUCN LC
Bodrum Islands	B2	Audouin's Gull *Larus audouinii*—IUCN VU

lxxv http://datazone.birdlife.org/site/ibacriteria

Marine IBA	IBA Criteria[lxxv]	Marine bird trigger species
Bosphorus	A4i, A4ii, A4iii, A4iv, B1i, B1ii, B1iv, B3	Yelkouan Shearwater *Puffinus yelkouan*—IUCN VU European Shag *Gulosus aristotelis*—IUCN LC Great Cormorant *Phalacrocorax carbo*—IUCN LC Black-headed Gull *Larus ridibundus*—IUCN LC Mediterranean Gull *Larus melanocephalus*—IUCN LC Yellow-legged Gull *Larus michahellis*—IUCN LC A4iii Species group—waterbirds
Büyük Menderes Delta	A1, A4i, A4iii, B1i, B2	Ruddy Shelduck *Tadorna ferruginea*—IUCN LC Eurasian Wigeon *Mareca penelope*—IUCN LC Greater Flamingo *Phoenicopterus roseus*—IUCN LC Common Coot *Fulica atra*—IUCN LC Dalmatian Pelican *Pelecanus crispus*—IUCN NT Pygmy Cormorant *Microcarbo pygmaeus*—IUCN LC Great Cormorant *Phalacrocorax carbo*—IUCN LC Pied Avocet *Recurvirostra avosetta*—IUCN LC Kentish Plover *Charadrius alexandrinus*—IUCN LC Collared Pratincole *Glareola pratincola*—IUCN LC Caspian Tern *Hydroprogne caspia*—IUCN LC A4iii Species group - waterbirds
Çiçek Islands	B1i	Yellow-legged Gull *Larus michahellis*—IUCN LC
Datça and Boğburun Peninsula	A1, A3, B2	Audouin's Gull *Larus audouinii*—IUCN VU
Giresun Island	B1i	Velvet Scoter *Melanitta deglandi*—IUCN VU
Karaburun and İldir Strait Islands	A1, A3, A4ii, B1ii, B2	Audouin's Gull *Larus audouinii*—IUCN VU Yelkouan Shearwater *Puffinus yelkouan*—IUCN VU
Marmara Islands	A4ii, B1i, B1ii, B2, B3	Yelkouan Shearwater *Puffinus yelkouan*—IUCN VU European Shag *Gulosus aristotelis*—IUCN LC Yellow-legged Gull Larus michahellis—IUCN LC
Sakarya Delta	B1i	Velvet Scoter *Melanitta deglandi*—IUCN VU
Şile Coast	B1i, B3	European Shag *Gulosus aristoteli*—IUCN LC

3.3 EBSAs

EBSAs are special areas in the ocean that support the healthy functioning of oceans and the many services that it provides. The Conference of the Parties (COP 9) to the Convention on Biological Diversity adopted the following seven scientific criteria for identifying EBSAs: Uniqueness or Rarity, Special importance for life history stages of species, Importance for threatened, endangered or declining species and/or habitats, Vulnerability, Fragility, Sensitivity, or Slow recovery, Biological Productivity, Biological Diversity, and Naturalness. The identification of EBSAs and the selection of conservation and management measures is a matter for States and competent intergovernmental organizations, in accordance with international law (including the UN Convention on the Law of the Sea). The criteria do not include quantitative threshold, but in principle they have a lot in common with WBG/IFC Natural Habitat definition and Critical Habitat criteria, and could therefore constitute and important high-level planning consideration for offshore wind development. However, within Türkiye the majority of EBSA features are better defined by other designations such as KBAs and IMMAs. Therefore, they have been included within the Restriction Zone layer.

There are four EBSAs (Secretariat of the Convention on Biological Diversity n.d.) in Türkiye: North Aegean, Central Aegean, Hellenic Trench, and North-East Levantine Sea. Together, they cover the entire Mediterranean coastal area of Türkiye. The important features recognised in each of the EBSA designations are summarised in Table 3.

TABLE 3: EBSAS IN TÜRKİYE (CONVENTION ON BIOLOGICAL DIVERSITY, 2014)

EBSA	Marine mammals	Turtles	Birds	Fish	Natural Habitats
North-East Levantine Sea	The Mediterranean Monk Seal (*Monachus monachus*) is perhaps the most critical element of the ecosystem. Important breeding habitats have been identified in the Taseli strait, west coast of Mersin.	The area provides important nesting sites to Green Turtle (*Chelonia mydas)* and Loggerhead Turlte (*Caretta caretta).* The pelagic area is also important for foraging of both species, while the area between Cyprus and Türkiye is part of a migratory corridor of Green Turtle. The dense seagrass beds off Babadıl creek is a favorable foraging area.	Audouin's gull nests on the Gilindire islands in Aydıncı. The main accumulations of feeding juveniles occur around Sanca cape and Beşparma island.	Bluefin Tuna (*Thunnus thynnus*)—IUCN Endangered. One of only six spawning areas in the Mediterranean which supports the entire eastern Atlantic and Mediterranean bluefin tuna stock. The spawning site for Bluefin Tuna is not currently included in any KBA. The spawning area used by Bluefin Tuna are influenced by environmental factors such as sea temperature, turbulence and high plankton densities (Druon 2009), which varies spatially year to year. Based on the results of the modelling and survey studies (e.g., Yalçın 2019), a large proportion of the North-East Levantine Sea EBSA area is of importance to breeding Bluefin Tuna.	*Posidonia oceanica* seagrass beds

EBSA	Marine mammals	Turtles	Birds	Fish	Natural Habitats
Hellenic Trench	A deep trench ranging from between 200-2000 metres extends is an arch starting from the Greek Ionian islands, around the Peloponnese, to the south of Crete and further north-east, past the southern coast of the island of Rhodes towards the south-west coast of Türkiye. Surveys have shown that it supports significant populations of the deep-diving cetaceans, Sperm Whale (*Physeter macrocephalus*) and Cuvier's Beaked Whale (*Ziphius cavirostris*).	n/a	n/a	n/a	Coastal areas of important Natural Habitats include including Posidonia seagrass beds, brown algae forests, and coralligenus formations
Central Aegean Sea	The deep area between the Cyclades and the Dodecanese archipelagos constitutes an important corridor for Sperm Whales migrating between the northern Aegean Sea and rest of the Mediterranean Sea. The area also hosts populations of bottlenose (*Tursiops truncatus*), striped (*Stenella coeruleoalba*) and common dolphins (*Delphinus delphis*).	n/a	Features of interest in the Turkish portion of the EBSA include migratory Yelkouan Shearwater, as well as breeding colonies of Audouin's Gull and the Mediterranean subspecies of European shag.	Sandbar shark (*Carcharhinus plumbeus*)—IUCN Vulnerable. Boncuk Bay is one of only two known nursery grounds of the Sandbar shark in the Mediterranean basin. The nursery area for Sandbar Shark in Boncuk Bay is included within the Datça and Bozburun Peninsula KBA.	Coralligenous formations and maerl beds are coralline algal frameworks, which in the eastern Mediterranean usually occur below 70 m deep Their exact distribution within the EBSA is not known. *Posidonia oceanica* seagrass beds

EBSA	Marine mammals	Turtles	Birds	Fish	Natural Habitats
North Aegean	The only area in the Mediterranean hosting a regular population of Endangered Black Sea Harbour Porpoise (*Phocoena phocoena ssp. relicta*) and likely to host the highest diversity of marine mammals in the eastern Mediterranean.	n/a	n/a	The North Aegean is possibly the most productive part of the Eastern Mediterranean in terms of primary production and small pelagic fisheries, such as Sardine (*Sardina pilchardus*) and White Anchovy (*Engraulis albidus*), due to the incoming waters from the Black Sea, as well as inflow from rivers. The fish fauna includes 28 shark and ray species, some of which are protected species such as *Oxynotus centrina, Squatina aquatina, Squatina oculata, Squalus acanthias and Rostroraja alba.* The area also supports pelagic fish spawning grounds. There is some overlap within the North Aegean EBSA with KBAs and nationally protected areas within Saros Bay, which is designated as a Special Protection Area. However, the majority of the EBSA is not designated.	n/a

3.4 Important Marine Mammal Areas

Important Marine Mammal Areas (IMMAs) is a joint project between the IUCN Species Survival Commission (SSC) and World Commission on Protected Areas (WCPA) (IUCN-MMPATF 2019). IMMAs are defined as discrete portions of habitat, important to marine mammal species, that have the potential to be delineated and managed for conservation. IMMAs are designated using standard criteria, through the organisation of regional expert workshops:

- Criterion A—Species or Population Vulnerability: Areas containing habitat important for the survival and recovery of threatened and declining species.
- Criterion B—Distribution and Abundance
- Sub-criterion B1—Small and Resident Populations: Areas supporting at least one resident population, containing an important proportion of that species or population, that are occupied consistently.
- Sub-criterion B2—Aggregations: Areas with underlying qualities that support important concentrations of a species or population.
- Criterion C—Key Life Cycle Activities
- Sub-criterion C1—Reproductive Areas: Areas that are important for a species or population to mate, give birth, and/or care for young until weaning.
- Sub-criterion C2—Feeding Areas: Areas and conditions that provide an important nutritional base on which a species or population depends.
- Sub-criterion C3—Migration Routes: Areas used for important migration or other movements, often connecting distinct life-cycle areas or the different parts of the year-round range of a non-migratory population.
- Criterion D—Special Attributes
- Sub-criterion D1—Distinctiveness: Areas which sustain populations with important genetic, behavioural or ecologically distinctive characteristics.
- Sub-criterion D2—Diversity: Areas containing habitat that supports an important diversity of marine mammal species.

Each criteria have quantitative thresholds that are aligned with both IUCN standard for the identification of KBAs (IUCN 2016), and IFC PS6 criteria for Critical Habitat. Therefore, IMMAs should generally meet IUCN KBA and potentially IFC Critical Habitat criteria. There are five IMMAs in Türkiye (Table 4). All IMMAs in Türkiye are designated for Mediterranean Monk Seal, either as qualifying species under IMMA criteria A, C (i) or as secondary species (IMMA Criterion D (ii) - Diversity). With a global population of just 350-450 mature individuals, any remaining areas regularly used by breeding or foraging Mediterranean Monk Seal are likely to be meet IFC PS6 Critical Habitat criteria for threatened species[lxxvi] (see 4.1.1). Therefore, all IMMAs have been included in the Restriction Zone layer.

lxxvi Areas that support globally-important concentrations of an IUCN Red-listed EN or CR species (0.5% of the global population AND 5 reproductive units of a CR or EN species).

TABLE 4: IMMAS IN TÜRKİYE

IMMA	Area (km^2)	Primary Species	IMMA Criteria[lxxvii]	Additional Species - (IMMA Criterion D (ii) Diversity)
Central Aegean	58,265	Mediterranean monk seal *Monachus monachus*	A; C (i)	*Delphinus delphis, Tursiops truncatus, Stenella coeruleoalba*
Chios and Turkish Coast	3,838	Mediterranean monk seal *Monachus monachus*	A; C (i)	
Cilician Basin	714	Mediterranean monk seal *Monachus monachus*	A; C (i)	
Hellenic Trench	56,568	Sperm whale *Physeter macrocephalus*	A; B (i, ii); C (i, ii); D (i)	*Stenella coeruleoalba, Grampus griseus, Delphinus delphis, Tursiops truncatus, Monachus monachus*
		Cuvier's beaked whale *Ziphius cavirostris*	B (ii); C (i, ii); D (i)	
Northern Coast and Islands of the Thracian Sea	5,441	Black Sea harbour porpoise *Phocoena phocoena relicta*	A; B (i); C (i, ii)	*Delphinus delphis, Tursiops truncates, Stenella coeruleoalba, Monachus monachus*

3.5 ACCOBAMS Cetaceans Critical Habitats

ACCOBAMS[lxxviii] is working on the identification of Cetaceans Critical Habitats (CCH) in the Mediterranean and Black Sea, in order to propose appropriate threats management or spatial management measures, in the form of Marine Protected Areas. The identification of CCH is based on the application of the following criteria:

- Areas used by cetaceans for feeding, breeding, calving, nursing and social behaviour;
- Migration routes and corridors and related resting areas;
- Areas where there are seasonal concentrations of cetacean species;
- Areas of importance to cetacean prey;
- Natural processes that support continued productivity of cetacean foraging species (upwellings,fronts, etc.);
- Topographic structures favourable for enhancing foraging opportunities for cetacean species (canyons, seamounts)

lxxvii https://www.marinemammalhabitat.org/immas/imma-criteria/

lxxviii The Agreement on the Conservation of Cetaceans of the Black Sea, Mediterranean Sea and contiguous Atlantic area

These criteria can be applied for the identification of sites containing cetacean critical habitats, in need of protection due to the occurrence of significant interactions between cetaceans and human activities, where:

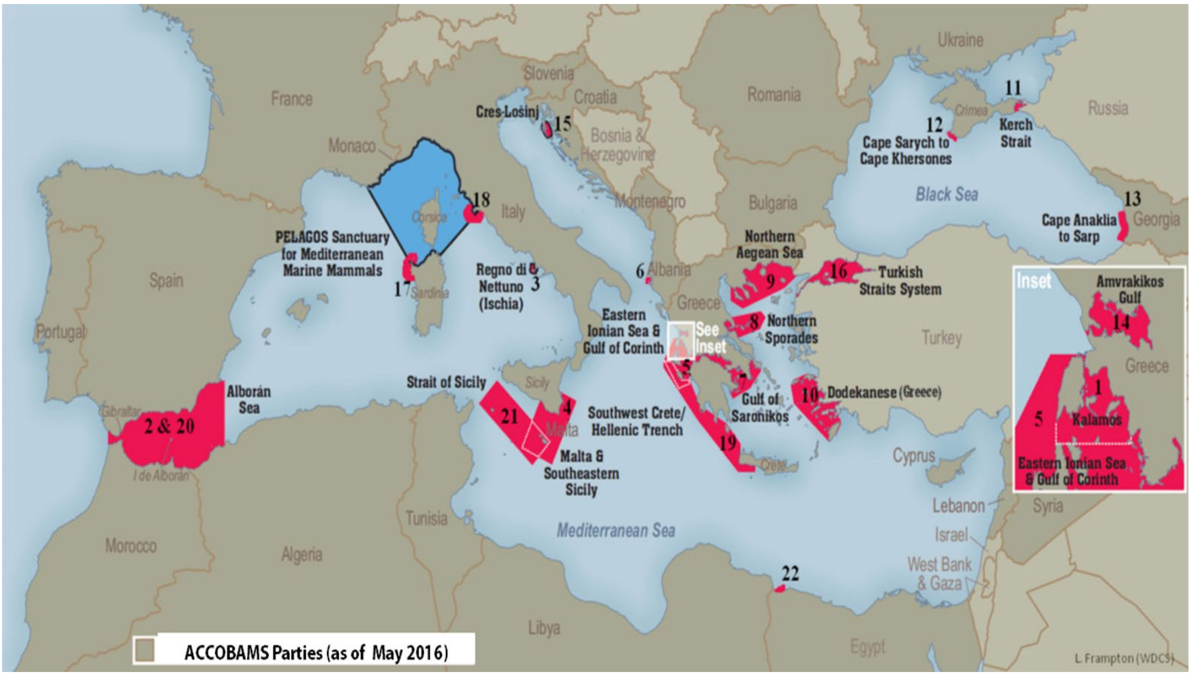
- Conflicts between cetaceans and fishing activities have been reported;
- Significant or frequent bycatch of cetaceans is reported;
- Intensive whale watching or other marine tourism activities occur;
- Navigation presents a potential threat to cetaceans;
- Pollution runoff, outflow or other marine dumping occur;
- Military exercises are known to routinely occur.

Although CCH criteria are broadly aligned with KBA criteria and IFC PS6 Critical Habitat criteria, it is not clear whether quantitative thresholds have been applied. Also, neither KBA nor IFC PS6 criteria include an assessment of the level of anthropogenic threat—therefore CCH should not be assumed to be Critical Habitat as defined by the IFC. ACCOBAMS has identified two areas of CCH in Türkiye (Figure 2):

- 10. Waters surrounding the Dodecanese (Greece)
- 16. The Turkish Straits system

It is not clear which criteria were applied to designate these two areas as CHH. The waters surrounding the Dodecanese (Greece) CCH area overlaps with Central Aegean IMMA. The Turkish Straits system CCH area is covered by an IMMA and is used by all Black Sea cetacean species. Therefore, it is recommended that The Turkish Straits system CCH area is treated as a Restriction Zone for marine mammals as further assessment is required in relation to marine mammals in the Marmara Sea to inform MSP, site selection and ESIA.

FIGURE 2: ACCOBAMS CCH (SOURCE: HTTPS://ACCOBAMS.ORG/CONSERVATIONS-ACTION/PROTECTED-AREAS/)



4 NATURAL HABITATS

Many PA and IRA designations focus on the protection of species as opposed to habitats. However, Natural Habitats are included as features of interest in the following:

- SPAs - Finike SPA designated for submarine mountains;
- EBSAs - Central Aegean EBSA and the North Aegean EBSA both cite the Natural Habitats of Coralligenous formations and maerl beds as important features.

4.1 Threatened Natural Habitats

The European Red List of Habitats[lxxix] (European Union, 2016) assessed 257 marine habitat types using a modification of the EUNIS habitat classification[lxxx]. The habitats identified as threatened in the Mediterranean Sea and Black Sea are listed in Table 5. The only digitised spatial data of marine Natural Habitat in Türkiye that was found was the modelled distribution of seagrass beds, coralligenous formations and maerl. These have been modelled by the Mediterranean Sensitive Habitats Project (MEDISEH), available from the EMODnet portal. Areas modelled as exceeding 70% probability of Coralligenous formations and maerl beds are recommended as Exclusion Zones and areas with a predicted probability of between 10-70% included in Restriction Zone layer.

lxxix https://ec.europa.eu/environment/nature/knowledge/redlist_en.htm

lxxx The EUNIS habitat classification is a comprehensive pan-European system for habitat identification. The classification is hierarchical and covers all types of habitats from natural to artificial, from terrestrial to freshwater and marine. The habitat types are identified by specific codes, names and descriptions - https://www.eea.europa.eu/data-and-maps/data/eunis-habitat-classification

TABLE 5: THREATENED HABITATS IN THE MEDITERRANEAN SEA AND BLACK SEA

Threat Status	Mediterranean Sea	Black Sea
Critically Endangered	n/a	• A5.xx Pontic circalittoral biogenic detritic bottoms with dead or alive mussel beds, shell deposits, with encrusting corallines (Phymatolithon, Lithothamnion) and attached foliose sciaphilic macroalgae
Endangered	• A2.31 Communities of Mediterranean mediolittoral mud estuarine • A3.13 Photophilic communities with canopy-forming algae in Mediterranean infralittoral and upper circalittoral rock • A3.238 Facies with *Cladocora caespitosa* • A5.52B Algal dominated communities in the Mediterranean infralittoral sediment • A5.6v Mediterranean infralittoral mussel beds • A5.6y Mediterranean infralittoral oyster beds	• A1.1xx Turf algae on Pontic moderately exposed lower mediolittoral rock • A1.44 Pontic mediolittoral caves and overhangs • A3.34 Fucales and other algae on Pontic sheltered upper infralittoral rock, well illuminated • A5.5w Seagrass meadows in Pontic lower infralittoral sands • A5.62 Mussel beds on Pontic circalittoral terrigenous muds
Vulnerable	• A2.25 Communities of Mediterranean mediolittoral sands • A2.33 Communities of Mediterranean mediolittoral mud • A2.7x Biogenic habitats of Mediterranean mediolittoral rock • A3.23 Photophilic communities dominated by calcareous, habitat forming algae • A3.36 Communities of Mediterranean infralittoral estuarine rock • A4.23 Communities of Mediterranean soft circalittoral rock • A5.27 Communities of Mediterranean lower circalittoral sand • A5.32 Communities of Mediterranean infralittoral mud estuarine • A5.38 Communities of Mediterranean infralittoral muddy detritic bottoms • A5.535 Posidonia beds in the Mediterranean infralittoral zone	• A4.24 Invertebrate-dominated Pontic circalittoral rock

4.2 Threatened marine benthic invertebrates in Türkiye

Only two species of threatened marine invertebrates have global ranges that overlap with the Turkish EEZ: Mediterranean Pillow Coral (*Cladocora caespitosa* - Endangered) and Fan Mussel (*Pinna nobilis* - Endangered) (Table 6).

Mediterranean Pillow Coral is the only species that forms monospecific reef-like structures in the Mediterranean. Although it occurs across much of the Mediterranean, it rarely forms reefs or beds. In Türkiye, it appears to be limited to a small number of locations. Recorded locations include the Strait of

Çanakkale, Gökçeada Island, Edremit Bay (Ozgalp & Alparslan 2011), Fethiye-Gocek SPA (Derinsu Sualti Muhendislik ve Danismanlik Ltd 2009) and Gülbahçe Bay (Pekçetinöz et al. 2009). No digitised spatial data for Mediterranean Pillow Coral were identified.

Since 2016, a devastating and geographically widespread mass mortality event (MME) has impacted Fan Mussel populations throughout its range, although is thought to still occur in some locations in Türkiye. Any remaining populations have a high probability to qualify as Critical Habitat. The species is generally found in sea grass beds between 0 - 60 metres water depth. According to the IUCN Red List, populations in the Northern Aegean are possibly extinct due to MME. However, small remnant populations occur within the Çanakkale Strait (Acarli et al. 2021) and around the Marmara Islands (Cinar et al. 2021) KBAs. The current status in the southern Aegean and Levantine seas has not been confirmed. Due to the close habitat association of Fan Mussel with seagrass beds, the MEDISEH modelled area exceeding 70% probability of seagrass is included as Exclusion Zone and areas with a predicted probability of between 10-70% included in Restriction Zone layer.

TABLE 6: THREATENED MARINE INVERTEBRATE SPECIES OCCURRING IN TÜRKİYE

Latin name	Common name	IUCN Threat status	Range Area km^2
Cladocora caespitosa	Mediterranean Pillow Coral	EN	409,911
Pinna nobilis	Fan Mussel	CR	63,265

5 MARINE MAMMALS

Marine mammals feature in the designations of several overlapping PAs and IRAs as described in Section 3, including:

- PAs—e.g., Foca SPA and Karaburun-Ildir Korfezi SPA, both designated for Mediterranean Monk Seal;
- KBAs—e.g., Aydıncık ve Ovacık Kıyıları KBA designated for Mediterranean Monk Seal;
- IMMAs—Central Aegean, Chios and Turkish Coast, Cilician Basin, Hellenic Trench and Northern Coast, Islands of the Thracian Sea, and Turkish Straits System;
- EBSAs—North Aegean, North-East Levantine Sea, Hellenic Trench, Central Aegean Sea;
- ACCOBAMS CCH—Waters surrounding the Dodecanese (Greece) and The Turkish Straits system

Taken together, these designated areas cover most of the Turkish EEZ within the Mediterranean Sea and Sea of Marmara.

5.1 Threatened marine mammals in Türkiye

Four threatened marine mammal species were identified to occur within Türkiye (Table 7). In addition, the IUCN Red List has assessed several marine mammal sub-species and sub-populations as threatened. With the exception of the Mediterranean Monk Seal (see Section 5.1.1) additional digitised spatial datasets were not found for marine mammals, although there are survey and sightings data available that would be useful to inform MSP, site selection and ESIA.

TABLE 7: THREATENED MARINE MAMMALS OCCURRING IN TUKEY

Latin name	Common name	IUCN threat status	Global range area km²
Monachus monachus	Mediterranean Monk Seal	EN	291,796
Phocoena phocoena ssp. relicta	Black Sea Harbour Porpoise	EN	-
Tursiops truncatus ssp. ponticus	Black Sea Bottlenose Dolphin	EN	-
Delphinus delphis (Mediterranean subpopulation)	Short-beaked Common Dolphin	EN (Sub-population) LC (Global)	-
Physeter macrocephalus (Mediterranean subpopulation)	Sperm Whale	EN (Sub-population) VU (Global)	347,262,854
Ziphius cavirostris Mediterranean subpopulation	Cuvier's Beaked Whale	VU (Mediterranean subpopulation) DD (Global)	1,344,103
Balaenoptera physalus	Fin Whale	VU (Global and Mediterranean subpopulation)	20,632,6476
Delphinus delphis ssp. Ponticus	Short-beaked Common Dolphin	VU	-
Tursiops truncatus (Mediterranean subpopulation)	Common Bottlenose Dolphin	VU (Sub-population) LC (Global)	-

5.1.1 Mediterranean Monk Seal

Historical commercial seal hunting and human persecution caused large declines in the global populations of Mediterranean Monk Seal, which number just 350-450 mature individuals (Karamanlidis & Dendrinos 2015). The largest sub-population of fewer than 250 mature individuals, remains in the Eastern Mediterranean. Although they once hauled out on beaches, the species is now restricted to undisturbed marine caves for hauling out, resting and pupping.

Offshore wind development poses several risks to the remaining Mediterranean Seal populations, of which disturbance is possibly of most concern. Faulkner et al (2019) predicted that Phocid seals would suffer Permanent Threshold Shift, (PTS—i.e., permanent hearing loss) up to 2.4 km from pile driving. However, as large wind farms might take over a year to construct, disturbance of Monk Seals at their breeding caves is possibly as significant a concern as PTS. Marine mammals may avoid wind farms that are under construction or operating. Such avoidance may lead to more time spent travelling or displacement from key habitats. A paucity of data on at-sea movements of marine mammals around wind farms limits our understanding of the nature of their potential impacts. Here, we present the results of a telemetry study on harbour seals Phoca vitulina in The Wash, south-east England, an area where wind farms are being constructed using impact pile driving. We investigated whether seals avoid wind farms during operation, construction in its entirety, or during piling activity. The study was carried out using historical telemetry data collected prior to any wind farm development and telemetry data collected in 2012 during the construction of one wind farm and the operation of another. Within an operational wind farm, there was a close-to-significant increase in seal usage compared to prior to wind farm development. However, the wind farm was at the edge of a large area of increased usage, so the presence of the wind farm was unlikely to be the cause. There was no significant displacement during construction as a whole. However, during pilingthere was significant displacement of Harbour

Seals, up to 25 km from the center of the wind farm. Reassessment of the data from Russell et al (2016) was completed by Whyte et al (2020). This predicted that four of the 24 tracked seals received noise levels that exceeded the threshold at which PTS would occur (186 dB re 1 μPa2.s) and twelve were predicted to exceed the threshold for Temporary Threshold Shift (TTS, i.e. temporary hearing loss) (171 dB re 1 μPa2.s). PTS thresholds were exceeded between 3.9 to 6.9 km from piling activities, and TTS thresholds were exceeded up to 17.0 km. In a separate study, significant reduction in seals on land at Rødsand seal sanctuary 10 km was observed during piling activities (Edrén *et al.* 2004). Noise propagation distances from piling will vary according to site-specific factors such as bathymetry, substrate and pile type—as well as potential mitigation measures that might be employed (e.g., bubble curtains).

Given very high sensitivity of Mediterranean Monk Seal, it is recommended that a 25 km buffer is treated as an Exclusion Zone around known important sites for the species.

6 MARINE TURTLES

Marine turtles feature in the designations of several overlapping PAs and IRAs as described in Section 3, including:

- PAs—e.g., Göksu Delta SPA and Ramsar Site, nesting beach;
- KBAs—e.g. Kumluca KBA, nesting beach; and
- North-East Levantine Sea EBSA—including turtle nesting, foraging and migratory routes.

Taken together, these designated areas are likely to cover most of the area that is important for marine turtles in the Turkish EEZ.

6.1 Threatened marine turtles in Türkiye

There are five threatened species of marine turtles within global ranges that overlap with the Turkish EEZ, although two of these are vagrants (Table 8). Leatherback Turtle (*Dermochelys coriacea*) is rarely found in the Aegean and eastern Mediterranean, which are far from its nesting sites and are at the periphery of range. There were nine recorded strandings of the species in Türkiye between 1985 and 2011 (Candan & Canbolat 2018). Hawksbill Turtle (*Eretmochelys imbricata*) does not frequently enter the Mediterranean Sea. These two species are therefore not considered further.

There are two true marine turtle species that breed in Türkiye, Loggerhead Turtle (*Caretta caretta*) and Green Turtle (*Chelonia mydas*). Türkiye supports the Mediterranean's most important breeding population of Green Turtle and the second-most important Loggerhead Turtle breeding population (Casale & Margaritoulis 2010). Breeding starts in early June and extends to October. There are 14 Green Turtle rookery sites distributed along the southern coast of Türkiye, although only four of these average more than 100 nests in any year (Stokes *et al.* 2015).

Whilst Loggerhead Turtle is a carnivorous species, Green Turtles are herbivores and seagrass can form a large portion of its diet (Stokes *et al.* 2019). In the Mediterranean as a whole, over 11,500 km^2 of Posidonia seagrass beds are known to occur. This includes seagrass beds on the Turkish Aegean and Levantine coastlines, as well as a small area within the Sea of Marmara. These are likely to form important foraging areas for Green Turtle. The Mediterranean Sensitive Habitats Project (MEDISEH)

(2013) modelled the distribution of Posidonia beds within the Mediterranean. This did not cover the Sea of Marmara or the Black Sea. The small areas of sea grass beds confirmed within the Sea of Marmara are located within the Marmara Islands KBA. The MEDISEH modelled distribution of seagrass beds is available from the EMODnet portal. Areas with a predicted probability greater than 70% has been included as Exclusion zones and areas with a predicted probability of between 10-70% included in the Restriction Zone layer.

Analysis of satellite tracks from 34 Green Turtles showed that the majority of migration (average 84%) occurs along the coastline, and identified that the Gulf of Antalya is an important foraging area for the species (Stokes *et al.* 2015). Loggerhead Turtles nest at 21 rookeries in Türkiye with a similar distribution to Green Turtle, often using the same beaches (Kaska *et al.* 2016). A number of tracking studies have shown that the neritic areas up to 10 km either side of a nesting beach are important habitat for both Green and Loggerhead Turtles, (possibly limited to 1-2 km from the coast for Green Turtle and 5 km for Loggerhead (Tucker *et al.* 1995; Schofield *et al.* 2010; Waayers *et al.* 2011)) and for juvenile turtles making their way to the ocean post-hatching. Casale and Margaritoulis (2010) provide a summary of important marine areas for Loggerhead Turtle as including a mating area within Datca-Bozburun (Muğla) SPA, feeding grounds near Kas-Kovan Island, Suluada and near Tekirova, and a wintering area between Mersin and Iskenderun.

UNEP-WCMC have produced spatial data layers for nesting sites (UNEP-WCMC 1999). This was visually compared to more recent distribution maps of nesting beaches from the literature and appeared to be still broadly accurate for Türkiye. It is recommended that the identified nesting beaches, plus a 5 km buffer should be treated as an Exclusion Zone.

African Softshell Turtle (*Trionyx triunguis*) is not a fully marine turtle species, although it is fully tolerant of sea water down to at least 55 metres depth. It nests on inland rivers and lakes, but also on beaches along the west African coast, and the eastern Mediterranean (IUCN 2016). In Türkiye it is distributed along the southern coast, as far west as Dalyan and has been recorded nesting on beaches at Belek, Göksu, Burnaz, Dalyan, and Dalaman (Candan 2018), often at the same locations as Green and Loggerhead Turtles. The IUCN have assessed the Mediterranean subpopulation as Critically Endangered, although a recent study at Dalaman suggested that the population might be larger than previously thought and that Vulnerable might be more a more appropriate assessment of extinction risk (Akçınar & Taşkavak 2017). The UNEP-WCMC turtle nesting beach layer is likely to adequately cover the known nest sites for African Softshell Turtle. An online distribution map of known records is maintained by MEDASSET, although the digitised spatial dataset is not available for download.

TABLE 8: THREATENED MARINE TURTLES OCCURRING IN TÜRKİYE

Latin name	Common name	IUCN threat status	Global range area (Km^2)
***Trionyx triunguis* (Mediterranean subpopulation)**	African Softshell Turtle	VU (Global) CR (Mediterranean subpopulation)	2,373,394
Chelonia mydas	Green Turtle	EN	176,482,666
Dermochelys coriacea	Leatherback	VU	216,124,441
***Caretta caretta* (Mediterranean subpopulation)**	Loggerhead Turtle	VU (Global) LC (Mediterranean subpopulation)	271,358,117
Eretmochelys imbricata	Hawksbill Turtle	CR	271,358,117

7 BIRDS

Birds are included within the designations of several overlapping PAs and IRAs as described in Section 3, including:

- PAs—e.g., Ramsar Sites;
- KBAS—Important Bird Areas
- EBSAs - East Levantine Sea, Audouin's Gull colony on Gilindire islands in Aydıncı; and Central Aegean Sea EBSA - Yelkouan Shearwater, Audouin's Gull and the Mediterranean subspecies of European shag.

These designated sites are likely to include the majority of seabird nesting colonies and non-breeding aggregations of international importance. However, there are gaps in relation to flyways and migratory bottlenecks (see Section 7.1)

7.1 Flyways / Bottlenecks

Migratory birds are at risk of collision with turbines, barrier effects and displacement due to offshore wind farms. Türkiye is situated on the Mediterranean / Black Sea Flyway which is one of three Palaearctic-African flyways connecting Europe with Africa. Large soaring migratory birds, which include cranes, storks, herons, pelicans and raptors, rely on daytime sun-generated thermals for migratory flight. They therefore route their migration to avoid long sea crossings. For many larger bird species, the Turkish Straits System crossing between Europe and Asia represents a major migratory bottleneck where they are funnelled between the Black Sea to the north and the Mediterranean Sea to the south (Fülöp *et al.* 2014). the largest numbers tend to concentrate over the Bosphorus crossing point, with numbers exceeding 400,000 White Storks (*Ciconia ciconia*), 140,000 raptors, and 16,000 Black storks (*Ciconia nigra*) (Fülöp *et al.* 2014). Large numbers also cross over the over Kapıdağ Peninsula (Tuncalı 2010) and the Dardanelles. Migratory birds are also concentrated into a bottleneck by the Mediterranean Sea at the southern eastern corner of Türkiye (Ünal Altundağ & Karataş 2020). Many large migratory birds cross the Gulf of İskenderun at this point.

There are several published studies that record the numbers of birds observed at the Turkish Straits System, however few have recorded precise flight trajectories and heights, which are required to quantify collision risk. Satellite tracking studies provide a good source of data on flight trajectories that can be assessed to provide an indication of relative density of birds. To identify sea areas crossed by large soaring migratory birds during migration, available satellite track data was downloaded from Movebank.org for White Stork and Egyptian Vulture (*Neophron percnopterus*). An analysis of cumulative length of track was completed using a five-kilometre grid cell to indicate relative density of bird migration. The sea areas, shown by the analysis to be crossed by migratory birds are included in the Restriction Zone layer.

7.2 Threatened marine birds in Türkiye

Only six threatened marine bird species occur in Türkiye (Table 9), including a single true seabird (Procellariidae) species—Yelkouan Shearwater (Puffinus yelkouan - Vulnerable). The largest breeding colonies for this species are situated on the coasts of Croatia, Tunisia, southern France, Italy, Greece and Malta (Bourgeois 2012). The species is assumed also to breed on the coastline of Türkiye, although no colonies have yet been located. Tracking studies of breeding birds from the Mediterranean suggest that the Black Sea is a critically important non-breeding habitat for this species (Raine et al. 2013) and that a large proportion of the global population migrate through the Bosporus. Monitoring results completed on the Bosporus (Sahin et al. 2012) shows that there is strong seasonal migratory pattern, with highest passage occurring during January and February. Şahin et al. (2012) recorded a maximum passage of 55,862 individuals through the Bosporus in one morning on 3rd February 2011. The numbers recorded remained high from March through to the end of June, when they quickly dropped off and few birds were recorded between July and the beginning of December. The bottlenecks of the Bosporus and the Canekale Strait are both included in KBAs, however the migratory routes used by Yelkouan Shearwater through the Sea of Marmara are unknown and not protected. Habitat suitability modelling suggests that southern Black Sea coastal waters are important non-breeding habitat for this species and occur outside of designated areas (Pérez-Ortega & İsfendiyaroğlu 2017).

The Turkish Breeding Bird Atlas (Boyla *et al.* 2019) shows that Velvet Scoter (*Melanitta fusca*—Vulnerable) no longer breeds in Türkiye, although the species still winters along the Turkish Black Sea Coast in small numbers (Dagys & Hearn 2018). The Horned Grebe (*Podiceps auratus* - Vulnerable) also winters in the Black Sea, although predominantly outside of the Turkish EEZ (BirdLife International 2018). The Black Sea-East Mediterranean region, is an important wintering area for Common Pochard (*Aythya farina* - Vulnerable), although the largest counts have been made on inland freshwater lakes rather than on the coast (Atkinson *et al.* 2006). Marbled Teal (*Marmaronetta angustirostris*) no longer breeds in Türkiye—with no recent records from the Goksu Delta where it formally bred (Boyla *et al.* 2019).

TABLE 9: THREATENED MARINE BIRD SPECIES OCCURRING IN TÜRKİYE

Latin name	Common name	IUCN threat status	Global range area km^2
Larus audouinii	Audouin's Gull	VU	1,457,920
Puffinus yelkouan	Yelkouan Shearwater	VU	2,989,517
Melanitta fusca	Velvet Scoter	VU	5,835,558
Marmaronetta angustirostris	Marbled Teal	VU	12,540,156
Podiceps auritus	Horned Grebe	VU	23,719,284
Aythya ferina	Common Pochard	VU	27,566,004

8 FISH

Fish are not included as specific features of interest in very many PA and IRA designations (Section 3), although many are likely to be importance to fish. For example, fish are identified as important features of the North-East Levantine Sea EBSA and North Aegean EBSAs (Table 3).

8.1 Threatened fish species in Türkiye

According to the IUCN Red List, there are 15 threatened bony fish and 30 threatened cartilaginous fish species whose global ranges overlap the Turkish EEZ (Table 10), of which four and seven respectively are Critically Endangered. Three of the four Critically Endangered bony fish species are sturgeons: Stellate Sturgeon (*Acipenser stellatus*), Russian Sturgeon (*A. gueldenstaedtii*) and Beluga (*Huso huso*). These three species until recently spawned in rivers on the southern Black Sea coast, including the Sakarya, Kizilirmal and Yesilirmak rivers (Zengin *et al.* 2013), although this is may no longer be the case (World Sturgeon Conservation Society & WWF 2018). Adults are likely to occur in the Black Sea. The fourth Critically Endangered bony fish species, European Eel (*Anguilla anguilla*) occurs widely in Turkish rivers and streams draining into the Mediterranean Sea, Aegean Sea and parts of the Black Sea (Yalçin Özdilek & Özdilek 2020). The only Endangered bony fish species in Turkish marine waters is the Bluefin Tuna. In addition to the threatened species of bony fish, six have global ranges less than 100,000 km^2 and therefore potentially meet the IFC PS6 definition of range-restricted—however none of these species are threatened.

Kabasakal (2020) provides a recent assessment of the status of the 36 species of shark that have been recorded in Türkiye, listing 14 species as resident, 15 as seasonal and seven vagrants. The Turkish Straits System (Çanakkale Strait, Sea of Marmara and İstanbul Strait) along with the anoxic waters of the Black sea below 150-200 m are a barrier to the dispersal of shark species and fewer species occur in the Black Sea than the Aegean. Data from bycatch and monitoring studies suggest that many of the Critically Endangered and Endangered shark species are rare in Turkish waters.

No additional digitised spatial data has been identified in relation to fish.

TABLE 10: THREATENED MARINE FISH SPECIES OCCURRING IN TÜRKİYE

Class	Latin name	Common name	IUCN threat status	Range Area km^2
ACTINOPTERYGII	*Acipenser nudiventris*	Ship sturgeon	CR	521,938
ACTINOPTERYGII	*Acipenser gueldenstaedtii*	Russian sturgeon	CR	945,921
ACTINOPTERYGII	*Acipenser stellatus*	Stellate sturgeon	CR	1,002,667
ACTINOPTERYGII	*Anguilla anguilla*	European Eel	CR	13,670,345
ACTINOPTERYGII	*Thunnus thynnus*	Atlantic Bluefin Tuna	EN	31,897,138
ACTINOPTERYGII	*Labrus viridis*	Green Wrasse	VU	1,973,787
ACTINOPTERYGII	*Umbrina cirrosa*	Shi Drum	VU	2,303,797
ACTINOPTERYGII	*Dentex dentex*	Common Dentex	VU	2,647,406
ACTINOPTERYGII	*Sardinella maderensis*	Madeiran Sardinella	VU	2,894,826
ACTINOPTERYGII	*Epinephelus marginatus*	Dusky Grouper	VU	4,718,666

Class	Latin name	Common name	IUCN threat status	Range Area km²
ACTINOPTERYGII	*Pomatomus saltatrix*	Bluefish	VU	7,820,131
ACTINOPTERYGII	*Balistes capriscus*	Gray Triggerfish	VU	8,869,772
ACTINOPTERYGII	*Trachurus trachurus*	Atlantic Horse Mackerel	VU	9,315,506
ACTINOPTERYGII	*Mola mola*	Ocean Sunfish	VU	57,060,250
ACTINOPTERYGII	*Kajikia albida*	White Marlin	VU	61,012,604
CHONDRICHTHYES	*Glaucostegus cemiculus*	Blackchin Guitarfish	CR	503,726
CHONDRICHTHYES	*Squatina aculeata*	Sawback Angelshark	CR	1,448,529
CHONDRICHTHYES	*Squatina oculata*	Smoothback Angelshark	CR	2,192,250
CHONDRICHTHYES	*Squatina squatina*	Angelshark	CR	3,646,901
CHONDRICHTHYES	*Galeorhinus galeus*	Tope	CR	5,755,915
CHONDRICHTHYES	*Sphyrna mokarran*	Great Hammerhead	CR	31,445,766
CHONDRICHTHYES	*Carcharhinus longimanus*	Oceanic Whitetip Shark	CR	200,950,876
CHONDRICHTHYES	*Centrophorus uyato*	Little Gulper Shark	EN	1,028,242
CHONDRICHTHYES	*Rhinobatos rhinobatos*	Common Guitarfish	EN	1,138,313
CHONDRICHTHYES	*Raja radula*	Rough Skate	EN	1,384,309
CHONDRICHTHYES	*Raja undulata*	Undulate Skate	EN	2,107,562
CHONDRICHTHYES	*Rostroraja alba*	White Skate	EN	3,271,708
CHONDRICHTHYES	*Echinorhinus brucus*	Bramble Shark	EN	4,527,329
CHONDRICHTHYES	*Isurus paucus*	Longfin Mako	EN	185,106,241
CHONDRICHTHYES	*Mobula mobular*	Spinetail Devil Ray	EN	200,430,791
CHONDRICHTHYES	*Cetorhinus maximus*	Basking Shark	EN	221,820,483
CHONDRICHTHYES	*Isurus oxyrinchus*	Shortfin Mako	EN	222,540,198
CHONDRICHTHYES	*Chimaera monstrosa*	Rabbitfish	VU	1,879,030
CHONDRICHTHYES	*Mustelus mustelus*	Common Smoothhound	VU	3,627,464
CHONDRICHTHYES	*Gymnura altavela*	Spiny Butterfly Ray	VU	3,913,983
CHONDRICHTHYES	*Oxynotus centrina*	Angular Roughshark	VU	4,577,910
CHONDRICHTHYES	*Carcharhinus melanopterus*	Blacktip Reef Shark	VU	5,899,761
CHONDRICHTHYES	*Squalus acanthias*	Spiny Dogfish	VU	5,974,824
CHONDRICHTHYES	*Odontaspis ferox*	Smalltooth Sand Tiger	VU	7,833,841
CHONDRICHTHYES	*Sphyrna zygaena*	Smooth Hammerhead	VU	17,880,511
CHONDRICHTHYES	*Carcharhinus plumbeus*	Sandbar Shark	VU	21,432,404
CHONDRICHTHYES	*Lamna nasus*	Porbeagle	VU	93,415,753
CHONDRICHTHYES	*Alopias superciliosus*	Bigeye Thresher	VU	200,525,954
CHONDRICHTHYES	*Alopias vulpinus*	Common Thresher	VU	263,899,683
CHONDRICHTHYES	*Carcharodon carcharias*	White Shark	VU	273,801,458

SUMMARY

The preceding sections provide the rationale for the spatial data included within the Exclusion and Restriction Zone layers to be take into account with the Türkiye offshore wind roadmap. These are summarised in Table 11.

TABLE 11: SUMMARY TABLE OF SPATIAL DATA TO BE INCLUDED IN EXCLUSION AND RESTRICTION ZONE LAYERS

Priority Biodiversity Feature	Exclusion Zone layer	Restriction Zone layer
Protected Areas and Internationally Recognized Areas	• Special Protection Areas • Ramsar Sites • Key Biodiversity Areas (KBAs), including Important Bird Areas and Alliance for Zero Extinction (AZE) Sites	• EBSAs • ACCOBAMS CCH (Marmara Sea) • IMMAs
Natural Habitats	• MEDISEH modeled Coralligenous formations Mearl beds distribution (>70 % probability) • MEDISEH modeled seagrass bed distribution (>70 % probability)	• MEDISEH modeled Coralligenous formations Mearl beds distribution (10-70 % probability) • MEDISEH modeled seagrass bed distribution (10-70 % probability)
Marine Mammals	• Important sites for Mediterranean Monk Seal, plus a 25 km buffer.	–
Marine Turtles	• WCMC turtle nesting beaches, plus a 5 km buffer • MEDISEH modeled seagrass bed distribution (>70% probability)	• MEDISEH modeled seagrass bed distribution (10-70% probability)
Birds	–	• Migratory flight density for large soaring bird species
Fish	–	–

REFERENCES

References for the main body of this report are listed on page 143.

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