THE WORLD BANK
IBRD • IDA | WORLD BANK GROUP
IFC International Finance Corporation
WORLD BANK GROUP
Funded by the European Union

Offshore Wind Development Program

OFFSHORE WIND ROADMAP FOR ROMANIA

This document was produced with the financial assistance of the European Union. Its content is the sole responsibility of the author(s). The views expressed herein can in no way be taken to reflect the official opinion of the European Union.

This project was carried out with funding by the European Union via the Structural Reform Support Programme managed by the European Commission's Directorate General for Structural Reform Support (DG REFORM) and implemented by the World Bank with the support and the partnership of DG REFORM.

1818 H Street NW
Washington DC 20433
Telephone: 202-473-1000
Internet: www.worldbank.org

CONTENTS

BOXES

FIGURES

TABLES

ACKNOWLEDGEMENTS

This study was prepared by the World Bank under the EC Contract No. REFORM/IM2021/027 (TF073710) signed between the European Commission and the International Bank for Reconstruction and Development on August 16, 2021. It incorporates the expert research and analytical work performed by BVG Associates (Bruce Valpy, Mona Pettersen), CMS and ISPE. Additionally, The Biodiversity Consultancy contributed with a country-level biodiversity review. This report is a deliverable under the "Internal Energy Market and Energy Transition in Romania" Trust Fund implemented by the World Bank Group (WBG), for Romanian Ministry of Energy (MoE), with the support and partnership of European Commission's Directorate General for Structural Reform Support (DG Reform). This project was carried out with funding by the European Union via the Structural Reform Support Programme managed by DG REFORM.

The report was overseen by Mariano Gonzalez (Senior Energy Specialist, World Bank), Sean Whittaker (Principal Wind Specialist, IFC), and Melisa Fanconi (Senior Energy Specialist, World Bank). Additional support was provided by Daniel Kockisch (Senior Investment Officer, IFC), Christopher Lloyd (Senior Energy Specialist, World Bank), Mark Leybourne (Senior Energy Specialist, World Bank) and Alyssa Pek (Energy Specialist, World Bank). Peer review was carried out by The Biodiversity Consultancy, Lizet Ramirez (Senior Analyst for Offshore Wind, WindEurope) and Nikola Mihajlovic (Investment Officer, IFC) - we are thankful for their time and feedback. We express our profound gratitude to the Ministry of Energy for the collaboration in this project. We are truly thankful to a wide range of stakeholders that provided feedback during the report consultation process, such as, Authority for the Regulation of Offshore Oil Operations in the Black Sea (ACROPO), Ministry of Development, Public Works and Administration, Ministry of Environment, Water and Forests, Ministry of Foreign Affairs, Ministry of National Defense, National Administration of Romanian Waters, The National Agency for Mineral Resources, Competition Council, and Romanian Energy Regulatory Authority.

We are equally thankful to Copenhagen Offshore Partners (COP), European Energy, HENRO, Hidroelectrica, Jan de Nul, Port of Constanța, Romanian Association for Wind Energy, TotalEnergies and Transelectrica, among others, for participating in the industry consultation.

Finally, we thank the ESMAP-IFC Offshore Wind Development Program, led by Sean Whittaker and Rafael Ben (Senior Energy Specialist, ESMAP) for their precedent-setting work and guidance in development of this Roadmap.

EXECUTIVE SUMMARY

KEY MESSAGES

Globally, offshore wind (OSW) technology delivers large volumes of energy from GW-scale projects at prices competitive with those of new-build conventional generation technologies.

Romania already has 3 GW of installed onshore wind capacity and a sufficiently vigorous offshore wind resource that could produce more energy than Romania will ever need.

This report highlights the potential for up to 7 GW of OSW capacity, located at least 50 km from shore and mostly in relatively shallow water, that could be constructed from the early 2030s, using Romania's well-equipped port facilities, steel-based supply chain and other local workers.

Although the Black Sea is not as windy as much of the sea area in northern Europe, it is likely that a regional market will establish, with the development of projects in the exclusive economic zones of Bulgaria, Türkiye and Ukraine. The regional and the global OSW markets will offer further opportunities for Romanian suppliers.

Environmental impacts are a key consideration, beyond the reduction in carbon dioxide production and water use relative to conventional generation technologies. A key uncertainty in Romania in this regard is around avian migration routes to/from the wetlands of the Danube Delta.

RENEWABLE ENERGY IN EUROPE

Operational OSW capacity in the EU totaled about 31 GW at the end of 2022. The European Commission's 2020 *EU Strategy to harness the potential of offshore renewable energy for a climate neutral future offshore wind* set EU-wide targets of at least 60 GW of OSW capacity by the end of 2030 and 300 GW by the end of 2050, with the Black Sea designated as one of five key sea basins for development of OSW.[1]

As part of the European Green Deal[2], The European Commission's 2021 Fit for 55 package (which aims to deliver 55% reduction in the EU's net greenhouse gas emissions by 2030 compared to 1990 levels and to achieve climate neutrality in 2050) increased these 2030 OSW objectives to 79 GW.[3] Combined national targets of EU member states already amount to about 100 GW of OSW capacity by 2030.

The European Commission's 2022 *REPowerEU* Plan seeks to accelerate plans further in the wake of the Russia's invasion of Ukraine and the resulting need for diversifying the EU's energy sources, recognizing OSW as a stable and abundant energy source with a high level of public acceptance.[4] The ongoing situation in Ukraine could be a challenge for OSW development in the Black Sea. Romania is the first member of the EU for which the WBG has developed an OSW roadmap. Various EU directives and initiatives provide important structure to help Romania prepare for OSW, including:

- The European Green Deal (including Fit for 55), including for energy:
  - Ensuring a secure and affordable energy supply for the EU.
  - Developing a fully integrated, interconnected and digitalized EU energy market.
  - Prioritizing energy efficiency, improving the energy performance of buildings and developing a power sector based largely on renewable sources.
- The regulation on the Governance of the Energy Union and Climate Action (Regulation (EU)2018/1999), agreed as part of the *Clean energy for all Europeans package* which was adopted in 2019, that requires that each Member State drafts a 10-year National Energy and Climate Plan (NECP), setting out how to reach its national targets. Romania published its *2021-2030 Integrated National Energy and Climate Plan* (NECP) in April 2020.[5]
- The Maritime Spatial Planning Directive (2014/89/EU), mandating the form of national marine spatial plans, for completion of a first version by end March 2021. Romania, working together with Bulgaria, is targeting completion of its plan by end March 2023.
- The National Resilience and Recovery Plan[6] (NRRP), allocates funding through the Recovery and Resilience Facility, created in the wake of the COVIC-19 pandemic, which is a measure through which EU member states can implement reforms and investments that make their economies and societies more sustainable, resilient and prepared for the green and digital transitions..
- The Modernisation Fund, a dedicated EU funding program to support 10 lower-income EU Member States (including Romania) in their transition to climate neutrality by helping to modernize their energy systems and improve energy efficiency.
- This context is beneficial as it gives support to the Romanian Government and increased confidence to investors. The Modernisation Fund also offers a potentially significant source of funding for OSW activities,

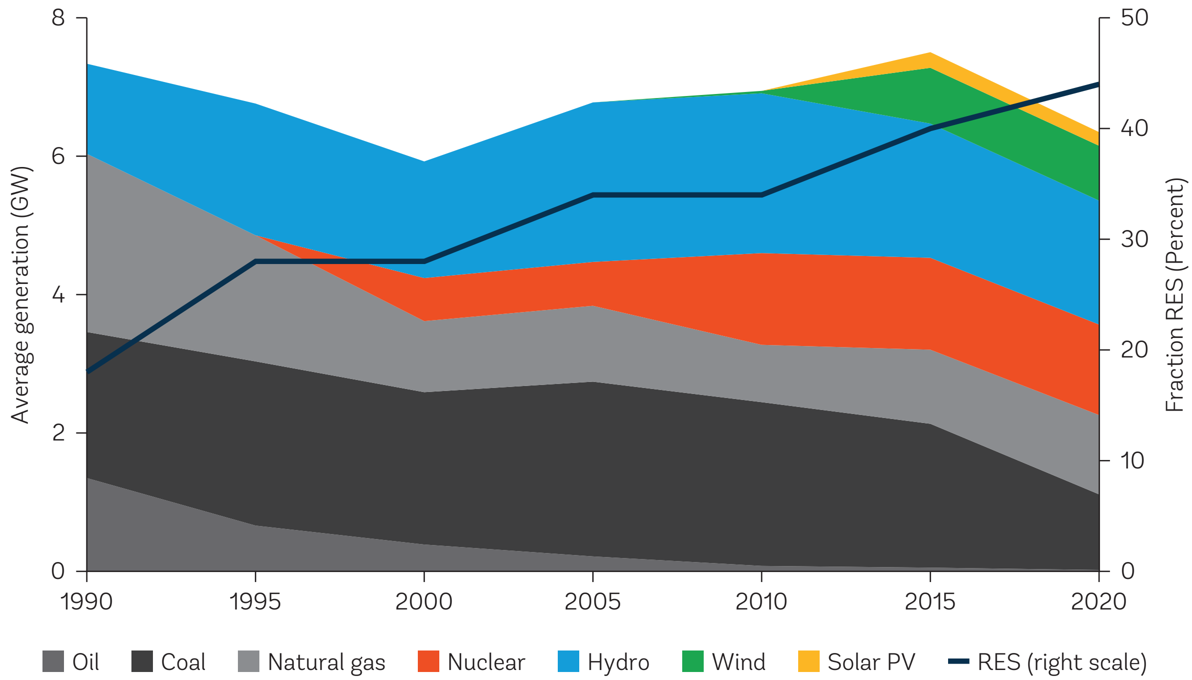
RENEWABLE ENERGY IN ROMANIA

Romania's electricity supply has transitioned from being dominated by fossil fuels to well over half coming from low carbon technologies by 2020 (45% renewable energy supply (RES)), as shown in Figure ES.1.

Romania's NECP targets 30.7% renewable energy in gross final energy consumption and 49.4% RES share in electricity supply by the end of 2030. Since publication, the Government has announced that these targets will be 'significantly increased' to around 34% in the next revision of the NECP, taking benefit of significant funding through the NRRP and the Modernisation Fund. The expectation is that the vast majority of new RES will be from wind and solar.

Think tank EPG, in its multi-sector energy and carbon analysis Recommendations for Romania's Long-Term Strategy: Pathways to climate neutrality, models 15 GW of OSW, 17 GW of installed onshore wind and 21 GW of solar PV capacity installed in Romania by 2050.[7]

FIGURE ES.1 THE START OF ROMANIA'S ENERGY TRANSITION: THE CHANGE IN ELECTRICITY GENERATION IN ROMANIA FROM 1990 TO 2020



Source IEA.

THE OPPORTUNITY AND POTENTIAL IMPACT OF OFFSHORE WIND IN ROMANIA

OSW potentially offers Romania a local, competitively priced, large scale and clean source of electricity and long-term jobs. To take full benefit of the resources that Romania has, requires[i]:

- Clarity on energy strategy and policy, including targets for OSW deployment up to 2035.
- Establishing OSW energy areas in the most suitable locations from a technical, commercial, environmental and social standpoint.
- Development of a new OSW law defining frameworks for exploration licensing, leasing, permitting and offtake.
- Significant and targeted upgrades of the transmission network, both to transfer energy from OSW projects and potentially to support the production, storage and use of green hydrogen; and
- Support to key areas of the Romania supply chain, to enable export as well as manufacture for domestic projects. The Capital Expenditure (CAPEX) for the high growth scenario to 2035 is about €19 billion.

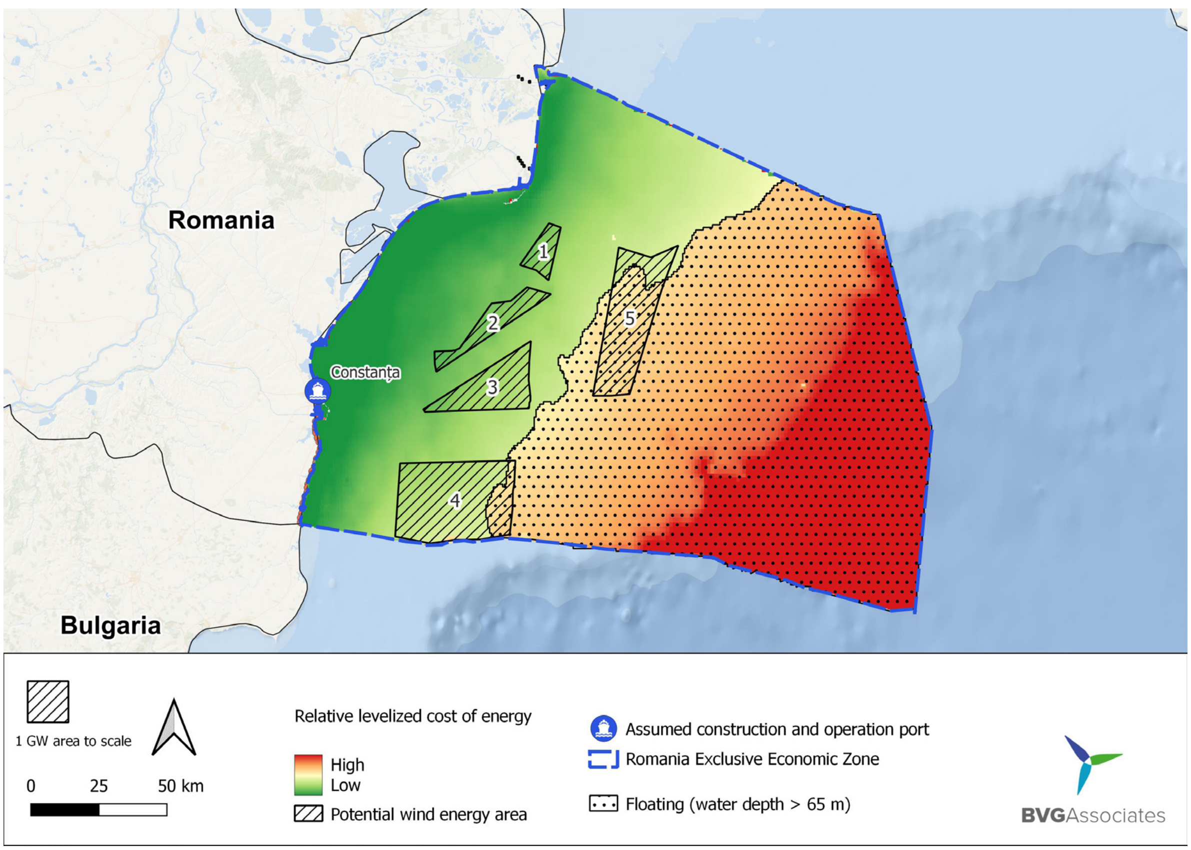
A vision for where OSW capacity could be installed in Romania is shown in Figure ES.2. The relative levelized cost of energy (LCOE) shown in the figure is for projects installed in 2032. The areas shown are likely to be sufficient for installation of up to 7 GW of OSW capacity, recognizing uncertainty about

i. These points summarise the recommendations that need to be implemented to enable the high growth scenario. Some (but not all) are needed for the low growth scenario. Recommendations relevant to each scenario are discussed in Section 5.

avian migration routes to/from the wetlands of the Danube Delta. To address this, it is recommended to conduct a Strategic Environmental Assessment (SEA) in line with Good International Industry Practice (GIIP) early in the process, covering at least the areas shown in the figure. This SEA can benefit from work already carried out on the National Maritime Plan and feed in to a future revision of this plan. The EU Habitat and Birds Directives also require all plans and projects to be assessed as to whether they are likely to have a significant effect on a Natura 2000 site.

> The cost analysis includes the cost of the export system, connecting each OSW project to the transmission network:
>
> - Offshore substation, subsea export cable and 20 km of onshore export cable, to an onshore substation; and
> - Wind-farm specific switchgear and auxiliary equipment in the substation that is located on the transmission network.
>
> The analysis does not considered the onward cost of transmission network upgrades, which will contribute to the ongoing electrification of Romania.

FIGURE ES.2 POTENTIAL OFFSHORE WIND ENERGY AREAS IN ROMANIA PENDING STRATEGIC ENVIRONMENTAL ASSESSMENT.



Source: BVG Associates.

The outcomes of the low- and high-growth scenario considered in this report summarized in Figure ES.3.

FIGURE ES.3 IMPACT OF OFFSHORE WIND IN ROMANIA UNDER LOW AND HIGH GROWTH SCENARIOS, PERIOD TO 2035 / 2050[ii]

Source: BVG Associates.

The key difference is that in the high growth scenario, 2.3 times the installed capacity by the end of 2035, compared to the low growth scenario, results in more cost reduction, 3.7 times as many local full-time equivalent (FTE) job years and 3.7 times local gross value added (GVA) up to 2035.

Local jobs and local gross value added:

- The larger local market, with good visibility, enables more local supply chain investment and optimization, and also some export to the regional and global market.
- This creates 1.5 times as many local FTE job years per MW installed.
- With 2.3 times as many MW installed up to 2035, this means 3.7 times as many FTE job years are created overall and about the same increase in local GVA.

The Government of Romania has the opportunity to develop a significant OSW market by providing a robust policy framework and good market visibility. International experience shows this to be an effective approach to generate local economic benefit without having to resort to restrictive local content requirements. It is also the dominant way to minimize the cost to consumers and create a more sustainable, internationally competitive supply chain.

ii. All figures are cumulative over the period to 2035, unless stated. CO_2 avoided is to 2050 as 2035 is so early in the lifecycle of all OSW projects. The fraction of electricity supply is discussed in Sections 3.2 and 4.2. Offshore wind capacity operating is discussed in Section 2. Electricity produced is discussed in Sections 3.2 and 4.2. Local jobs and GVA are discussed in Sections 3.4 and 4.4. CO2 avoided is discussed in Sections 3.6 and 4.6.

At the same time, like any large infrastructure, OSW developments have the potential to give rise to adverse environmental and social impacts and higher growth means higher risk of impacts. Some of the considerations identified in Section 11 include:

- Almost all the coastline and large sea areas around the Danube Delta are Protected Areas and have been excluded from the potential wind energy areas identified in this report. Surveys will be important to establish any natural habitats, especially in relation to bringing ashore export cables, and any necessary mitigation actions. In addition, more data is needed regarding migratory birds, and seasonal patterns need to be considered for avian and marine life, including black sea dolphins and porpoises.
- Important tourism areas and heritage sites will need to be identified during the environmental and social impact assessment (ESIA) process, as well as subsequent necessary mitigation actions.
- Consultation with owners of larger fishing vessels will be important in identifying potential wind energy areas. The main sea ports in Romania, including the Port of Constanța, the Midia and Mangalia area of Constanța , and the Port of Sulina, and shipping routes will need to be considered, as well as the impact on main naval bases in Constanța, Mangalia and Tulcea, and the Mihail Kogălniceanu International Airport, located outside Constanța,

This places even greater importance on the need to avoid areas of highest environmental and social sensitivity through proportionate marine spatial planning (MSP) and informed site selection. International financing for OSW depends on environmentally and socially sustainable sector development, in line with GIIP. This includes implementation of robust ESIA requirements and frameworks as part of the permitting processes, and careful management and mitigation thereafter to manage risks. Ongoing stakeholder engagement with affected communities and non-governmental organizations will form an important part of these MSP and ESIA processes.

A key prerequisite for a significant contribution from OSW is a significantly upgraded electricity transmission network, which is also needed for a decarbonized energy system.

ABOUT THIS REPORT

This report provides a strategic vision for development of OSW in Romania, considering both opportunities and challenges under different growth scenarios.

The report is based on two potential scenarios for OSW development:

- **Low growth,** which assumes development of OSW in line with existing government intent regarding renewables, where 3 GW OSW supplies 16% of Romania's electricity needs (by TWh) by the end of 2035.
- **High growth,** which assumes 7 GW OSW installed, where OSW supplies 37% of Romania's electricity needs by the end of 2035.

The report starts by describing a vision of Romania OSW sector in 2035 under both scenarios, including:

- Where the projects are located;
- How much energy will be generated and at what cost;
- What jobs and local economic benefit could be created;
- What associated infrastructure is needed;
- What the environmental and social impacts are; and
- How these projects are procured and financed.

The report then provides a roadmap that outlines the broad range of enabling actions that will need to be taken by the Government to achieve either outcome.

These recommendations are based on experience from other markets, engagement with industry and Government in Romania and on projections for regional developments.

The remainder of the report provides the supporting analysis and evidence behind each of the recommendations.

The purpose of the report is to provide a good understanding about OSW in Romania and a roadmap to establish OSW if it is decided that OSW fits within the energy strategy of Romania. The report does not set targets, but rather describes potential paths that will help inform government target-setting. The report is intended to provide an initial view of most main considerations. Inevitably, there will be much further work to do by many stakeholders in order finalize decisions regarding policy, frameworks and delivery, including more detailed analysis such as planning sector models and environmental assessments.

Likewise, the preparation of the report has not included modelling of the current or future energy system[iii] – it is focused on OSW aspects only. The report therefore does not identify least-cost or preferred technology options.

ROADMAP FOR OFFSHORE WIND IN ROMANIA

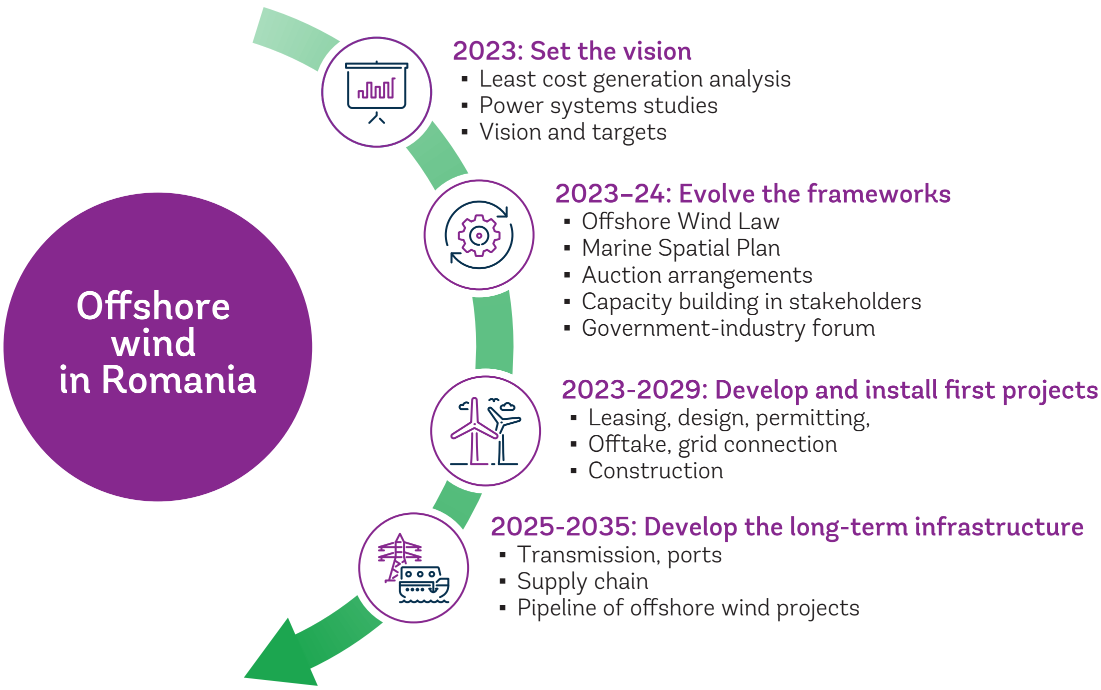
In order to develop a successful OSW industry, priority themes and a roadmap of recommended actions for the Government to consider are highlighted in Figure ES.4.

Appendix C contains a concept study for an early OSW project in Romania. The project described is 'small', with a rating of 300 MW, compared to commercial scale projects of rating 1 GW or more, but much of the description would apply if the project was an early commercial project.

iii. This includes consideration of the daily and seasonal patterns of generation and demand and the availability of competitively priced other sources of renewable energy. It is recognised that in markets where there are large areas of land with strong wind and solar resources and few environmental and social impacts, onshore renewables projects with scale 100 MW+ are likely to provide lower cost electricity and OSW.

Priority themes

FIGURE ES.4 PRIORITY THEMES TO CREATE A SUCCESSFUL OFFSHORE WIND INDUSTRY



Source: BVG Associates.

Recommended actions

Vision and volume targets

1. The Ministry of Energy (MOE) establishes how OSW fits within Romania's broader energy strategy, including through a least cost generation analysis, considering temporal patterns for generation by onshore wind, solar and OSW.
2. The MOE publishes its vision for OSW to 2035 and beyond as part of a decarbonized energy mix, considering plans also for transport and heat, explaining how and why OSW is important.
3. The MOE sets OSW installed capacity targets for 2030 and 2035 in the next revision of the NECP, showing clear plan for delivery of first projects, including the timetable for private-sector competitions.

Partnerships

4. The MOE establishes a long-term Government-industry forum involving local and international project developers and key suppliers, to work together to address the new OSW law, the recommendations throughout the roadmap and other considerations, as they arise.
5. The MOE agrees, with other relevant Government departments, to define inter-departmental cooperation and alignment on OSW, covering leasing, permitting, offtake, transmission and health

and safety frameworks, and key areas of delivery including supply chain and finance, to ensure there are no unexpected hurdles or non-unitary interpretations of legislation or frameworks.

6. The MOE leads in establishing which organization should play which role regarding the different frameworks needed for OSW.

Marine spatial planning, exploration licenses, leasing and offtake frameworks

7. The MOE progresses a proportionate OSW spatial plan, incorporating Strategic Environmental Assessment in line with Good International Industry Practice (GIIP), involving:
   - Sensitivity mapping of environmental and social attributes
   - Consideration of avian migration routes to/from the wetlands of the Danube Delta
   - Better understanding of the distribution and abundance of cetaceans, and
   - The cumulative impact of multiple projects.
   - This should include focus on engagement with key stakeholders and will result in early designation of offshore wind energy areas.
8. The MOE and Ministry of Development, Public Works and Administration include OSW in the next revision of the National Maritime Plan, formalizing the proportionate OSW spatial plan described above.
9. The MOE introduces a new, clear and investor-friendly OSW law and associated regulation relating to OSW frameworks, involving other public stakeholders, as required. All aspects, including with respect to transmission, need to be in compliance with national and European provisions in the field of competition and state aid.
10. The MOE proposes that the National Energy Regulatory Authority (ANRE) is given responsibility to grant seabed rights relating to OSW.
11. The MOE ensures curtailment compensation and indexation is in relevant contracts.
12. The MOE considers avoiding regulatory barriers for developers with regard to signing corporate power purchase agreements as an alternative route to market than winning a revenue competition.
13. The Ministry of Finance considers whether to signal its commitment to backstops offtaker obligations for multiple GW-scale projects, if needed.
14. The MOE, working with the Government General Secretariat, drives stability and predictability of the legal and fiscal regime, including stability clauses in OSW concession agreements.

Permitting

15. The Ministry of Environment, supported by the Ministry of Finance addresses any shortfalls in Romanian ESIA requirements compared to EU Regulations, GIIP, and lender standards.
16. The Government General Secretariat establishes a one-stop-shop permitting entity in order to simplify the decision-making process and interface for project developers and enables the use of digital services for submitting applications and similar.
17. The new permitting entity develops an OSW specific process based on the current permitting process, also ensuring that it meets GIIP to help de-risk projects and facilitate access to international finance.

18. New permitting entity explores access to (and benefits of use of) existing environmental data from impact assessment of oil and gas activities, held by Authority for Mineral Resources (NAMR) in order to increase efficiency of OSW environmental impact assessment.

Finance

19. MOE establishes the feasibility and attractiveness of using the Modernisation Fund to support OSW, including any flexibility regarding timescales due to the time it takes to develop OSW projects in a new market.
20. The MOE, with the Ministry of Finance considers financial mechanisms to reduce cost of capital for OSW projects, including access to climate and other concessional finance and ensures international market standards for contractual risk allocation and arbitration. Early engagement with MDBs is encouraged, in order to shape any guaranty scheme, credit enhancement, first loss support or other arrangement.
21. The MOE explores together with the Ministry of Finance any potential fiscal instruments relating to the support of OSW subject to the country's context and its position as an EU Member State.
22. The MOE works with others to ensure enforceability of contracts, both with Government and suppliers.

Grid connection and transmission network

23. Transelectrica develops a 2050 vision for a nationwide electricity transmission network for a decarbonized energy system, with milestone plans for 2030 and 2040 and consideration of finance. This is a topic much wider than OSW, considering all electricity, transport and heat, and should include viability of subsea interconnection between Ukraine, Romania, Bulgaria and Türkiye and also with Azerbaijan, providing balancing between the relevant states. Transelectrica incorporates MOE's OSW development vision into its next ten-year plan, published in 2024, and considers offshore hubs and the potential impact of international interconnects so that timely export and transmission solutions can be delivered.
24. Transelectrica undertakes power systems studies to understand the potential impacts of large volumes OSW on the future transmission network and ESIAs in line with GIIP and lender requirements to understand the environmental and social implications of transmission network upgrades, feeding these into MSP activities.
25. Transelectrica, MOE, distribution system operators (DSOs) and other relevant balancing parties agree a softening of the network management rules to better reflect the probabilistic nature of variable output renewables, including OSW, whilst remaining with EU regulations.
26. ANRE amends the template grid connection agreement (and any auxiliary regulations) to incorporate compensation terms in the grid connection agreement to apply if transmission network reinforcement is delayed and this impacts export of energy.
27. Transelectrica, potentially with WBG support, considers low cost solutions for the financing of transmission upgrades and the use of concessional finance.

Port infrastructure

28. The MOE creates an inter-ministerial group with the Ministry of Finance, the Ministry of Economy and the Ministry of Transport and Infrastructure. The inter-ministerial group creates and promotes a plan for port use for OSW manufacturing and construction, interfacing with current activity to develop the Naval Strategy. Consideration should be given to lead times for the upgrades to ensure suitable facilities are ready in time for project deployment and environmental and social considerations and robust ESIA analysis for any potential developments.
29. The MOE works with the Ministry of Transport and Infrastructure to encourage the publication of a simple OSW ports prospectus, showing port capabilities against physical OSW requirements, and use this to encourage dialogue with project developers.
30. Project developers explore any transport restrictions when entering the Black Sea for likely future wind turbine installation vessels.
31. The MOE considers prioritizing investments through the Resilience and Recovery Fund, or similar, into port infrastructure and supply chain for OSW, in the context of the green transition and the commitments to build renewable energy.

Supply chain development

32. The MOE, working with the Ministry of Development, Public Works and Administration, the Ministry of Economy and Ministry of Transport and Infrastructure, presents a balanced vision for local supply chain development, encouraging international competition (learning from elsewhere and avoiding restrictive local content requirements that add risk and cost to projects and slow deployment).
33. The MOE considers steps to support the expansion of supply chain for OSW, including the use of non-price criteria in auctions.

Hydrogen

34. The MOE finalizes and publishes domestic hydrogen policy to give clarity to industry, OSW project developers and other hydrogen industry stakeholders. This includes hydrogen as a storage solution to enable a greater share of variable renewable energy sources in the Romanian electricity mix.
35. The MOE encourages coordination between Transelectrica, Transgas, and other stakeholders to create legislation, regulations, standards, tariffs, transport, storage, import, export and trading arrangements for hydrogen.
36. The MOE explores how LCOH and interconnection policy in nearby countries will impact the requirements for domestic hydrogen production.
37. The MOE supports international efforts to establish a certification of origin framework for green hydrogen to allow meaningful competition with blue and gray hydrogen markets.
38. The MOE investigates small scale green hydrogen production as a flexible load that can be utilized to absorb intermittent renewable generation from a range of sources, not just OSW.

Health and safety and other standards and regulations

39. The Ministry of Labour and Social Solidarity adapts the existing framework of labor code and regulations to be suitable for OSW, adopting international industry standards where appropriate.

40. Authority for the Regulation of Offshore Oil Operations in the Black Sea (ACROPO) develops H&S regulations specifically designed for application to the OSW industry, which should be based on existing regulations in established EU markets, include reference to the international design and operational standards adopted in established OSW markets.
41. ACROPO ensures H&S regulations have a firm focus on the behavioral aspects of H&S and ensure that ongoing behavioral training forms a core element of compliance. Behavioral training forms an integral part of modern OSW H&S practices in established OSW markets.
42. ACROPO encourages companies active in OSW and oil and gas activities in Romania to collaborate on knowledge sharing. This will allow the OSW industry to build upon existing experience in oil and gas by using established facilities and personnel to train OSW workers, were possible.

Skills and gender equality

43. The MOE and the General Secretariat of Government lead in helping Government departments and other key stakeholders to grow capacity and knowledge needed to process the planned volume of OSW projects (through all frameworks).
44. The MOE, the Ministry of Economy, The Ministry of Education, relevant universities / training colleges and industry (through the Romanian Wind Energy Association (RWEA)) collaborate to enable education and investment in local supply chain businesses, including in training of onshore and offshore workers.
45. OSW project developers and suppliers collaborate to encourage women into the sector and get involved in gender equality working groups. Women's rights organizations in Romania, such as the Women's Association of Romania, the Association for Liberty and Equality of Gender and Centrul Filia, and industry bodies, such as Global Wind Energy Council (GWEC) and Global Women's Network for the Energy Transition (GWNET), should be included in these working groups.
46. The Ministry of Labour and Social Solidarity and industry set diversity targets and establish framework to measure progress.
47. OSW project developers and suppliers collaborate to publish a best practice guide for industry stakeholders and ensures opportunities for women in OSW are well-promoted. The best practice guide should discuss using gender decoders and gender-balanced language to ensure hiring practices are unbiased and creating spaces and opportunities for women to network within the OSW sector.

The MOE considers introducing diversity requirements into leasing and revenue frameworks.

1. INTRODUCTION

This report was carried out with funding from the European Union via the Structural Reform Support Programme and with the support and the partnership of the European Commission's DG REFORM.

The study follows an invitation from the Government of Romania to the WBG for assistance. The study was carried out over the period August 2022 to March 2023, with engagement and input from the Government of Romania and relevant agencies, the Romanian supply chain and the global OSW supply chain. See Section 21 for a list of stakeholders.

The study intends to outline options for a successful OSW industry in Romania and to support collaboration between the Government of Romania and the wind industry. It does not represent the views of the Government of Romania.

The report is structured as follows:

Roadmap

- Section 2: Description of two scenarios for OSW in Romania used in the following sections of this study.
- Sections 3 and 4: Short summaries of the key outcomes of each of these two scenarios.
- Section 5: Recommendations and roadmap for OSW in Romania.

Supporting information

- Sections 6 to 21: Analysis covering all key aspects of the future of OSW in Romania.

A glossary is provided in Appendix A and a list of organization abbreviations in Appendix B.

A study of an example early project is provided separately, with the purpose of informing the Government about the timeline and cost of early projects.

Throughout this report, we refer to *WBG's report Key Factors for Successful Development of Offshore Wind in Emerging Markets (Key Factors* report).[8] It describes experiences in OSW markets to date, covering:

- OSW as part of energy strategy;
- Policy;
- Frameworks; and
- Delivery.

2. TWO SCENARIOS FOR OFFSHORE WIND IN ROMANIA

Romania has a medium-speed wind resource that the World Bank's Energy Sector Management Assistance program (ESMAP) characterizes as having a technical potential of 76 GW (22 GW using foundations fixed to the sea bed and 54 GW using floating foundations).

This report explores the impact of two different, possible offshore wind (OSW) growth scenarios, chosen to illustrate realistic paths for Romania in the context of its future electricity needs, covering a reasonable breadth of the possible routes forward for Romania based on understanding from other emerging and established OSW markets. The purpose of the scenarios is to be able to consider the effect of industry scale on cost, consumer benefits, environmental and social considerations, economic benefits and other aspects in a quantifiable way. The scenarios were not established (and have not been tested) through deep energy system modelling, which is recommended in due course. All other conditions are unchanged between the two scenarios. The scenarios show capacity installed from 2029. This is as early as feasible. Based on experience in other markets, it is more likely that capacity will be installed from the early 2030s, but this does not change the relative impact of the two scenarios.

- **Low growth,** which assumes development of OSW in line with existing government intent regarding renewables, where 3 GW OSW supplies 16% of Romania' electricity needs by 2036 .[iv]
- **High growth,** which assumes 7 GW OSW installed, where OSW supplies 37% of Romania's electricity needs by 2036.

The key differences between the two scenarios are discussed below.

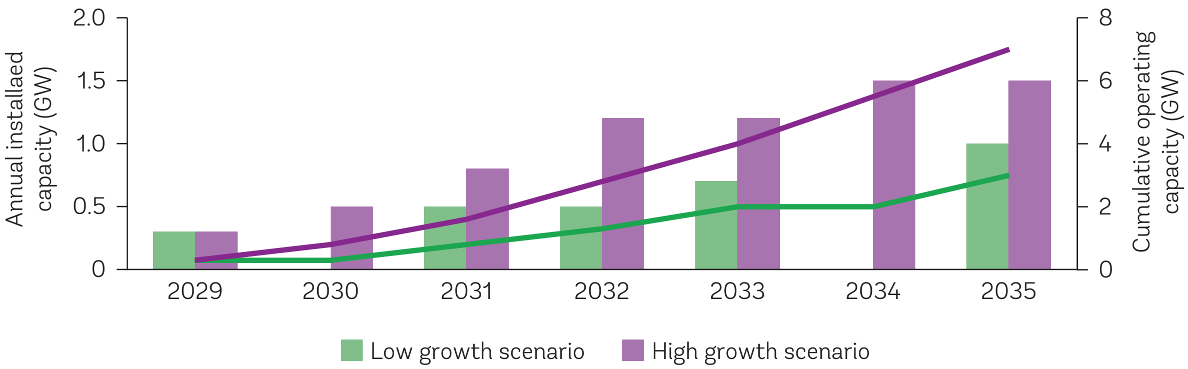
2.1 VOLUMES AND TIMING

Figure 2.1 shows the annual and cumulative installed OSW capacity for the two scenarios, both starting with a relatively small 'pathfinder' project. Larger projects reduce levelized cost of energy (LCOE) and smaller, pathfinder projects are not needed with respect to technology and by experienced project developers, so it is suggested in Romania to move straight to larger projects.[v] The low growth scenario comprises 5 projects. In the high growth scenario, new capacity is installed each year, reaching an average installation rate of 1.5 GW per year by 2035. Note that although the scenarios appear to show smooth trends in Figure 2.1, actual annual installation rates can be expected to vary due to specific project sizes and timings.

iv. Note that capacity installed in 2035 is assumed to provide a full year of generating capacity only in 2036. This scenario does not have any capacity installed after 2035, but additional capability could be added to the scenario in the later 2020s that could then be operational in the later 2030s.

v. Smaller, pathfinder projects have been used in a number of markets to prove technology, frameworks and processes needed to develop an OSW project, but the need for such projects has reduced as experience has grown.

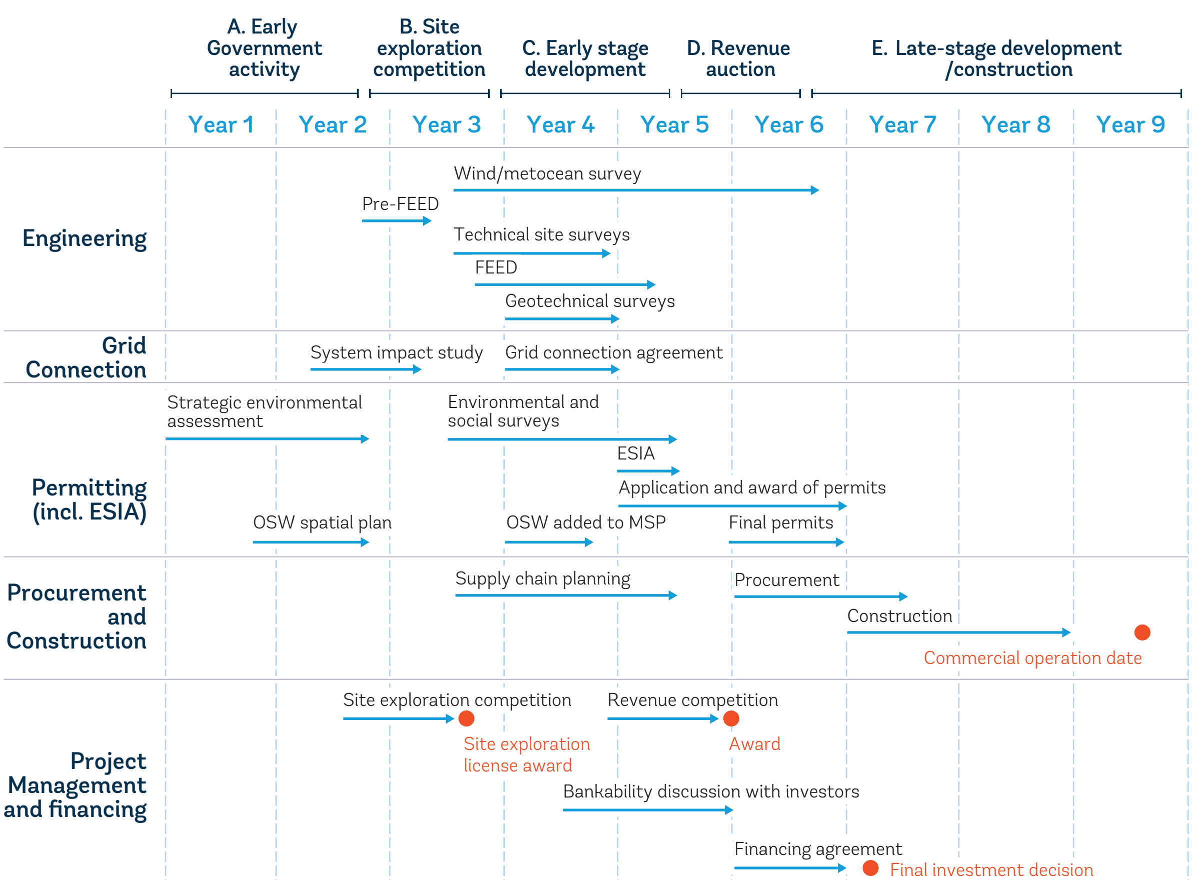
FIGURE 2.1 ANNUAL INSTALLED AND CUMULATIVE OPERATING CAPACITY IN THE TWO SCENARIOS



Source: BVG Associates.

The first projects are assumed to be installed in 2029. The study of an example early 'pathfinder' project in Appendix C sets out the anticipated timescales in developing a first project, as shown in Figure 2.2. Experience from established OSW markets is that timescales are longer than for onshore wind and solar projects.

FIGURE 2.2 ESTIMATED PROJECT PROGRAM FOR AN EARLY OFFSHORE WIND PROJECT IN ROMANIA



Source: BVG Associates.

BOX 2.1 TIMING OF EARLY OFFSHORE WIND ACTIVITY IN ROMANIA

The scenarios show capacity installed as early as feasible at the time of defining the scenarios. Based on experience in other markets, it is more likely that capacity will be installed 2 or 3 years later. Timing will depend both on the length of the project development processes but also on the time to implement primary and secondary legislation. For example, Section 5.13 shows a first competition for exploration rights in 2025, but the draft law at time of writing requires relevant competition rules to be finalized only by the start of 2027.

Ultimately, changed timing does not materially change the bulk of the content of the roadmap. Any delay drives the need for more generation using technologies with higher carbon dioxide production but is likely to benefit from ongoing reduction in levelized cost of energy as the global OSW industry continues to develop.

Headline characteristics of the scenarios, also beyond volume, are summarized in Table 2.1. Details of how to deliver these scenarios are covered in Section 5. The scenarios are indicative of how the OSW market could be built out.

The installation rates, especially in early years, will also depend on Government progress in establishing the policies and frameworks needed to enable OSW, as covered by the recommendations in Section 5. This will depend both on Government decisions on awards and auction caps, as well as industry's appetite to take projects forward and ability to bid below Government's ceiling prices. This relates to industry cost reduction progressing at the pace anticipated.

TABLE 2.1 CHARACTERISTICS OF THE TWO MARKET DEVELOPMENT SCENARIOS EXPLORED

	Low growth scenario	High growth scenario
Cumulative operating capacity by end 2035	3 GW	7 GW
Maximum installation rate	1 project (1 GW) per year	1 project (1.5 GW) per year
Policy environment	• Good visibility of OSW installation targets up to 2035 • No formal local content requirement	• As in low growth scenario
Frameworks	• New framework for exploration licensing set out in legislation • Competitive auctions for offtake agreements • Coordinated approach to transmission network upgrades • Improvements to frameworks for permitting and health and safety • OSW incorporated into national Maritime Spatial Plan	• As in low growth scenario

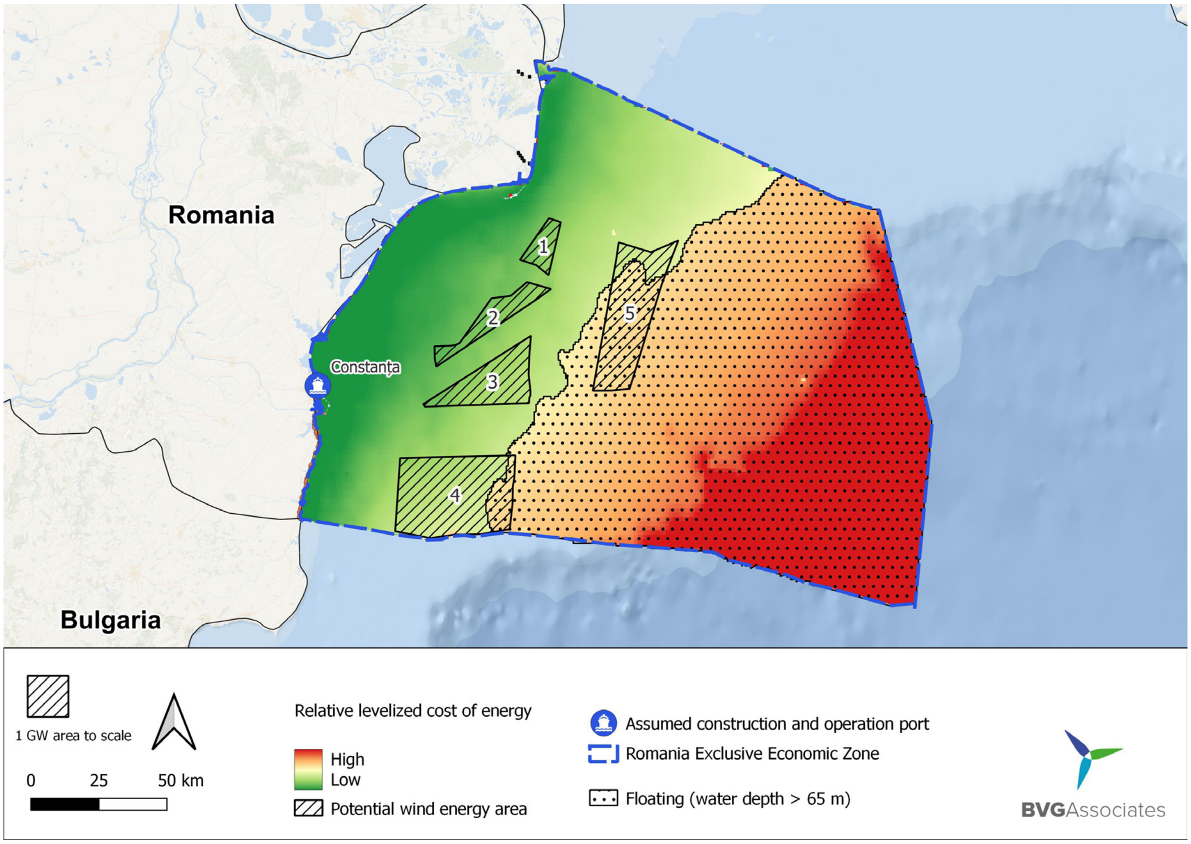
	Low growth scenario	High growth scenario
Supply chain	• Significant involvement of overseas project developers • Project development services and construction support services provided by local companies and a fraction of tower supply and offshore substation assembly and installation local. • Otherwise, mainly use suppliers active in the regional / global OSW market	• As in low growth scenario, with a higher fraction of towers, foundations and services supplied locally
Other prerequisites for scenario	• Engagement to smooth availability of sufficient volume of low-cost finance	• As in low growth scenario • Increased three-way collaboration between government, Romania's industry, and global OSW industry to proactively address barriers and opportunities and build confidence

2.2 POTENTIAL OFFSHORE WIND ENERGY AREAS

Figure 2.3 presents potential areas OSW development, following preliminary analysis summarized in Section 6. These areas, some of which have the space for more than one large project, have an indicative total capacity of 6.4 GW of fixed projects and 2.3 GW of floating projects, at a density of 3 MW/km^2.[vi] A significant caveat is that the analysis has not accounted for avian migration routes to/from the wetlands of the Danube Delta that could cut across these. There is little available data relating to this, which contributes to our suggestion in Section 6 to carry out a Strategic Environmental Assessment of these areas. The EU Habitat and Birds Directives also require all plans and projects to be assessed as to whether they are likely to have a significant effect on a Natura 2000 site. If it is likely there is significant effects, an Appropriate Assessment would also be required. Note the proximity of area 1 to Lobul sudic al Câmpului de Phyllophora al lui Zernov Special Area of Conservation (SAC), which is protected for features including sandbanks, bottle-nosed dolphins & harbour porpoises and areas 3 and 5 to Canionul Viteaz SAC which is protected for reefs and submarine structures. Note also that area 5 is further from shore, in deeper water and with lower wind resource, meaning that it has higher LCOE. Based on analysis to date. It is likely that other areas will be developed first, but that should Romania seek more OSW capacity, then area 5 would seem the next-most attractive area. Other seabed with lower associates LCOE is has been excluded for other reasons. See Section 6.

vi. A typical project has a density of 4.5 MW/ km^2 (for example, one 16 MW turbine in an area of about 3.6 km^2). Projects need buffer zones between them and not all of the potential space shown will prove to be suitable, meaning that at this stage it would be reasonable to expect to be able to install at an average density of 3 MW/ km^2 over the areas shown. These figures are indicative and may increase or decrease with further work.

FIGURE 2.3 POTENTIAL OFFSHORE WIND ENERGY AREAS IN ROMANIA PENDING STRATEGIC ENVIRONMENTAL ASSESSMENT



Source: BVG Associates.

THE POTENTIAL ROLE OF FLOATING OFFSHORE WIND

The areas with higher wind resource are generally about 50 km from shore and in shallow water, with wind resource decreasing when moving further from shore and into deeper water. This means that the most economically attractive sites are likely to be mainly using foundations fixed to the sea bed, and floating technology is unlikely to be used in commercial projects in Romania until into 2040s. This section provides a short summary relating to floating OSW technology below, but the rest of the roadmap focusses on fixed OSW technology.

Today, floating OSW has significantly higher LCOE than fixed OSW, all parameters being equal apart from water depth. Into the 2030s, this gap will close, such that in some places, floating projects with higher wind resource will show lower LCOE than fixed projects nearby with lower wind resource. The balance point between whether to develop fixed or floating sites will depend on the relative progress of the two technologies. Current expectations are that in time, the depth at which a project developer will choose to install floating instead of fixed technology is likely to be between 60 and 70 m.

In terms of hardware, there are minimal differences between floating and fixed OSW. Typically, turbine design, operation and reliability is almost the same, as is the turbine maintenance activities. The export system electrical hardware is the same, except for some mechanical aspects of cabling which are different.

Floating offshore wind offers some additional benefits beyond wind, including:

- It enables access to a wider range of sites;
- It allows for more onshore construction work;
- The foundation hull design is less dependent on ground conditions;
- The foundations are less susceptible to seismic activity and associated extreme wave events; and
- It generally has less-invasive activity on the seabed during installation.

At the same time, floating OSW is more challenging than fixed OSW in certain respects, including:

- Higher costs in early years; and
- Less confidence in technology and supply chain, as less proven. Key areas of difference are:
    - Floating foundation hulls;
    - Mooring systems;
    - Installation and major component replacements; and
    - The use of dynamic subsea cables which are able to cope with potentially almost constant movement during the life, as opposed to conventional subsea cables used in fixed OSW projects that are buried in the seabed over most of their length.

Overall, this means that floating OSW projects do have to carry more early project technology risks, and owners and lenders will price this. However, based on the current pace of technology activity, such risk will have been removed before any first floating projects in Romania.

3. LOW GROWTH SCENARIO

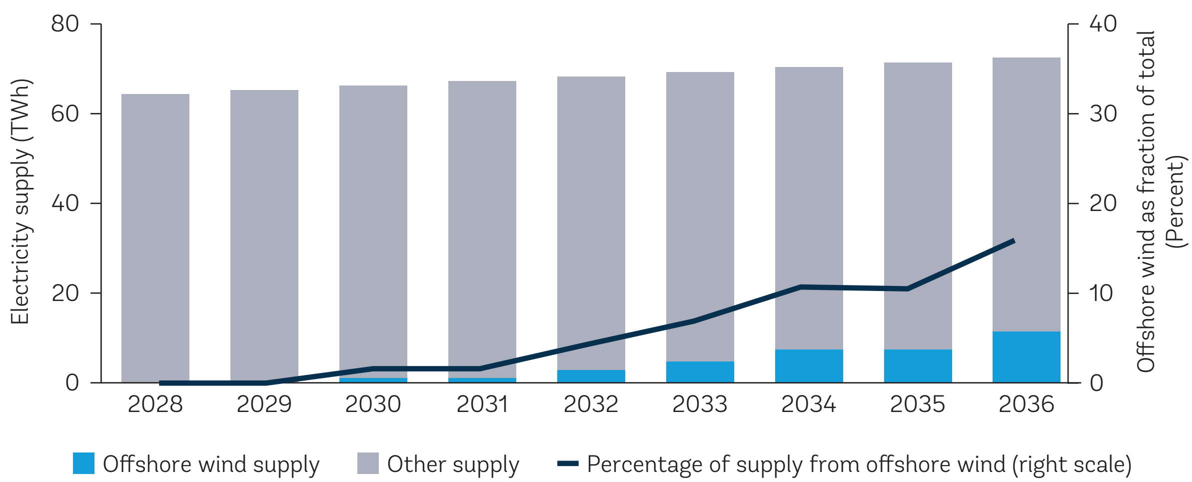
3.1 DEVELOPMENT AREAS

The low growth scenario assumes the development of five fixed offshore wind (OSW) projects located in the potential OSW energy areas shown in Figure 2.3.

3.2 ELECTRICITY MIX

Figure 3.1 shows supply from OSW in the context of the demand for electricity in Romania over the period. Under the low growth scenario, OSW will provide about 16% of electricity supply in 2036, by the time the final project installed in 2035 is online. The total electricity supply does not vary between the low and high growth scenarios, but the proportion of electricity supplied from OSW is greater in the high growth scenario.

FIGURE 3.1 ELECTRICITY SUPPLIED BY OSW AND OTHER SOURCES IN ROMANIA UP TO 2036 IN THE LOW GROWTH SCENARIO.



Source: BVG Associates.
Note: Estimates of total supply derived from Transelectrica *RET Development Plan for the period 2022-2031* (favourable scenario, extrapolated beyond 2031)[9].

3.3 LEVELIZED COST OF ENERGY

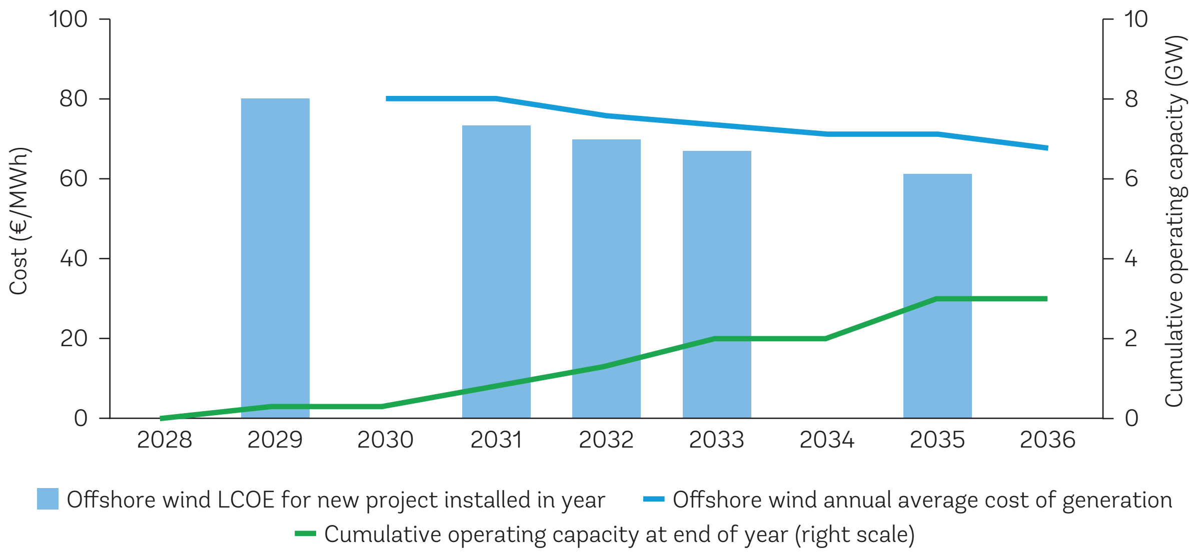
In this scenario the levelized cost of energy (LCOE) reduces over time, starting with a mid-estimate of €80/MWh (likely range €72/MWh to €93/MWh) in 2029, reaching a mid-estimate of €61/MWh (likely range €52/MWh to €76/MWh for a new project installed in 2035. Figure 3.2 shows this trend, along with the average cost of generation from OSW, derived from the portfolio of projects operating in a given year.

The reductions in cost of energy and the key drivers are discussed in Section 7, but include:

- The use of larger wind turbines;
- Global learning about OSW technology;
- Reduction in cost of capital due to reduction in risk and availability of significant volumes of finance; and
- Growth in local and regional supply, learning and competition, again driven by volume and market confidence.

Section 7 also discusses recent volatility in prices.

FIGURE 3.2 LCOE FOR NEW PROJECTS AND OFFSHORE WIND ANNUAL AVERAGE COST OF GENERATION IN THE LOW GROWTH SCENARIO.



Source: BVG Associates.

3.4 SUPPLY CHAIN AND ECONOMIC IMPACT

By 2035, Romania will have about 28% local content in its OSW farms, as derived in Section 8. It will be supplying 60% of towers and all onshore and offshore substations, as well as providing development, installation, and operations and maintenance services. It will also be exporting towers to other markets. A coordinated, multi-agency approach will be required to maximize local benefits and grow local capabilities.

3.4.1 Jobs

Figure 3.3 shows that by 2035, 21,000 full-time equivalent (FTE) years of employment will have been created in Romania by the OSW industry[vii]. Figure 3.3 shows the FTE years created up between now and 2035. To aid comparison with the high growth scenario, the same axis scale is used.

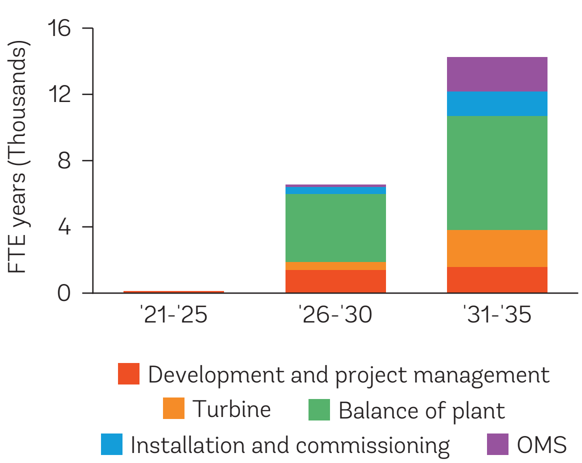
vii. Each FTE year of employment is the equivalent of one person working full time for a year. In reality the 21,000 FTE years of employment will be made up of some people working on the project for much less than a year and others working on the project for many years, especially during the operational phase. The employment profile for a typical project is shown inFigure 9.2.

Details of the supply chain, economic benefits of OSW and supply chain investment needs are discussed in Sections 8 and 9, including a description of where how the local content is broken down. In addition to this, 7,000 FTE years employment will have been created through the export of towers, as well as towers manufactured for onshore wind projects.

3.4.2 Gross value added

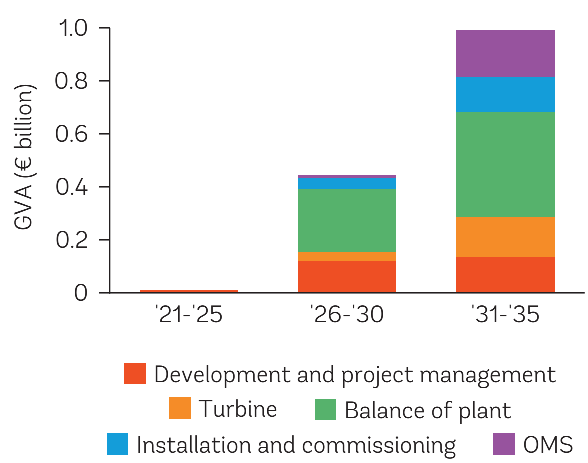
Figure 3.4 shows that by 2035, €1.4 billion gross value added (GVA) will have been created through supply to the OSW industry. In addition to this, €400 million of GVA will have been created by 2035 through the export of towers, as well as towers manufactured for the onshore wind industry.

FIGURE 3.3 FTE YEARS CREATED IN THE LOW GROWTH SCENARIO



Source: BVG Associates.

FIGURE 3.4 LOCAL GVA IN THE LOW GROWTH SCENARIO



Source: BVG Associates.

3.5 TRANSMISSION AND PORT INFRASTRUCTURE

In the low-growth scenario, the electricity transmission system will need some reinforcement, beyond ongoing revisions typical of regular transmission development plans, as discussed in Section 15.

At an annual installation rate of up to 1 GW per year, some investment in ports will be required to provide approximately 44 ha of manufacturing and staging space and 400 m quay length. Ports are discussed in Section 17. Overall Romania has good options for both construction and manufacturing on the Black Sea. Under the low growth scenario the demand for ports could be provided entirely by the main Constanța port area, or by a combination this and either the Mangalia or Midia area with additional investment.

3.6 ENVIRONMENT AND SOCIAL IMPACTS

By 2035, there will be about 150 large OSW turbines in five projects.

If not carefully planned and permitted, this level of development could give rise to adverse environmental and social effects, including on internationally important biodiversity. A proportionate OSW spatial plan is needed to designate offshore wind energy areas for early projects. This needs to incorporate a Strategic Environmental Assessment in line with Good International Industry Practice (GIIP). This analysis can then be incorporated into the National Maritime Plan in due course. Robust, project specific environmental and social impact assessments (ESIAs) to the standard of GIIP and in line with the permitting process will then be required to ensure appropriate ongoing mitigation and management of impacts is secured. It will not be possible to completely avoid adverse environmental and social impact, and government, developers, financiers and stakeholders will need to carefully consider the trade-offs between securing reliable low-carbon power and these adverse effects. Key environmental and social considerations associated with OSW development are discussed in Section 11.

Relative to using fossil fuel-based technologies to generate the same amount of electricity, OSW development in the low-growth scenario will benefit the people of Romania and the global environment by avoiding the emission of about 100 million metric tons CO_2 by 2050. In addition, about 220,000 metric tons of SO2 and 140,000 metric tons of NOx will be avoided. Both are air pollutants known for creating smog and triggering asthma attacks. OSW will also save about 3 trillion liters of water under the low growth scenario by 2050. See box for further details.

BOX 3.1 RELATIVE ENVIRONMENTAL IMPACT OF OFFSHORE WIND

CO_2 emissions. Fossil fuels release on average 500 metric tons of CO_2 per GWh of electricity generated.[10,11] OSW releases on average about 1-2% of this.[12] A typical 1 GW wind farm in Romania with capacity factor of about 44% therefore saves about 1.9 million metric tons of CO_2 per year. In the low growth scenario, by 2050 OSW will have produced about 200TWh, saving 97 million metric tons of CO_2, cumulatively, compared to fossil fuels, based on today's carbon intensities. Analysis has found that an OSW farm pays back the carbon produced during construction within§ 7.4 months of the start of operation.13 The life of an OSW farm is likely to be 30 years or more.

Other unhealthy pollutants. Fossil fuels release on average 1.1 metric tons of SO2 and 0.7 metric tons of NOx per GWh of electricity generated.[13] OSW releases hardly any. As an example of public health benefits from other markets, the American Wind Energy Association estimated that reductions in air pollution created the equivalent of €9 billion in public health savings in US in 2018 from the 96 GW of onshore wind generating in US that year.[14]

Water consumption. Thermal power plants require water to produce electricity and cool power generating equipment. Fossil fuels consume on average 15 million liters of water per GWh of electricity generated.[15] Wind farms use very little water. The simplified economic analysis provided in the roadmap covers jobs and GVA from OSW. In time, more effects (including those discussed here) can be assessed via more detailed sectoral and economic analysis.

People working on OSW farm construction and operations will be kept safe from harm through a comprehensive approach to health and safety. We discuss this in Section 20.

3.7 FINANCE AND PROCUREMENT

In both scenarios, we propose OSW will be delivered through competitive auctions. This structure will provide the best value to Romania. This is discussed in Section 13.

Projects will be developed by a combination of international private developers and local developers.

To achieve this scenario, the frameworks for leasing and offtake agreements will need improvements. These areas are discussed in Section 13 including recommendations.

A Capital Expenditure (CAPEX) of about €9 billion will be required for projects installed by the end of 2035. Sources of public finance will be accessed to fund projects and vital project infrastructure including port upgrades and transmission assets. Financial instruments such as multilateral lending, credit enhancements and the adoption of green standards can be used to attract international finance and reduce the cost of OSW. Access to finance is likely to be dependent on meeting lenders' performance standards, including those relating to environmental and social issues. Improvements to the ESIA and permitting process will be required to ensure that projects can meet these standards. This is discussed in Section 14.

3.8 ACTIONS TO DELIVER THE LOW GROWTH SCENARIO

Our recommendations for government actions are listed in Section 5.

3.9 SWOT ANALYSIS FOR ROMANIA IN THE LOW GROWTH SCENARIO

A strengths, weaknesses, opportunities and threats analysis for Romania adopting this scenario is presented in Table 3.1, comparing to the high growth scenario.

TABLE 3.1 SWOT ANALYSIS FOR ROMANIA IN THE LOW GROWTH SCENARIO

Strengths	Weaknesses
• Delivers local, large-scale source of clean electricity supply, with long-term jobs and economic benefit. • Going slower than in the high growth scenario enables more time to react as industry and technology changes. • Slightly less resource and urgency needed than in the high growth scenario on improving frameworks and addressing other challenges. • Transmission system does not need as much upgrade as in the high growth scenario.	• Lower volume of OSW means that higher volume of other sources of renewable energy will be needed. • Market size will not drive as much cost of energy reduction as the high growth scenario. • Delivers lower jobs and GVA compared to the high growth scenario. • Much work on frameworks and industry building is still required, but for lower benefit.
Opportunities	**Threats**
• Development can accelerate at any time, though with some delay to faster acceleration due to project development timescales. • Some local supply chain development and job creation. • Local manufacturing of some towers and manufacturing and installation of offshore substations.	• All Government preparatory work on policy and frameworks has a fiscal impact, with payback only if the industry progresses as planned. • Insufficient transmission network progress could slow OSW. • Industry may not have sufficient confidence in Government intent, so is not willing to invest sufficiently.

4. HIGH GROWTH SCENARIO

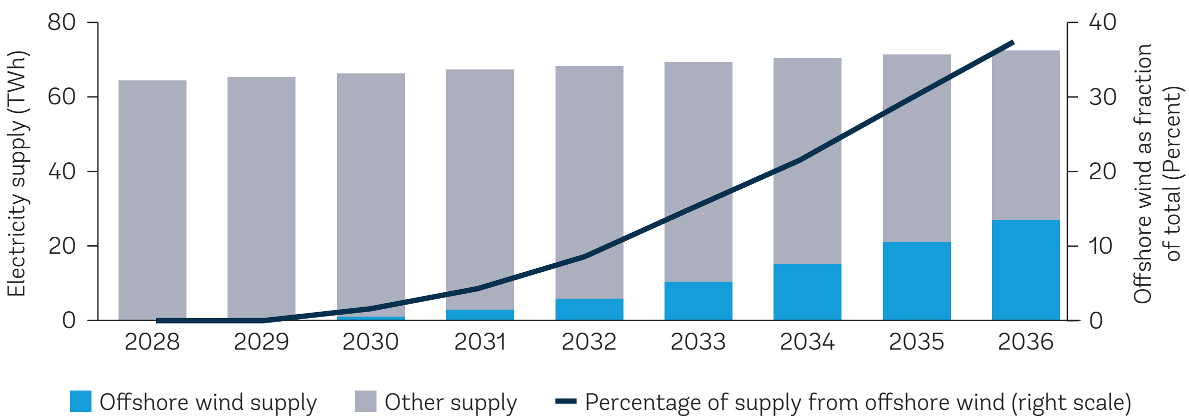
4.1 DEVELOPMENT AREAS

The high growth scenario assumes the development off seven fixed offshore wind (OSW) projects located in the potential OSW energy areas shown in Figure 2.3.

4.2 ELECTRICITY MIX

Figure 4.1 shows supply from OSW in the context of the demand for electricity in Romania over the period. In 2036, OSW will provide 37% of electricity supply, 2.4 times that in the low growth scenario.

FIGURE 4.1 ELECTRICITY SUPPLIED BY OSW AND OTHER SOURCES TO 2036 IN THE HIGH GROWTH SCENARIO.



Source: BVG Associates.
Note: Estimates of total supply derived from Transelectrica *RET Development Plan for the period 2022-2031* (favourable scenario, extrapolated beyond 2031).[10]

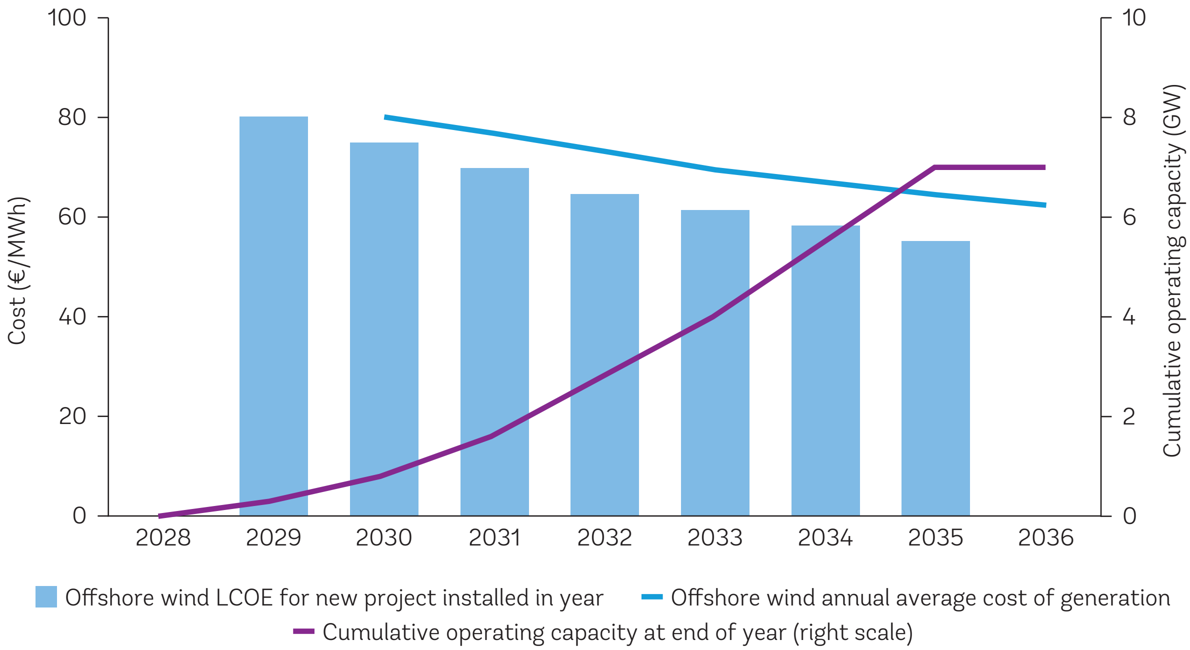
4.3 LEVELIZED COST OF ENERGY

In the high growth scenario the levelized cost of energy (LCOE) reduces faster over time, starting with a mid-estimate of €80/MWh (likely range €72/MWh to €93/MWh) in 2029, reaching a mid-estimate of €55/MWh (likely range €47/MWh to €68/MWh) for a new project installed in 2035. The 10% lower LCOE than in the low growth scenario is due to:

- Faster reduction of the initial costs of starting in a new market; and
- Lower weighted average cost of capital (WACC) from the expectation of more foreign investment and reduced risk under the high growth scenario.

This is discussed in Section 7, along with recent volatility in prices.

FIGURE 4.2 LCOE FOR NEW PROJECTS AND OFFSHORE WIND ANNUAL AVERAGE COST OF GENERATION IN THE HIGH GROWTH SCENARIO



Source: BVG Associates.

4.4 SUPPLY CHAIN AND ECONOMIC IMPACT

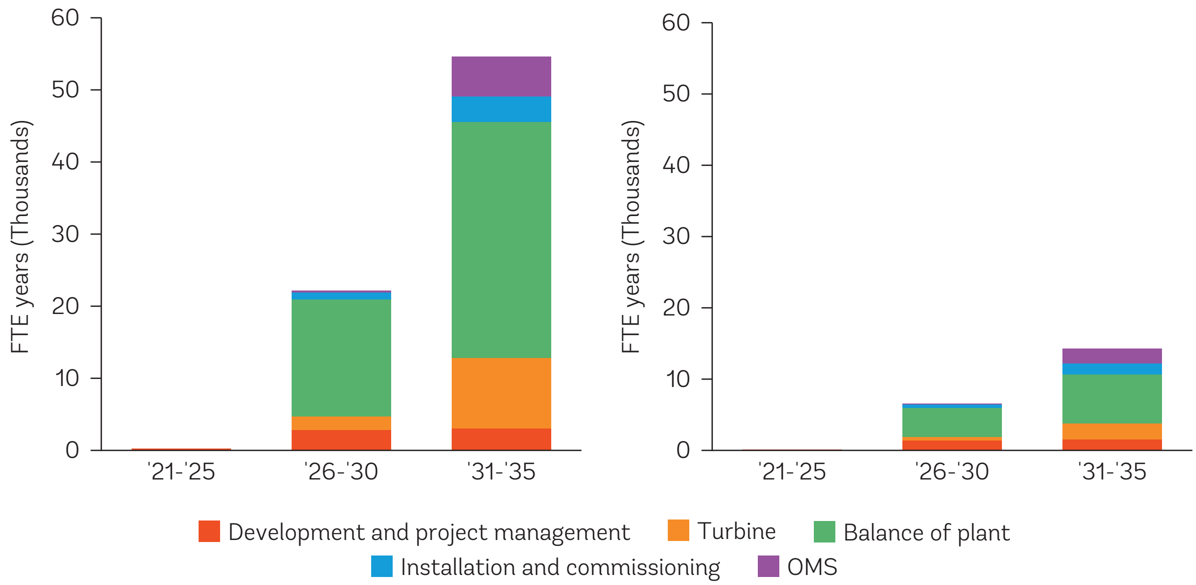
By 2035, Romania will have about 38% local content in its OSW farms, as derived in Section 9. It will be supplying 60% of towers and monopiles, and all onshore and offshore substations, as well as providing development, installation, and operations and maintenance services. It will also be exporting towers and monopiles to other markets. Increased market size has a significant impact on local economic benefit, as discussed in Section 9.

Details of the supply chain, economic benefits of OSW and supply chain investment needs are discussed in Sections 8 and 9, including a description of how the local content is broken down.

4.4.1 Jobs

Figure 4.3 shows that by 2035, 77,000 full time equivalent (FTE) years of employment will have been created by the OSW industry, which is 3.7 times as much as in the low growth scenario. This assumes the installation of 2.3 times as much OSW generation capacity as in the low-growth scenario, and the creation of 1.5 times as many local jobs per MW installed due to increased local supply. In addition to this, 38,000 FTE years will have been created through the export of towers and monopiles, as well as towers manufactured for onshore wind projects.

FIGURE 4.3 FTE YEARS CREATED IN THE HIGH GROWTH SCENARIO (LOW GROWTH SCENARIO ON THE RIGHT USING SAME SCALE, FOR COMPARISON)

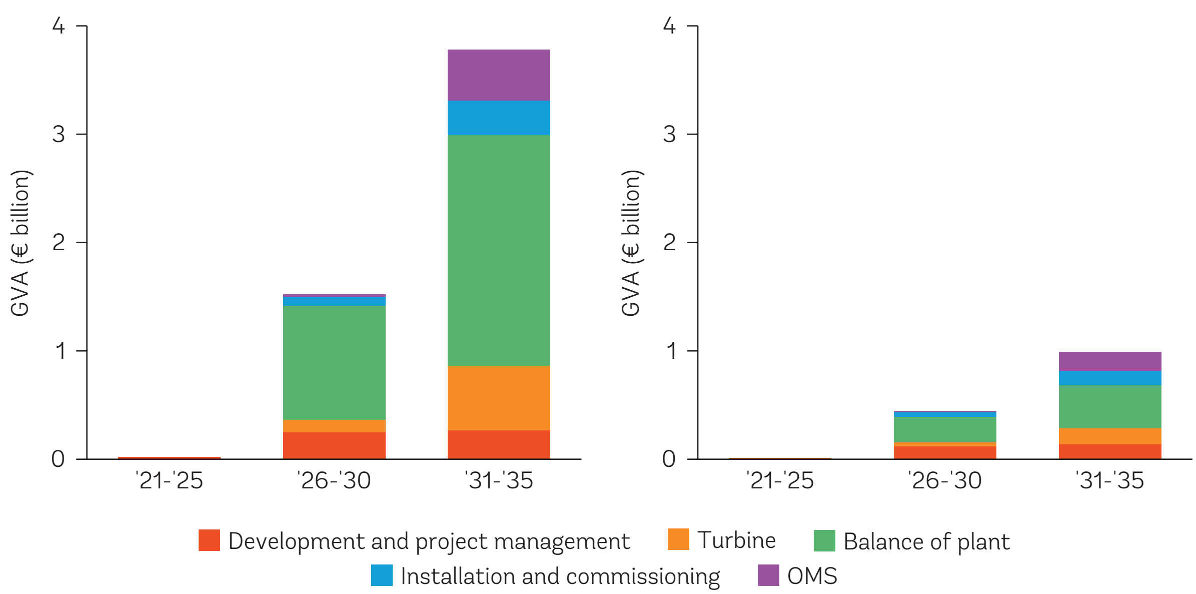


Source: BVG Associates.

4.4.2 Gross value added

Figure 4.4 shows that by 2035, €5.3 billion of gross value added (GVA) will have been created through supply to the OSW industry, which again is 3.7 times as much as in the low growth scenario. In addition to this, €2.6 billion of GVA will have been created by 2035 through the export of towers and monopiles, as well as towers manufactured for the onshore wind industry.

FIGURE 4.4 LOCAL GVA IN THE HIGH GROWTH SCENARIO (LOW GROWTH SCENARIO ON THE RIGHT USING SAME SCALE, FOR COMPARISON)



Source: BVG Associates.

4.5 TRANSMISSION AND PORT INFRASTRUCTURE

In the high-growth scenario significantly more transmission network upgrades will be required, as discussed in Section 15.

It is likely that only marginally more investment in ports will be required to provide approximately 58 ha of manufacturing and staging space and 400 m quay. Ports are discussed in Section 17. Overall Romania has good options for both construction and manufacturing on the Black Sea. Under the high growth scenario the demand for ports could be provided by Constanța, assuming that such a significant area could become commercially available for OSW construction, with the Mangalia / Midia areas of Constanța supplementing supply. Alternatively, Midia area of Constanța could deploy the full annual capacity, but only if the existing petrochemical area can be repurposed.

4.6 ENVIRONMENT AND SOCIAL IMPACTS

By 2035, there will be about 360 large OSW turbines in seven projects, with increased positive impacts (and potential adverse impacts, due to noise and seabed disturbance during construction and ongoing activity during operation) than described in Section 3.6.

The people of Romania will benefit from reduced local pollution from electricity generation, and the global environment will benefit from the displacement of 230 million metric tons CO_2 avoided by 2050. In addition, about 510,000 metric tons of SO2 and 320,000 metric tons of NOx will be avoided. Both are air pollutants known for creating smog and triggering asthma attacks. Last, OSW will save about 7 trillion liters of water under the high growth scenario by 2050. See box in Section 3.6 for further details.

4.7 FINANCE AND PROCUREMENT

As in this low growth scenario, OSW will be delivered through competitive auctions. This structure will provide the best value to the economy. This is discussed in Section 13. The other content of Section 3.7 is fully relevant to this scenario.

A Capital Expenditure (CAPEX) of about €19 billion will be required for projects installed to the end of 2035. As in the low growth scenario, sources of public finance will be accessed to fund projects and vital project infrastructure including port upgrades and transmission assets, with the same dependencies as discussed in Section 3.7.

4.8 ACTIONS TO DELIVER THE HIGH GROWTH SCENARIO

Our recommendations for government actions are listed in Section 5.

4.9 SWOT ANALYSIS FOR ROMANIA IN THE HIGH GROWTH SCENARIO

A strengths, weaknesses, opportunities and threats analysis for Romania adopting this scenario is presented in Table 4.1, comparing to the low growth scenario.

TABLE 4.1 SWOT ANALYSIS FOR ROMANIA IN THE HIGH GROWTH SCENARIO.

Strengths	Weaknesses
• Delivers local, large-scale source of clean electricity supply, with long-term jobs and economic benefit. • Drives more innovation and supply chain investment than the low growth scenario. • Larger market size will sustain local competition and support exports, delivering 3.7 times more jobs and GVA compared to the low growth scenario, by 2035. • Cost of energy 10% lower than the low growth scenario. • Displaces 2.3 times more CO_2 than the low growth scenario, with climate benefits scaled similarly.	• Transmission network needs more reinforcement, which will require significant vision, finance and time. • Requires greater commitment across Government, and somewhat more urgent action than in the low growth scenario. • Needs increase in capacity in the organizations administering frameworks compared to in the low growth scenario.
Opportunities	**Threats**
• Local manufacturing of a higher proportion of towers than the low growth scenario, manufacturing of some foundations and manufacturing and installation of offshore substations. • Export potential for steel items to the wider European market, especially if using green steel.	• All Government preparatory work on policy and frameworks has a fiscal impact, with payback only if the industry progresses as planned. More work is needed sooner than in the low growth scenario. • Lack of cross-Government support could increase risk. • Insufficient transmission network progress could slow OSW. • Industry may not have sufficient confidence in Government intent, so is not willing to invest sufficiently.

5. ROADMAP FOR OFFSHORE WIND IN ROMANIA: RECOMMENDATIONS

Offshore wind (OSW) has seen tremendous growth in some parts of the world, most notably in northwest Europe and in People's Republic of China.

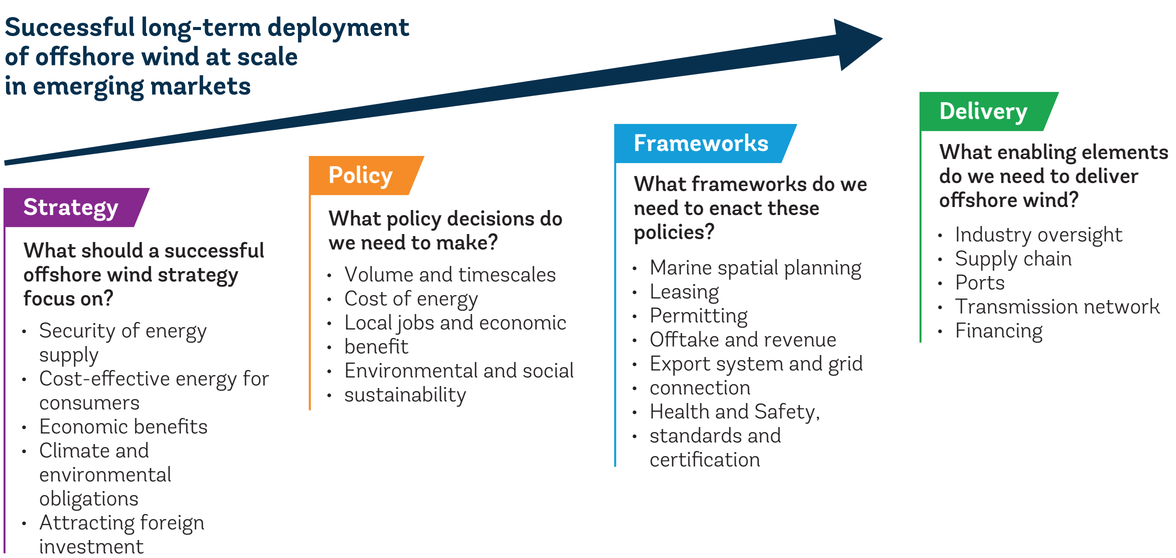
Where OSW has been a success in Europe (for example in the UK, Germany, Denmark and the Netherlands) it is because successive governments have implemented and sustained strategic policies and frameworks that encourage the development of OSW farms in their waters by private developers and investors, using marine spatial planning (MSP) processes to balance the needs of multiple stakeholders and environmental constraints.

Governments have recognized that if they provide a stable and attractive policy and regulatory framework, looking at least 10 years ahead, then developers will deliver OSW farms that provide competitively priced and carbon free electricity to power their economies.

These frameworks set out robust, transparent and timely processes for seabed leasing and for project permitting. In parallel, they consider what investment in grid and other infrastructure will be required to deliver a sustainable pipeline of projects. Finally, they have understood what they can do to make sure projects are financeable and can attract competitive capital by offering a stable and attractive route to market for the electricity generated.

Much learning from the industry so far is captured in World Bank Group's *Key Factors* report.[9] Key questions and topics that report addresses are summarized in Figure 5.1.

FIGURE 5.1 STRATEGY, POLICY, FRAMEWORK, AND DELIVERY: THE FOUR KEY PILLARS FOR SUCCESSFUL DEVELOPMENT OF OFFSHORE WIND[9]



The key recommendations in the roadmap are presented in Sections 5.2 to 5.12 and summarized for the two scenarios in Figure 5.4 and Figure 5.5, showing suggested timing of activities, which is somewhat different for the two scenarios. The suggested timing is designed to enable delivery of early projects in 2029 and establish a pipeline of projects to carry on delivering the volumes shown in the scenarios. It is recognized that urgency is required to enable delivery of projects to these timescales. Should Government progress more slowly, then it is likely that early projects will be delayed and industry confidence somewhat reduced. There is also a risk of delays should industry cost reduction not progress at the pace anticipated.

Each recommendation is labelled S (strategy), P (policy), F (frameworks) or D (delivery) showing what they relate to, aiding reference to the World Bank Group's *Key Factors* report.[9]

Many of the recommendations apply to both the low- and high-growth scenarios, but could happen later and to a lesser degree in the low growth scenario. Those that may still be advantageous, but could be avoided in the low growth scenario, are marked (H), indicating for high growth scenario only, and are not shown in Figure 5.4, giving a reduced list of roadmap actions.

Those recommendations where early progress is most critical to the timely delivery of the high growth scenario are marked *.

The roadmap timelines presented in Figure 5.4 and Figure 5.5 are based on the principle of delivering the first projects as early as practically possible. The timelines represent the best case scenario, based on a prompt and committed start by Government. There are several critical factors that could impact the suggested timeline, including:

- The effort required by Government to develop policies and frameworks for OSW and build confidence in those frameworks with stakeholders and industry;
- The requirement for improved data to inform spatial planning, and social and environmental impact assessment;
- The requirement to plan, finance and build transmission network (and potentially port) infrastructure in time for the planned OSW capacity; and
- OSW industry progress in developing technology and supply chain, especially relating to floating OSW.

To maximize the opportunity of delivering the roadmap to this timetable, Government should pay particular attention to managing and mitigating these critical factors.

5.1 RATIONALE FOR KEY ROADMAP RECOMMENDATIONS

The recommendations in this roadmap are based on robust analysis, consultation and experience. The rationale for key roadmap recommendations is provided below.

5.1.1 Evolution of frameworks, rather than major changes

We believe that there is already a strong basis for OSW development in many areas.

It will be vital, however, that Government, Romanian industry and global wind industry players work together to address the changes in frameworks that are needed.

A summary of our assessment of key conditions for OSW in Romania is provided in Table 5.1.

TABLE 5.1 SUMMARY OF ASSESSMENT OF KEY CONDITIONS FOR OSW IN ROMANIA

Condition	Assessment
Wind resource	Medium
Demand for clean power	High
Leasing framework	New framework needed
Permitting framework	Needs some change
Offtake framework	New framework needed
Grid connection framework	Needs some change
Health and safety framework	Needs some change
Transmission network	Needs upgrades, especially for high growth scenario
Cost of energy	May not be competitive with onshore wind and solar
Local supply chain	Good opportunities in some areas, also for export

5.1.2 Timescales for industry growth

Industry experience indicates that establishing robust and bankable frameworks is critical, and that large, nationally relevant infrastructure projects take a long time to develop, even in established OSW markets. We believe the timescales proposed fit with reasonable expectations of progress regarding transmission network upgrades, which are likely to be needed to facilitate OSW. . Currently, the Romanian grid could only accommodate around 3 GW of additional wind energy capacity by 2030, which is likely to be taken up by onshore wind projects. Additional urgency could come from requirements of the Modernisation fund (see Section 19), which we suggest is addressed early.

5.2 VISION AND VOLUME TARGETS

Communicating a clear long-term vision and associated volume targets for OSW is an important step in attracting interest and investment from the global industry and supply chain, stakeholders, Government departments and the people of Romania. It is recommended that:

1. The Ministry of Energy (MOE) establishes how OSW fits within Romania's broader energy strategy, including through a least cost generation analysis, considering temporal patterns for generation by onshore wind, solar and OSW. (see Section 13) (S, H)
2. The MOE publishes its vision for OSW to 2035 and beyond as part of a decarbonized energy mix, considering plans also for transport and heat, explaining how and why OSW is important. (see Section 13) (S, H)
3. The MOE sets OSW installed capacity targets for 2030 and 2035 in the next revision of the National Energy and Climate Plan (NECP), showing clear plan for delivery of first projects, including the timetable for private-sector competitions. (see Section 13) (D*)

5.3 PARTNERSHIPS

The large scale and high complexity of OSW projects makes it entirely different from onshore wind or solar. Projects combine the scale of large hydroelectricity schemes and the complexity of offshore hydrocarbon extraction. Government-industry collaboration is therefore essential to build confidence, develop a successful new sector and deliver the benefits seen in other markets. On this basis, it is recommended that:

4. The MOE establishes a long-term Government-industry forum involving local and international project developers and key suppliers, to work together to address the new OSW law, the recommendations throughout the roadmap and other considerations, as they arise. (see Section 18) (D*)
5. The MOE agrees with other relevant Government departments, to define inter-departmental cooperation and alignment on OSW, covering leasing, permitting, offtake, transmission and health and safety frameworks, and key areas of delivery including supply chain and finance, to ensure there are no unexpected hurdles or non-unitary interpretations of legislation or frameworks. (see Section 18) (D*)
6. The MOE leads in establishing which organization should play which role regarding the different frameworks needed for OSW. (see Section 20) (F*)

5.4 MARINE SPATIAL PLANNING, EXPLORATION LICENSES, LEASING AND OFFTAKE FRAMEWORKS

To develop a sustainable OSW energy industry Romania needs processes for exploration licenses, leasing and offtake that are robust, transparent and timely.

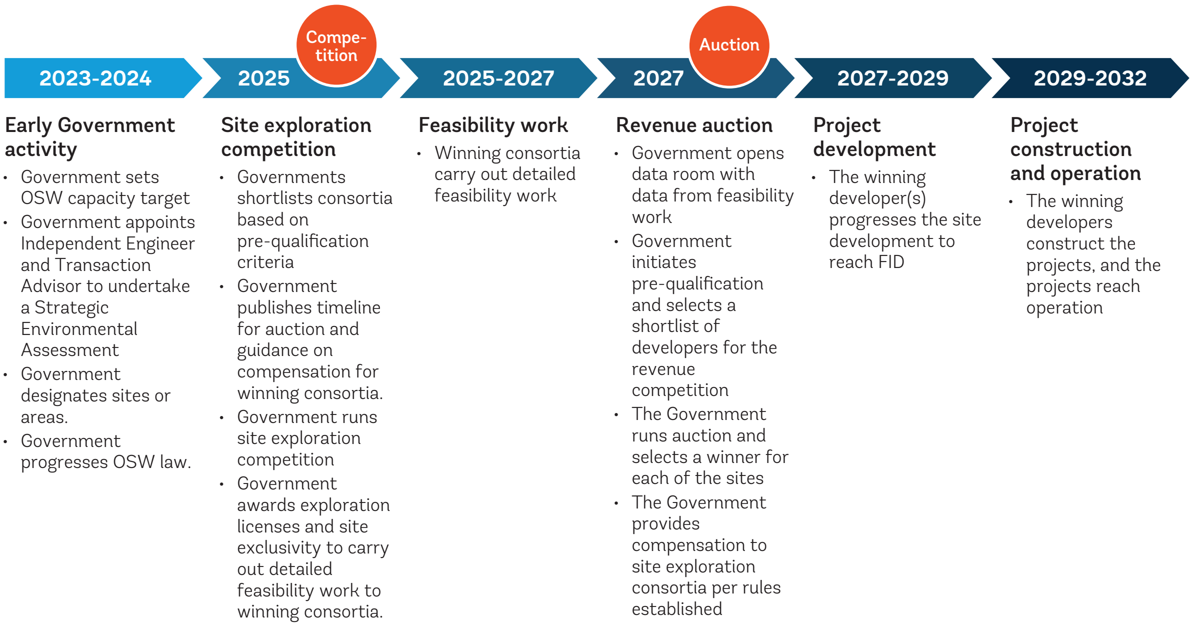
International investment will be required to develop the potential volumes of OSW discussed in this report. A stable route to selling electricity is required to make this happen. It is recommended that:

7. The MOE progresses a proportionate OSW spatial plan, incorporating Strategic Environmental Assessment in line with Good International Industry Practice (GIIP), involving:
   - Sensitivity mapping of environmental and social attributes
   - Consideration of avian migration routes to/from the wetlands of the Danube Delta
   - Better understanding of the distribution and abundance of cetaceans, and
   - The cumulative impact of multiple projects.

   This should include focus on engagement with key stakeholders and will result in early designation of offshore wind energy areas. (see Section 6) (F*)
8. The MOE and Ministry of Development, Public Works and Administration include OSW in the next revision of the National Maritime Plan, formalizing the proportionate OSW spatial plan described above. (see Section 6) (F)
9. The MOE introduces a new, clear and investor-friendly OSW law and associated regulation relating to OSW frameworks, involving other public stakeholders, as required. All aspects, including with respect to transmission, need to be in compliance with national and European provisions in the field of competition and state aid. (see Section13). (F*)
10. The MOE proposes that the National Energy Regulatory Authority (ANRE)) is given responsibility to grant seabed rights relating to OSW. (see Section 13) (F)
11. The MOE ensures curtailment compensation and indexation is in relevant contracts. (see Section 18) (F)
12. The MOE considers avoiding regulatory barriers for developers with regard to signing corporate power purchase agreements as an alternative route to market than winning a revenue competition. (see Section 13) (F)
13. The Ministry of Finance considers whether to signal its commitment to backstops offtaker obligations for multiple GW-scale projects, if needed. (see Section 18) (F)
14. The MOE, working with the Government General Secretariat, drives stability and predictability of the legal and fiscal regime, including stability clauses in OSW concession agreements. (see Section 18) (F)

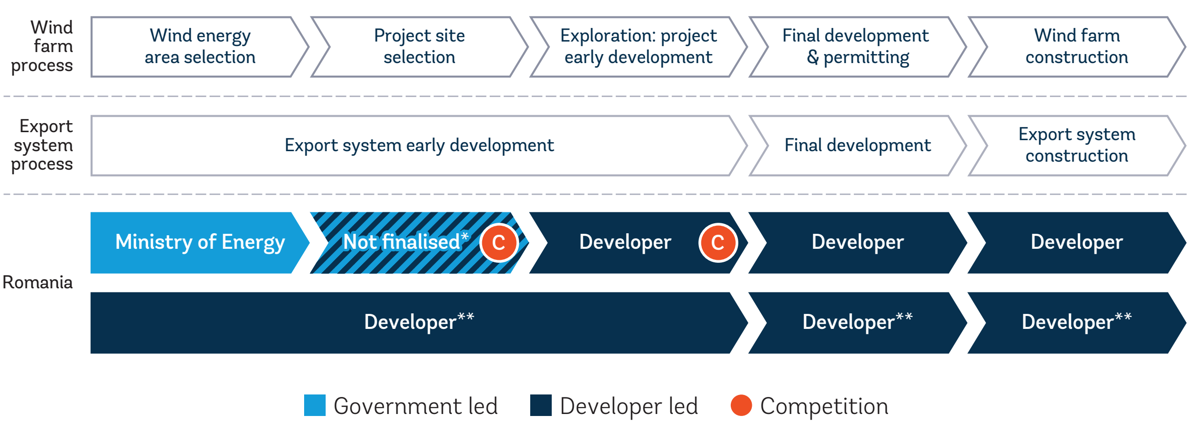
A summary of the proposed model for leasing and revenue frameworks for OSW in Romania is shown in Figure 5.2. The model suggested for Romania consists of two competitions, one for an exploration license, then a later competition for revenue support and lease. The principles underpinning this design is discussed in Section 13.

FIGURE 5.2 BEST ESTIMATE TIMELINE FOR LEASING AND REVENUE FRAMEWORKS IN THE HIGH GROWTH SCENARIO



A summary of recommended Government and project developer responsibilities for OSW activities through the project lifecycle, is shown in Figure 5.3, in the format of Figure 3.4 of World Bank Group's *Key Factors* report, which presents responsibilities in a range of established OSW markets.[9]

FIGURE 5.3 SUMMARY OF RECOMMENDED GOVERNMENT AND PROJECT DEVELOPER RESPONSIBILITIES FOR OFFSHORE WIND ACTIVITIES THROUGH THE PROJECT LIFECYCLE IN ROMANIA



Notes: * Government may define broad areas for OSW development or define specific sites. This detail to be finalised in due course (see Section 6). ** If only one OSW project will use the export system, then the developer will deliver. If more than one project will use the same export system, transmission network operator, Transelectrica will deliver.

5.5 PERMITTING

Key to industry confidence and ensuring careful stewardship of the environment and communities is a transparent and bankable permitting process. It is recommended that:

15. The Ministry of Environment, supported by the Ministry of Finance addresses any shortfalls in Romanian ESIA requirements compared to EU Regulations, GIIP, and lender standards. (see Section 19) (F)
16. The Government General Secretariat establishes a one-stop-shop permitting entity in order to simplify the decision-making process and interface for project developers and enables the use of digital services for submitting applications and similar. (see Section 14) (F, H)
17. The new permitting entity develops an OSW specific process based on the current permitting process, also ensuring that it meets GIIP to help de-risk projects and facilitate access to international finance. (see Section 14) (F, H)
18. New permitting entity explores access to (and benefits of use of) existing environmental data from impact assessment of oil and gas activities, held by Authority for Mineral Resources (NAMR) in order to increase efficiency of OSW environmental impact assessment (See Section 11) (D).

5.6 FINANCE

Enabling sufficient finance and reducing the cost of capital for OSW projects in Romania are key drivers in enabling volume delivery at low levelized cost of energy (LCOE). It is recommended that:

19. MOE establishes the feasibility and attractiveness of using the Modernisation Fund to support OSW, including any flexibility regarding timescales due to the time it takes to develop OSW projects in a new market. (see Section 19) (D)
20. The MOE, with the Ministry of Finance considers financial mechanisms to reduce cost of capital for OSW projects, including access to climate and other concessional finance and ensures international market standards for contractual risk allocation and arbitration. Early engagement with MDBs is encouraged, in order to shape any guaranty scheme, credit enhancement, first loss support or other arrangement. (see Section 19) (D)
21. The MOE explores together with the Ministry of Finance any potential fiscal instruments relating to the support of OSW subject to the country's context and its position as an EU Member State. (see Section 19) (D)
22. The MOE works with others to ensure enforceability of contracts, both with Government and suppliers. (see Section 18) (D)

5.7 GRID CONNECTION AND TRANSMISSION NETWORK

The transmission network currently offers only limited opportunity for grid connection of early projects via local upgrades. To deliver a transmission network enabling large-scale OSW development will require strategic leadership and finance. This is a topic wider than OSW, considering all electricity, transport and heat. It is recommended that:

23. Transelectrica develops a 2050 vision for a nationwide electricity transmission network for a decarbonized energy system, with milestone plans for 2030 and 2040 and consideration of finance. This is a topic much wider than OSW, considering all electricity, transport and heat, and should include viability of subsea interconnection between Ukraine, Romania, Bulgaria and Türkiye and also with Azerbaijan, providing balancing between the relevant states. Transelectrica incorporates MOE's OSW development vision into its next ten-year plan, published in 2024, and considers offshore hubs and the potential impact of international interconnects so that timely export and transmission solutions can be delivered.. (see Section 15) (S, H)
24. Transelectrica undertakes power systems studies to understand the potential impacts of large volumes OSW on the future transmission network and ESIAs in line with GIIP and lender requirements to understand the environmental and social implications of transmission network upgrades, feeding these into MSP activities. (see Section 15) (D, H)
25. Transelectrica, MOE, distribution system operators (DSOs) and other relevant balancing parties agree a the network management rules to better reflect the probabilistic nature of variable output renewables, including OSW, whilst remaining with EU regulations. (see Section 15) (D)
26. ANRE amends the template grid connection agreement (and any auxiliary regulations) to incorporate compensation terms in the grid connection agreement to apply if transmission network reinforcement is delayed and this impacts export of energy. (see Section 15) (D)
27. Transelectrica, potentially with WBG support, considers low cost solutions for the financing of transmission upgrades and the use of concessional finance. (see Section 15) (D, H)

5.8 PORT INFRASTRUCTURE

Romania has port facilities relevant to OSW. It is recommended that:

28. The MOE creates an inter-ministerial group with the Ministry of Finance, the Ministry of Economy and the Ministry of Transport and Infrastructure. The inter-ministerial group creates and promotes a plan for port use for OSW manufacturing and construction, interfacing with current activity to develop the Naval Strategy. Consideration should be given to lead times for the upgrades to ensure suitable facilities are ready in time for project deployment and environmental and social considerations and robust ESIA analysis for any potential developments. (see Section 17) (D)
29. The MOE works with the Ministry of Transport and Infrastructure to encourage the publication of a simple OSW ports prospectus, showing port capabilities against physical OSW requirements, and use this to encourage dialogue with project developers. (see Section 17) (D)
30. Project developers explore any transport restrictions when entering the Black Sea for likely future wind turbine installation vessels. (see Section 17) (D)
31. The MOE considers prioritizing investments through the Resilience and Recovery Fund, or similar, into port infrastructure and supply chain for OSW, in the context of the green transition and the commitments to build renewable energy. (see Section 17) (D)

5.9 SUPPLY CHAIN DEVELOPMENT

Romania has a competitive supply chain for a range of areas relevant to OSW. A proactive approach will help increase local readiness for supply. It is recommended that:

32. The MOE, working with the Ministry of Development, Public Works and Administration, the Ministry of Economy and Ministry of Transport and Infrastructure, presents a balanced vision for local supply chain development, encouraging international competition (learning from elsewhere and avoiding restrictive local content requirements that add risk and cost to projects and slow deployment). (see Section 8) (P)
33. The MOE considers steps to support the expansion of supply chain for OSW, including the use of non-price criteria in auctions. (see Section 8) (D)

5.10 HYDROGEN

The ability to store significant volumes of energy as hydrogen (or derivatives) is a potentially significant enabler for increased offshore wind production in Romania and other markets. Hydrogen also offers a route to decarbonizing hard-to-abate processes such as steel manufacture. It is recommended that:

34. The MOE finalizes and publishes domestic hydrogen policy to give clarity to industry, OSW project developers and other hydrogen industry stakeholders. This includes hydrogen as a storage solution to enable a greater share of variable renewable energy sources in the Romanian electricity mix. (see Section 16) (P, H)
35. The MOE encourages coordination between Transelectrica, Transgas, and other stakeholders to create legislation, regulations, standards, tariffs, transport, storage, import, export and trading arrangements for hydrogen. (see Section 16) (F, H)
36. The MOE explores how LCOH and interconnection policy in other nearby countries will impact the requirements for domestic hydrogen production. (see Section 16) (D, H)
37. The MOE supports international efforts to establish a certification of origin framework for green hydrogen to allow meaningful competition with blue and gray hydrogen markets. (see Section 16) (F, H)
38. The MOE investigates small scale green hydrogen production as a flexible load that can be utilized to absorb intermittent renewable generation from a range of sources, not just OSW. (see Section 16) (D)

5.11 HEALTH AND SAFETY AND OTHER STANDARDS AND REGULATIONS

Safeguarding the environment and societal interests, designing and installing safe structures and protecting workers needs to be a priority at all levels of the industry. Having a recognized framework of technical legislation and design codes is an important element in establishing bankability and attracting and sustaining international interest and investment in the market. It is recommended that:

39. The Ministry of Labour and Social Solidarity adapts the existing framework of labor code and regulations to be suitable for OSW, adopting international industry standards where appropriate. (see Section 12) (F)
40. Authority for the Regulation of Offshore Oil Operations in the Black Sea (ACROPO) develops H&S regulations specifically designed for application to the OSW industry, which should be based on existing regulations in established EU markets, and include reference to the international design and operational standards adopted in established OSW markets. (see Section 12) (F)

41. ACROPO ensures H&S regulations have a firm focus on the behavioral aspects of H&S and ensure that ongoing behavioral training forms a core element of compliance. Behavioral training forms an integral part of modern OSW H&S practices in established OSW markets. (see Section 12) (D)
42. ACROPO encourages companies active in OSW and oil and gas activities in Romania to collaborate on knowledge sharing. This will allow the OSW industry to build upon existing experience in oil and gas by using established facilities and personnel to train OSW workers, were possible. (see Section 12) (D)

5.12 SKILLS AND GENDER EQUALITY

Strong frameworks only deliver if they are implemented through agencies with clear roles, well-defined mandates, and sufficiently resourced staff. Gender equality is key to development of an excellent pool of capability, both within stakeholders and with the OSW industry and is an important focus for an establishing, future-focused industry. It is recommended that:

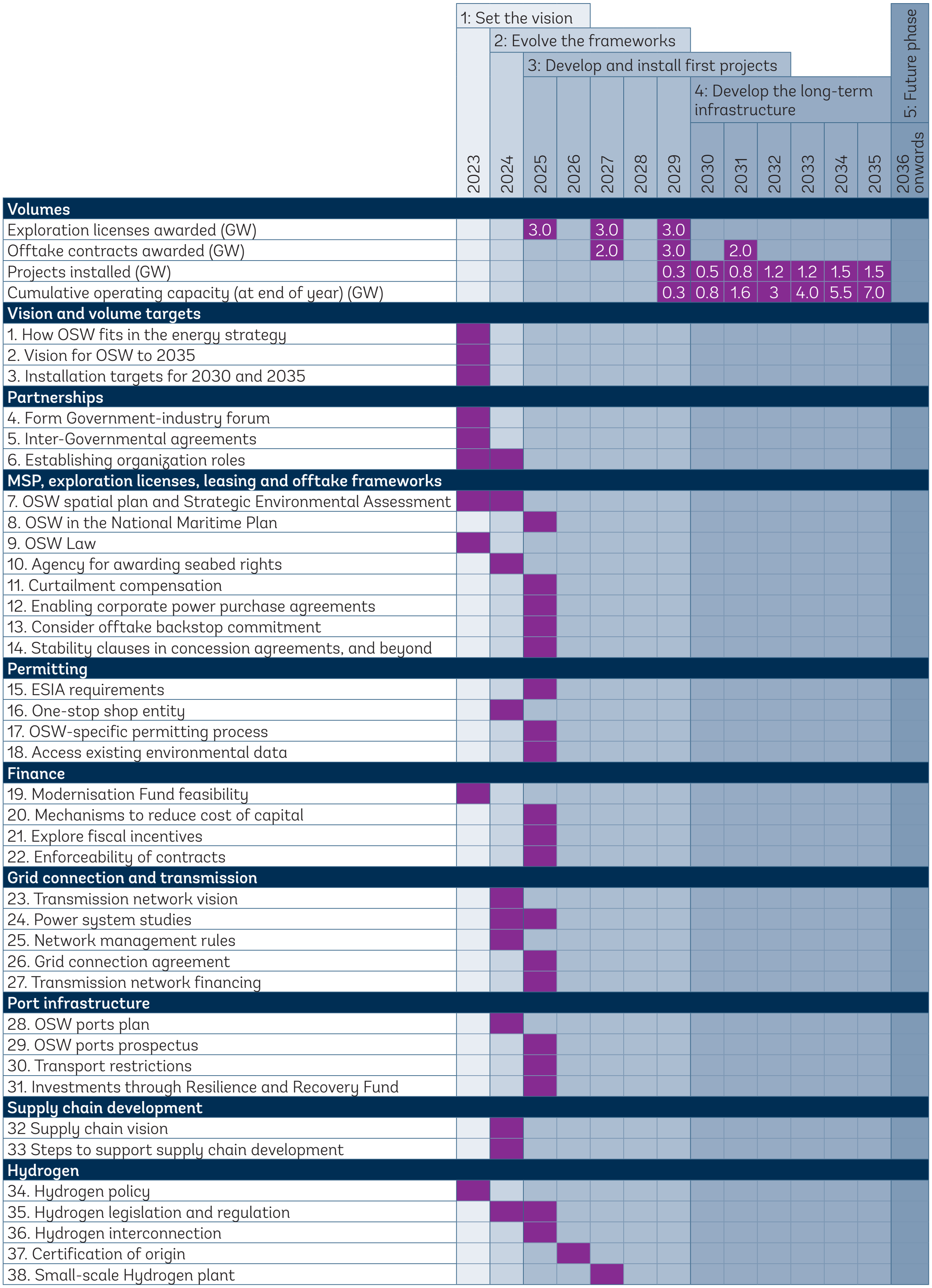
43. The MOE and the General Secretariat of Government lead in helping Government departments and other key stakeholders to grow capacity and knowledge needed to process the planned volume of OSW projects (through all frameworks). (see Section 11) (D)
44. The MOE, Ministry of Economy, The Ministry of Education, relevant universities / training colleges and industry (through the Romanian Wind Energy Association (RWEA)) collaborate to enable education and investment in local supply chain businesses, including in training of onshore and offshore workers. (see Section 8) (D)
45. OSW project developers and suppliers collaborate to encourage women into the sector and get involved in gender equality working groups. Women's rights organizations in Romania, such as the Women's Association of Romania, the Association for Liberty and Equality of Gender and Centrul Filia, and industry bodies, such as Global Wind Energy Council (GWEC) and Global Women's Network for the Energy Transition (GWNET), should be included in these working groups. (see Section 10) (D)
46. The Ministry of Labour and Social Solidarity and industry set diversity targets and establish framework to measure progress. see Section 10) (D)
47. OSW project developers and suppliers collaborate to publish a best practice guide for industry stakeholders and ensures opportunities for women in OSW are well-promoted. The best practice guide should discuss using gender decoders and gender-balanced language to ensure hiring practices are unbiased and creating spaces and opportunities for women to network within the OSW sector. see Section 10) (D)
48. The MOE considers introducing diversity requirements into leasing and revenue frameworks. see Section 10) (F)

5.13 ROADMAP SUMMARIES

FIGURE 5.4 LOW GROWTH SCENARIO ROADMAP FOR OFFSHORE WIND IN ROMANIA

	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036 onwards
	1: Set the vision													5: Future phase
		2: Evolve the frameworks												
			3: Develop and install first projects											
								4: Develop the long-term infrastructure						
Volumes														
Exploration licenses awarded (GW)			2.0		2.0									
Offtake contracts awarded (GW)					1.0		2.0							
Projects installed (GW)							0.3		0.5	0.5	0.7		1.0	
Cumulative operating capacity (at end of year) (GW)							0.3	0.3	0.8	1.3	2.0	2.0	3.0	
Vision and volume targets														
3. Installation targets for 2030 and 2035	■													
Partnerships														
4. Form Government-industry forum	■													
5. Inter-Governmental agreements	■													
6. Establishing organization roles	■	■												
MSP, exploration licenses, leasing and offtake frameworks														
7. OSW spatial plan and Strategic Environmental Assessment	■	■												
8. OSW in the National Maritime Plan			■											
9. OSW Law	■													
10. Agency for awarding seabed rights		■												
11. Curtailment compensation			■											
12. Enabling corporate power purchase agreements			■											
13. Consider offtake backstop commitment			■											
14. Stability clauses in concession agreements, and beyond			■											
Permitting														
15. ESIA requirements			■											
18. Access existing environmental data			■											
Finance														
19. Modernisation Fund feasibility	■													
20. Mechanisms to reduce cost of capital			■											
21. Explore fiscal incentives			■											
22. Enforceability of contracts			■											
Grid connection and transmission														
25. Network management rules		■												
26. Grid connection agreement			■											
Port infrastructure														
28. OSW ports plan		■												
29. OSW ports prospectus			■											
30. Transport restrictions			■											
31. Investments through Resilience and Recovery Fund			■											
Supply chain development														
32 Supply chain vision		■												
33 Steps to support supply chain development		■												
Health and safety and other standards and regulations														
39. Labor code			■											
40. H&S regulations			■											
41 & 42. Start H&S training and knowledge sharing				■										
Capacity building and gender equality														
43. Start growing stakeholder capacity and knowledge	■													
44. Start supply chain and workforce education and support		■												
45. Establish gender equality working groups		■												
46. Diversity targets and measurement				■										
47. Gender best practice guide				■										
48. Diversity requirements part of frameworks					■									

FIGURE 5.5 HIGH GROWTH SCENARIO ROADMAP FOR OFFSHORE WIND IN ROMANIA



	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036 onwards
1: Set the vision	1: Set the vision													
2: Evolve the frameworks		2: Evolve the frameworks												
3: Develop and install first projects			3: Develop and install first projects											
4: Develop the long-term infrastructure								4: Develop the long-term infrastructure						
5: Future phase														5: Future phase
Health and safety and other standards and regulations														
39. Labor code			■											
40. H&S regulations			■											
41 & 42. Start H&S training and knowledge sharing				■										
Capacity building and gender equality														
43. Start growing stakeholder capacity and knowledge	■													
44. Start supply chain and workforce education and support		■												
45. Establish gender equality working groups		■												
46. Diversity targets and measurement				■										
47. Gender best practice guide				■										
48. Diversity requirements part of frameworks					■									

SUPPORTING INFORMATION

6. SPATIAL PLANNING

6.1 PURPOSE

The purpose of this section is to present an overview of the publicly available spatial data relating to environmental, social, and technical considerations that may impact prospective offshore wind (OSW) development in Romania, and to recommend steps to establish suitable locations for OSW development.

6.2 METHOD

At the time of writing, Romania had almost completed a robust National Maritime Plan.[viii] This plan refers to OSW but does not identify specific areas, as specific volumes of OSW had not been formalized in Government plans.

We have not carried out a detailed parallel process to identify areas suitable for OSW, rather highlighted key considerations and recommended next steps in this area.

We have, however, provided an indicative map (independent of the National Marine Plan) for potential offshore wind energy areas, useful for defining typical site conditions and supply chain needs.

In the sections below, we present:

- The technical potential for OSW in Romania based on a simplified assessment;
- Relevant environmental, social and technical considerations and a data gap analysis;
- Our spatial view of levelized cost of energy (LCOE);
- Potential offshore wind energy areas; and
- Recommended steps to establish formally suitable locations for OSW in Romania.

6.2.1 Technical potential

The WBG ESMAP program has developed technical potential for 56 OSW markets, including Romania. It shows a technical potential of 22 GW on fixed sites and 54 GW on floating sites [16]The analysis methodology is explained in detail on the web page.[17]

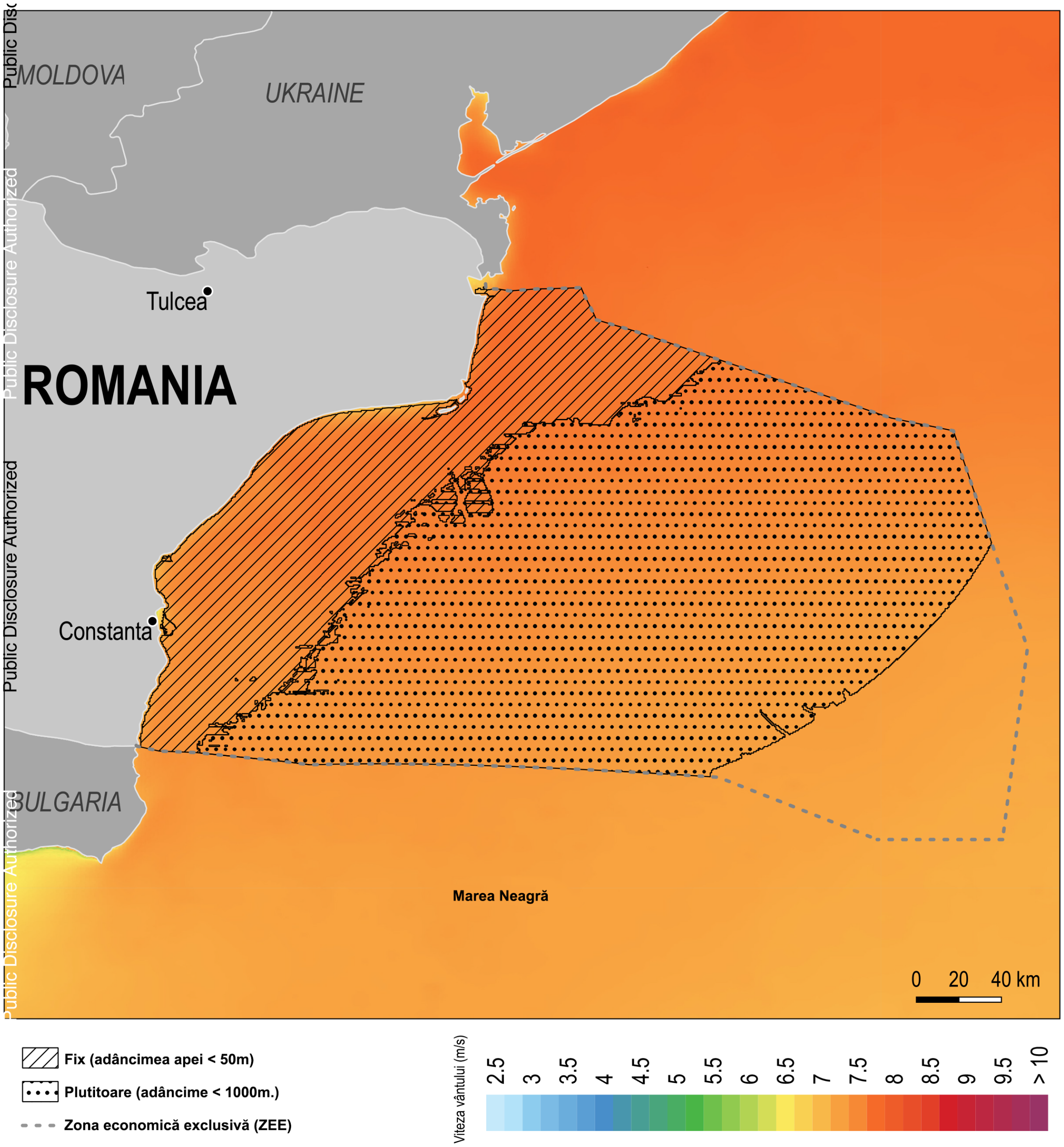
viii. At the national level, the general framework for strategic planning, sustainable and integrated development of the various uses of marine waters is established by the National Maritime Plan. The plan has a directive and regulatory character, having the role of identifying the spatial and temporal distribution of current and future activities and uses in marine waters.
The National Maritime Plan was developed with the participation and consultation of the competent authorities established by Government Ordinance no. 18/2016 regarding the development of the maritime space. At time of writing, the plan was going through the strategic environmental assessment procedure, during which the Environmental Report and the Adequate Assessment Study (together, a Strategic Environmental Assessment (SEA)) are drawn up, according to the Decision of the framework stage regarding the plan, issued by the Ministry of the Environment, Water and Forests (no. 11/09/11/2022).
Following the completion of the environmental assessment procedure, the sectoral strategies aimed at the development objectives included in the plan will no longer be subject to SEA, according to Government Decision no. 1076/2004 on establishing the procedure for carrying out the environmental assessment for plans and programs. For OSW projects, it will be necessary to go through an environmental and social impact assessment (ESIA) procedure.

Technical potential is defined as the maximum possible installed capacity as determined by wind speed and water depth. Mean wind speeds (at 100 m height) exceeding 7 m/s are considered viable for OSW, and water depths of up to 50 m and up to 1000 m are considered viable for fixed and floating foundations, respectively. The datasets used in this analysis are listed under technical considerations in Table 6.1.

The analysis of technical potential does not consider other factors that could influence the planning and siting of OSW projects including environmental, social and economic considerations.

The technical potential is shown in Figure 6.1.

FIGURE 6.1 OFFSHORE WIND TECHNICAL POTENTIAL IN ROMANIA



Source: World Bank Group and ESMAP.

6.2.2 Environmental, social & technical considerations

Table 6.1 provides a list of the spatial layers relevant to OSW spatial planning, showing known data gaps.

TABLE 6.1 SPATIAL DATA LAYERS RELEVANT TO OFFSHORE WIND SPATIAL PLANNING.

Data layer	Notes	Data Source	Reference	In National Maritime Plan
Environmental considerations				
Marine Protected Areas	Protected areas under the EU Natura 2000 program, protecting key breeding, foraging and resting sites for rare and threatened species, and important congregations of migratory species. This also includes multiple Special Areas of Conservation for which bottle-nosed dolphin and harbour porpoise are designated features along the Romanian coast	Natura 2000	https://ec.europa.eu/environment/nature/natura2000/index_en.htm	Yes
Critical Habitats	Areas of known habitats of threatened species, designated under EU Habitats Directive and Birds Directive, including estuaries and mudflats.	Habitats Directive Birds Directive	https://ec.europa.eu/environment/nature/legislation/habitatsdirective/index_en.htm https://environment.ec.europa.eu/topics/nature-and-biodiversity/birds-directive_en	Yes
Important Shark and Ray Areas	Areas of importance for vulnerable species	ISRA	https://sharkrayareas.org/portfolio-item/vama-veche-isra/#-toggle-id-1	
Ecologically or Biologically Significant Marine Areas	Areas of importance in terms of supporting a healthy ocean	EBSA	https://www.cbd.int/ebsa/	
Key Biodiversity Areas (including Alliance for Zero Extinction sites and Important Bird Areas (IBA)	Areas of international importance in terms of biodiversity conservation.	IBAT	https://www.ibat-alliance.org/sample-downloads?tab=gis-downloads&anchor_id=resource-header	No
Ramsar sites	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.	IBAT Ramsar Convention	http://ihp-wins.unesco.org/layers/geonode:sites https://www.ramsar.org/country-profile/romania	No

Data layer	Notes	Data Source	Reference	In National Maritime Plan
Important Marine Mammal Areas (IMMAs)	Habitats important to marine mammal species that have the potential to be delineated and managed for conservation. Dolphins are a particular consideration Romanian waters, but limited recent dolphin population datasets are available.[ix]	Marine Mammal Protected Areas Task Force	https://www.marine-mammalhabitat.org/imma-eatlas/	Yes, unsourced information on dolphin sightings and activity are included
UNESCO World Heritage Natural Sites	Natural heritage sites with outstanding universal value to humanity.	UNEP	http://www.un-ep-wcmc.org	Yes
UNESCO-MAB Biosphere Reserves	The MAB program is an intergovernmental scientific program that aims to establish a scientific basis for enhancing the relationship between people and their environments.	UNESCO	http://ihp-wins.une-sco.org/layers	No
Endemic Bird Areas (EBAs)	Areas of overlapping breeding ranges of restricted range bird species	BirdLife International Data Zone.	http://datazone.birdlife.org/eba/	No
Social considerations				
UNESCO World Heritage Sites	Cultural and/or natural heritage sites with outstanding universal value to humanity	UNESCO	http://ihp-wins.unesco.org/layers/worldheritagesites:-geonode:worldherita-gesites	No
Fishing effort	Apparent fishing effort derived from satellite monitoring	Global Fishing Watch Marine Manager	https://globalfish-ingwatch.org/ma-rine-manager-portal/	No
Commercial fisheries				Yes, contains data on commercial fishing. No sources available
Marine aquaculture				Yes, contains data on traditional fishing areas and, mussels
Landscape and seascape		No dataset found		No
Tourism areas		No dataset found		No
Wrecks and historic offshore sites	The Global Maritime Wrecks Database (GMWD) is a worldwide ArcView point shapefile of more than 250,000 wreck locations	NASA	https://cmr.earth-data.nasa.gov/search/concepts/C1214613883-SCIOPS	Yes

ix. Some information from vessel surveys can be found in https://blackmeditjournal.org/wp-content/uploads/2-20193_266-279.pdf and http://olteniastudiisicomunicaristiintelenaturii.ro/cont/37_2/III.%20ANIMAL%20BIOLOGY%20III.b.%20VERTEBRATES/20%20Paiu.pdf

Data layer	Notes	Data Source	Reference	In National Maritime Plan
Technical considerations				
Airports	Regions around airports may need to be avoided to reduce radar impacts.	Openflights 2020	https://openflights.org/data.html	No
Exclusive Economic Zones (EEZ)	Internationally recognized marine boundaries.	Marine Eco Regions	https://www.marineregions.org/	Yes
Extreme wind speeds	Used for information. Not a consideration for Romania, no risk of significant cyclone wind speeds recorded	PREVIEW Global Data Risk Platform	https://preview.grid.unep.ch/	No
Mean wind speed	Used to determine annual energy production (AEP) and LCOE	The Global Wind Atlas v3.3, released in 2023 (Danish Technical University (DTU) and WBG)	https://globalwindatlas.info/	No
Military bases	Locations of military bases and facilities of NATO. Public dataset for Romania national military not available	NATO	https://www.nato.int/nato-on-the-map/	No
Military exclusion zones	Public data not available			Military training areas identified
Offshore oil and gas activity	Locations of offshore oil and gas activity	Global oil and gas infrastructure - US Department of Energy	https://www.eia.gov/maps/	Yes
Ports	Locations and size of ports	World Port Index 2019	https://msi.nga.mil/Publications/WPI	Yes
Seismic activity	Used for information. Details peak ground acceleration for a 250 year return period	PREVIEW Global Data Risk Platform	https://preview.grid.unep.ch/	No
Shipping density	The raster layers were created using IMF's analysis of hourly AIS positions received between Jan-2015 and Feb-2021 and represent the total number of AIS positions that have been reported by ships in each grid cell with dimensions of 0.005 degree by 0.005 degree (approximately a 500 m x 500 m grid at the Equator)	World Bank	https://datacatalog.worldbank.org/search/dataset/0037580/Global-Shipping-Traffic-Density	No. Some shipping lanes around Constanța included
Undersea cables	Datasets includes official submarine cable system name, cable system length and landing points. Additional information such as the owners of the cable systems can be found on www.submarinecablemap.com. The routes of the cables do not accurately reflect the exact route taken by each cable but give an indication of approximate location.	TeleGeography Submarine Cable Map	https://www.submarinecablemap.com/	Yes

Data layer	Notes	Data Source	Reference	In National Maritime Plan
Water depth	Used to determine areas of fixed/ floating foundations, and as input to the LCOE model.	The General Bathymetric Chart of the Oceans (GEBCO_2020)	https://www.gebco.net/data_and_products/gridded_bathymetry_data/	Yes
Aggregate and material extraction areas		No known data		No
Offshore disposal sites		No known data		No

6.2.3 Levelized cost of energy

The site parameters that have the most influence on cost of energy are:

- Wind speed;
- Water depth;
- Distance to construction port;
- Distance to operation port; and
- Distance to grid.

These site parameters were used along with typical project characteristics and assumptions, to estimate a spatial distribution of relative LCOE for a project installed in 2032 in Romanian waters. The analysis is compatible with the LCOE trajectories for typical projects presented in Section 7. The analysis is detailed, but not as sophisticated as one carried out for an actual OSW project, involving months of detailed design and optimization.

The wind speed and water depth spatial datasets used were the same as those used for the technical potential mapping.

We calculated travel distance from the port of Constanța, assuming it would be used for construction and operation.

A grid connection point close to Constanța was assumed to avoid landfall within Natura 2000 protected areas. It is assumed that 20 km of onshore transmission cable would be required, in addition to the offshore transmission infrastructure. We assumed floating foundations would be used for sites with water deeper than 65 m, in line with current industry expectation. In practice, the cut-off between fixed and floating depths will be determined on a project-by-project basis.

We considered the LCOE for the entire exclusive economic zone (EEZ), including some areas in the south east of the EEZ with water depth greater than 1000 m, although in practice these areas may present technical feasibility challenges in addition to being the highest LCOE areas.

We constrained distance to shore to less than 200 km to rule out sites where novel transmission infrastructure or alternative energy conversion would be needed. This was also the limit of the wind speed data set.

6.2.4 Potential offshore wind energy areas

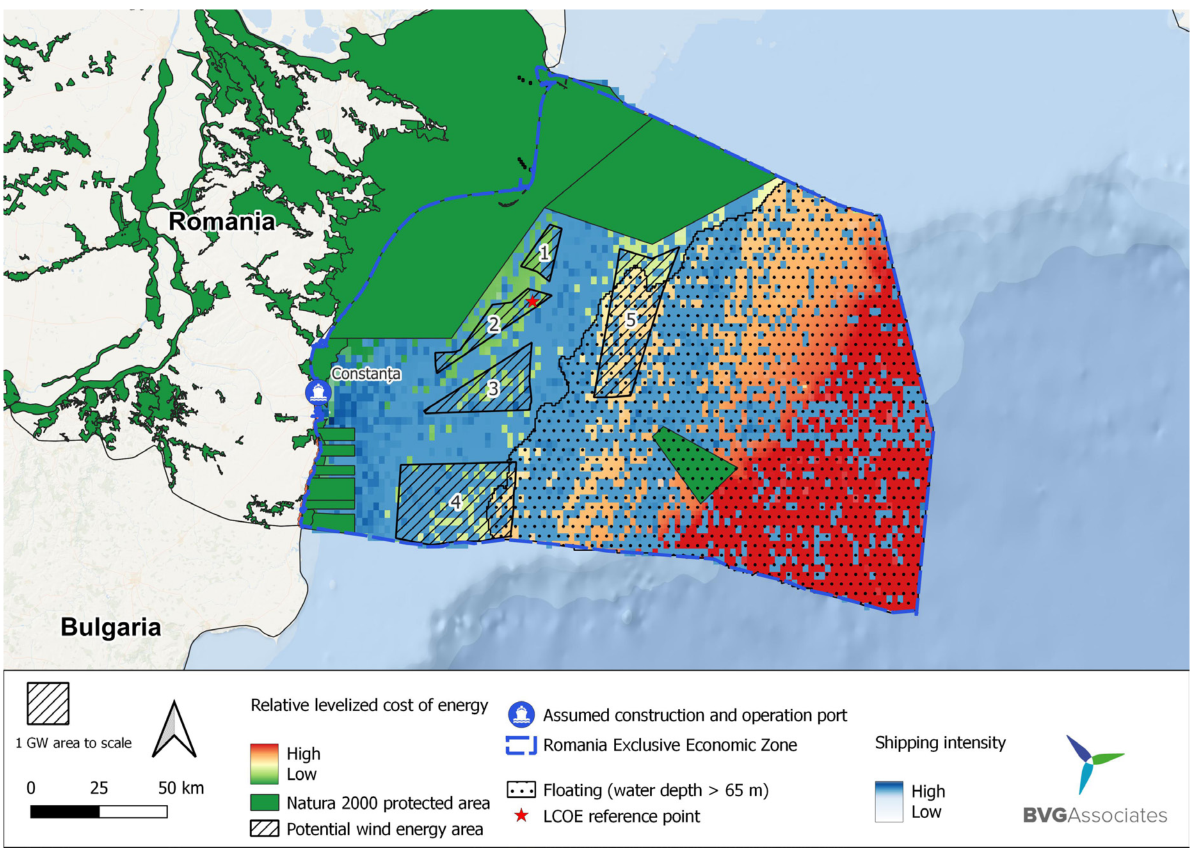
Indicative potential OSW energy areas are shown in Figure 6.2. These are based on:

- Consideration of major environmental exclusions based on the Natura 2000 protected areas;
- Shipping densities and shipping lanes; and
- Prioritizing lower LCOE areas.

A significant caveat is that we have not accounted for avian migration routes to/from the wetlands of the Danube Delta that could cut across these. There is little available data relating to this, which contributes to our suggestion in Section 6.2.5 to carry out a Strategic Environmental Assessment. This means that any updated assessment of offshore wind energy areas needs to be flexible enough to account for new data and understanding, enabling habitat and species protection.

Given the existence of important areas with protection status in the vicinity of the potential offshore wind energy areas proposed, it is important to comply with environmental regulations and, through the whole life of projects, to develop solutions that are sensitive to the needs and vulnerabilities of relevant receptors.

FIGURE 6.2 POTENTIAL OFFSHORE WIND ENERGY AREAS IN ROMANIA



The total identified area covers about 2,100 km^2 suitable for projects with fixed foundations and 750 km^2 in water deeper than 65 m, suitable for projects with floating foundations. The latter might be relevant should project developers want to progress this technology, or Romania choose to increase OSW capacity beyond what it can deliver from fixed sites.

A typical project has a density of 4.5 MW/ km^2 (for example, one 16 MW turbine in an area of about 3.6 km^2). Projects need buffer zones (typically of at least 10 km) between them and not all of the potential space shown will prove to be suitable, meaning that at this stage it would be reasonable to expect to be able to install at an average density of 3 MW/ km^2 over the areas shown. At this density. these potential wind energy areas would facilitate 6.4 GW of fixed projects and 2.3 GW of floating capacity, with more space available for floating projects at a later date, if required. These figures are indicative and may increase or decrease with further work.

6.2.5 Steps to finalize suitable locations for offshore wind in Romania

In order to support the long-term development of OSW in Romania, a strategic approach to OSW and transmission network development will be needed. In support of this, we recommend that OSW is fully incorporated into the National Maritime Plan as early as possible.

As there may be a delay in incorporating OSW fully into the National Maritime Plan, and there is a need to de-risk and progress OSW development with urgency, it is suggested that a high-level assessment is carried out to enable award of exploration licenses in areas that are likely to be suitable for OSW development, especially with respect to environmental and social considerations.

This requires the completion of an OSW spatial plan (including basic technical review) and Strategic Environmental Assessment (SEA).

Offshore wind spatial plan

This plan will:

- Use all relevant information from the National Maritime Plan and source any other geographical data needed (see World Bank Roadmap for the Philippines, for example) to establish potential OSW energy areas, based on a wide range of environmental and social considerations;
- Include a basic technical review of these provisional OSW energy areas (a desk-study considering windspeed, ground conditions and other relevant technical parameters) in order to help finalize,
- Involve inter-departmental engagement to enable cross-government agreement, and
- Use the above to designate OSW energy areas, conditional on the Strategic Environmental Assessment.

The above activity needs to follow good international industry practice, and might require assessment under the Habitat and Bird Directives. The precise scope should be agreed with an Independent Engineer. The output will include:

- OSW energy areas, conditional on the SEA;
- Justification of these OSW energy areas, including methodology to use in next update of the National Maritime Plan; and
- Spatial data to be made public in due course to support OSW development activities (where allowed).

Strategic Environmental Assessment

This assessment will include:

- Assessment of an area larger than the potential wind energy areas derived above, for example encompassing all five wind energy areas, including all space between the areas;

- A risk mapping according to biodiversity sensitivities for area under consideration, by relevant receptor;
- Any surveys shown to be needed by the risk mapping to establish increased confidence in the risk mapping results[x]; and
- Considerations important to OSW, including:
  - Addressing data gaps in relation to the biodiversity baseline, which may require additional field surveys to be completed according to Good International Industry Practice (GIIP). Based on engagement to date, a key data gap relates to bird migration to and from the Danube delta;
  - Establishing Exclusions and Restrictions based on biodiversity, social and technical considerations:
    - Exclusions – areas of highest environmental or social sensitivity to be excluded from OSW assessment; and
    - Restrictions – high risk areas requiring further evaluation for OSW site selection and environmental and social impact assessment (ESIA);
  - Establishing buffer distances to subsea cables, shipping routes and point considerations, such as airports;
  - Consideration of cumulative impact of multiple projects in a given area, including any reasonably foreseeable projects elsewhere in the Black Sea; and
  - Ongoing dialogue with OSW developers to ensure alignment in expectations regarding spatial considerations and the incorporation of latest international thinking.

The above activity needs to follow GIIP. The precise scope should be agreed with an Independent Engineer, based on a scoping study. The output will include:

- Results of surveys and risk mapping;
- Resulting changes to OSW energy areas; and
- Guidance on the scope of an ESIA to be carried out by a developer of a specific project within a specific OSW energy area, in due course, based on these results.

6.3 RECOMMENDATIONS

Based on this analysis, it is recommended that:

- The Ministry of Energy (MOE) progresses a proportionate OSW spatial plan, incorporating Strategic Environmental Assessment in line with GIIP, involving sensitivity mapping and considering environmental and social considerations (including about avian migration routes to/from the wetlands of the Danube Delta and the cumulative impact of multiple projects). This should include focus on engagement with key stakeholders and will result in early designation of offshore wind energy areas.
- The MOE and Ministry of Development, Public Works and Administration include OSW in the next revision of the National Maritime Plan, formalizing the proportionate OSW spatial plan described above.

x. Currently, there is uncertainty especially about avian migration routes to/from the wetlands of the Danube Delta that could cut across potential offshore wind energy areas.

7. COST OF ENERGY

7.1 PURPOSE

In this work package, we determine the long-term cost trajectory of offshore wind (OSW) in Romania, considering global cost reduction trends, resource potential, country characteristics, regional supply chain development, and other key factors.

We do this under the two industry scenarios outlined in Section 2. This is important as it is helpful to understand, long-term, what the cost of energy from OSW will be and how to influence this.

We focus on fixed OSW, as this is likely to be the dominant technology, due to potential floating sites in Romania generally having lower wind resource and being further from shore, which increases cost.

7.2 METHOD

We modelled costs and levelized cost of energy (LCOE) under the two scenarios, as presented in Section 2.

We established baseline costs (for installation in 2029, recognizing key differences between established market and Romanian projects) and trajectories (costs in 2032 and 2035) based on key parameters defined in Table 7.1.

We chose these years to fit with the scenarios described in Section 2. We recognize that these scenarios both have first capacity installed in 2029, which is optimistic. Delays will slow installation but will mean early projects should be able to benefit from marginally lower global prices as technology continues to progress.

Note details such as project lifetime gradually extending in line with trend anticipated in established OSW markets. We then interpolated between these points for intermediate years.

A detailed explanation of our methodology, plus detailed definitions and assumptions, is provided in Section 7.4. The analysis also uses the supply chain assumptions presented in Section 8.

The analysis presented in this section has the same basis as (and hence is fully compatible with) the spatial LCOE analysis presented in Section 6. It is also used directly as the basis for the economic benefit analysis presented in Section 9.

The method is detailed and robust, breaking down project capital; expenditure (CAPEX) and operational expenditure (OPEX) each into a number of key elements. Annual energy production (AEP) (and hence capacity factor) is derived by combining a wind speed distribution at hub-height (based on mean wind speed at 100 m height and a typical annual wind speed distribution and change in wind speed with height) with a representative power curve (derived for the given turbine power rating and rotor diameter). This AEP is then adjusted to account for a range of real-world factors presented in Table 7.4.

In assessing costs, we consider the local supply chain that could be established to serve the Romanian market, wider regional market and further afield.

TABLE 7.1 KEY PARAMETERS FOR THE TYPICAL SITES MODELLED, AGAINST YEAR OF INSTALLATION

Parameter	2029	2032	2035
Mean wind speed (at 100 m height) (m/s)[xi]	7.6	same	same
Water depth (m)	50	same	same
Distance from construction port (km)	80	same	same
Distance from operations port (km)	80	same	same
Distance from grid (offshore) (km)	80	same	same
Distance from grid (onshore) (km)	20	same	same
Turbine rating (MW)[xii]	16	19	22
Rotor diameter (m)	256	279	298
Project size (MW)	1000	1000	1500
Project lifetime[xiii] (years)	30	31	32

7.3 RESULTS

LCOE results in this roadmap were derived as mid- (P50) estimates, meaning 50% chance of exceedance. We are currently experiencing much volatility in commodity prices, meaning that there is significant uncertainty about where such prices will head over the next five years, though we expect prices of many commodities to return to previous levels before project developers commit to significant expenditure for Romania OSW projects [xiv] OSW uses large volumes of raw material (dominated by mild steel, typically followed by cast iron, aluminum, composites and copper).

Changes in energy prices also impact OSW, both through the energy needed to manufacture components and to fuel installation and operation vessels. Changes in energy prices have an even greater impact on electricity prices from fuel burning.

xi. Mean wind speeds are quoted at a standard reference height to give clarity regarding trends, and because these wind speeds characterise project sites, independent of what size turbine is used. We adjust the mean wind speeds at reference height to the mean wind speeds at hub height of a given turbine when deriving annual energy production. This means that a higher-rated turbine with larger rotor on the same site will have a higher hub high mean wind speed than a smaller turbine.

xii. Note that industry experience is that (all other things being equal), the use of turbines with the highest rating (with associated large rotors) offers the lowest LCOE. This applies equally for sites with lower and higher mean wind speeds – there is not a correlation between optimum wind speed and optimum turbine scale, recognising that the optimum specific rating (ratio of turbine rating to rotor swept area, W/m2) drops with decreasing wind speed. See also Appendix C Section 5.3.1.
Separate from this is the potential challenge of the largest turbine installation vessels transiting to the Black Sea (as discussed in Section 17 to install the largest wind turbines. This challenge relates mainly to clearance for jack-up legs, with relates as much to water depth as to turbine size. Overall, it is not considered that vessel challenges will drive a choice to use anything but the highest rating turbines available.

xiii. Over time, as global and national market experience of technology grows and the pace of LCOE decreases, project lifetimes will continue to extend. In OSW, they started at 20 years, the original default design lifetime of an onshore wind turbine. The anticipated lifetimes shown here reflect these trends.
Experience in northern Europe is that some early onshore wind projects were repowered with larger turbines before the end of their design life, due to the rapid pace of technology development offering a better return from the site through repowering than continuing operation. Generally now, most owners seek to extend the operating life of their projects beyond the initial design life. By the time first project are installed in Romania, the same situation is likely, with a drive to extend the life of operating projects where possible.

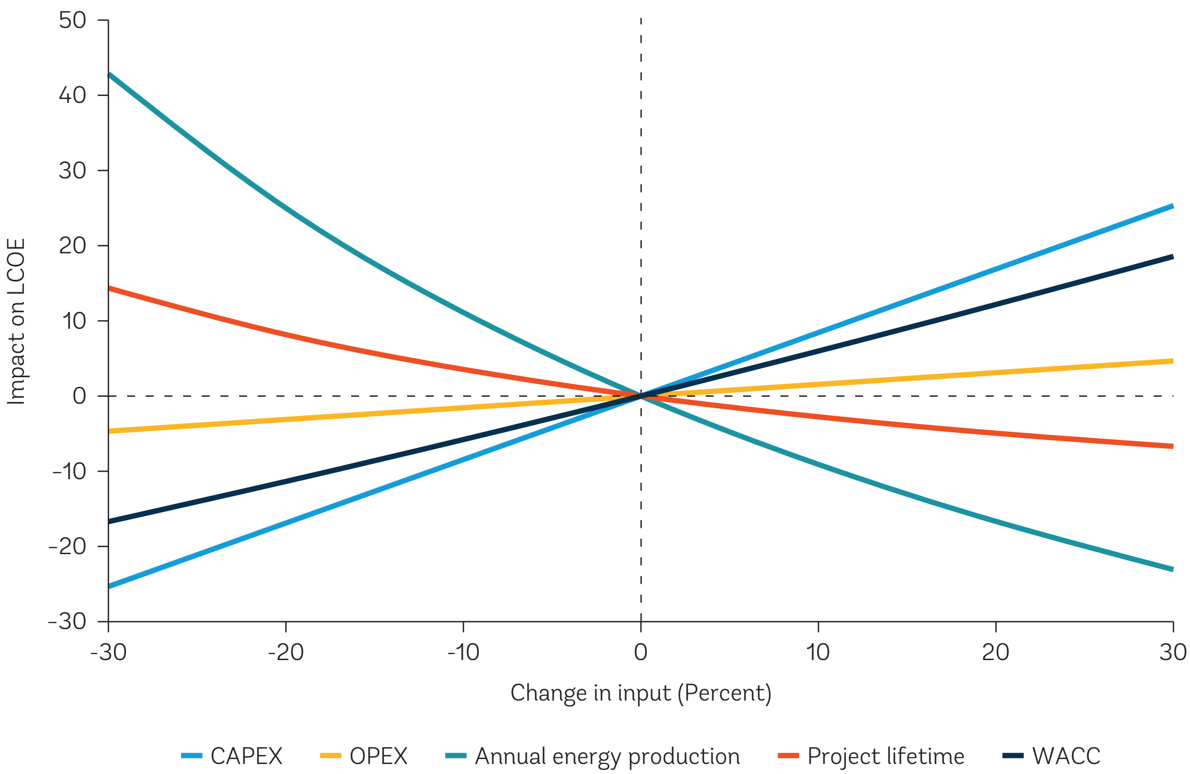
xiv. Prices and price volatility have increased due to post-covid demand and various geopolitical events. Federal Reserve Economic data shows a peak increase of about 3.5 times for the hot rolled steel index, compared to 2020 levels, followed by a steep start to return towards 2020 levels. Freightos shows a peak in shipping price of about 7 times 2020 levels, with 2023 levels returned to 2020 levels.

In this context, throughout the roadmap we have continued to state mid-estimates, but we recognize uncertainties, for example due to:

- Technology. How will past trends of significant reduction in cost change looking forward.
- Supply chain (including commodity prices). How will competition in the global and local supply chain evolve, and what will be the long-term trends in commodity prices.
- Finance. How will competition to finance OSW develop.

To give an understanding of the sensitivity of OSW LCOE to key parameters, see Figure 7.1.

FIGURE 7.1 SENSITIVITY ANALYSIS AROUND PROJECT INSTALLED IN 2029



Source: BVG Associates.

The LCOE under the two scenarios is shown in Table 7.2 and Figure 7.2, along with established market trend[xv] and indicative uncertainty bars. The LCOE trends are compatible with the LCOE reduction trajectories seen in established OSW markets. For a detailed discussion and background reading on LCOE reduction, see Section 2.2 of World Bank Group's *Key Factors* report.[9]

- The main differences between Romania sites modelled and established market projects are that the Romania sites have lower wind speeds; and
- LCOE in the low growth scenario is 8% higher than in the high growth scenario in 2032. This gap grows to 11% by 2035.

xv. The established market trends are based on the same bottom-up modelling discussed in Section 7.4, but using typical turbine sizes and site conditions anticipated in established OSW markets over the period.

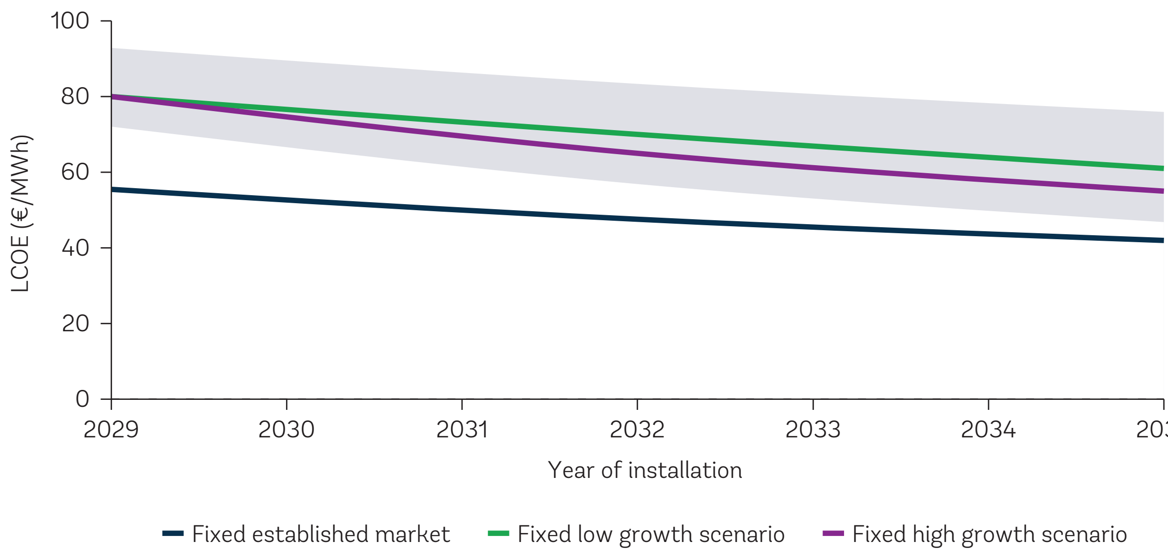
The detail behind these headline LCOE trajectories is discussed in the following sub-sections. Note that data relate to scenarios, with smooth trends shown over time. In reality for new projects the project sizes, costs, lifetimes, cost of money and nominal capacity factors will vary from this trend. In addition, actual generation for operating projects will vary year-by-year mean wind speeds.

Note also that the trends presented here are of technology costs on typical sites with properties consistent over time. In reality, sites will be developed in an order driven by LCOE, transmission network availability and other practical considerations.

TABLE 7.2 INDICATIVE LCOES FOR THE TYPICAL SITES MODELLED

Year of installation	Romania low growth scenario (€/MWh)	Romania high growth scenario (€/MWh)	Established market fixed (€/MWh)
2029	80 (likely range +16/-10%, 72 to 93)[xvi]		55
2032	70	65	48
	(likely range +19/-12%, 57 to 83)		
2035	61	55	42
	(likely range +24/-15%, 47 to 76)		

FIGURE 7.2 ESTIMATED LCOE TRAJECTORY FOR ROMANIA, COMPARED TO THE TREND FOR ESTABLISHED OFFSHORE WIND MARKETS



Source: BVG Associates.

Figure 7.2 shows an ongoing reduction in LCOE, greater in the high growth scenario. This is because the ~~roadmap drives~~

- Development of a reasonable scale, long-term market based on strong logic and clear vision, and supported by robust, transparent frameworks to de-risk project development, evolved from current arrangements, rather than starting afresh.

xvi. LCOEs at each end of this likely range could be obtained in various ways, for example:
- Lower end of range €72/MWh achievable through any of:
  - WACC is reduced from 6.0% to 5% through project de-risking, more balance-sheet financing and access to increased levels of concessional finance, or
  - Measurements show wind resource 8% better than anticipated and project life extended by 3 years (reflecting anticipated trend in established OSW markets).
- Upper end of range €93/MWh through any of:
  - 15% increase in CAPEX and OPEX due to further commodity price rises beyond consumer inflation
  - WACC increases from 6.0% to 7.6% due to perceived market risks / macroeconomic conditions, or
  - Measurements show wind resource 16% worse than anticipated.

Note that the likely ranges are indicative, designed to represent P20 to P80 ranges. It is still possible for LCOEs to be higher or lower than these ranges. Any extreme position is likely to be due to a combination of the above possibilities.

- Delivery of large-scale projects from early on, as the global industry will be mature enough by then to not need the ramp-up seen over years in established OSW markets. These markets were also managing significant technology and supply chain learning at the time.
- Focus on cost reduction, through clear policy intent, with visibility of competition and without restrictive local content requirements. This means that Romania will be able to benefit from what will be a highly experienced supply chain by the time first projects are installed, with local supply growing consistently over time.
- Availability of low-cost finance, through competitive local and international commercial debt and by accessing concessional finance through involvement of multilateral development banks (MDBs).
- Government-industry collaboration in a forum involving local and international project developers and key suppliers, to work together to address roadmap recommendations and other considerations, as they arise.

2029 is optimistic for installation of a first large project. If this is delayed, then LCOE will continue to reduce somewhat due to global trends. Whenever the first projects are installed, there will still be an early premium due to in-country learning and as the industry establishes.

CAPEX, OPEX, energy production, project lifetime and weighted average cost of capital (WACC) from which the LCOEs in established OSW markets and in Romania in 2029 have been calculated are provided in Table 7.3. Note that unrounded central values output from modelling is shown for full transparency. The uncertainty discussed above is not shown.

TABLE 7.3 COST ELEMENT BREAKDOWN SUPPORTING LCOES FOR 2029

Cost element	Unit	Established market	Romania
CAPEX	€/MW	2,700,000	2,990,000
OPEX	€/MW/year	46,200	42,200
Net annual energy production (capacity factor)	MWh/MW/year	4,330 (49%)	3,590 (41%)
Project lifetime	year	32	30
WACC*	%	5.0%	6.0%
LCOE**	€/MWh	55	80

Notes: * The WACC for these initial projects in Romania is assumed to be lowered by concessional finance blended with commercial debt. As an example, the 6.0% is made up of 50% concessional debt at about 3.5%, 30% commercial, non-recourse project debt at 7% and 20% equity at 11%. Currently, the view of projects in emerging markets is of higher risk than in northern Europe, where large project developers often balance sheet finance, say with 35% debt (against their own balance sheet rather than the project) at about 1% and 65% equity at about 7%, giving WACC below 5%. Should this practice extend to emerging markets faster than expected, then this will offer lower WACC and hence LCOE. Likewise, should this not happen and concessional finance not be available, then this will drive higher WACC and LCOE. ** See Table 7.4 for treatment of construction phase contingency and decommissioning.

The global LCOE reduction in Figure 7.2 comes from improving technology and processes, increasing turbine size, and increasing farm size.

The increases in turbine and wind farm size bring economies of scale in manufacture and logistics, including OMS. There are also economies of scale in individual components because the larger turbines need less infrastructure per MW. The largest turbines available for projects now are at about 16 MW-scale and we anticipate turbines of 20-25 MW-scale to be used in projects installed in 2035. It is unclear how much larger turbines will get, as typically the percentage LCOE savings is stable (or drops) with each new generation of larger turbines, but the cost (to the turbine supplier and the rest of the supply chain) to develop the necessary technology, manufacturing and logistics solutions increases rapidly.

7.3.1 LCOE in 2029

In Romania, the LCOE in 2029 is about 45% higher than in established OSW markets. 2/3 of this is due to the different site conditions, especially lower wind speeds (resulting in lower AEP, with capacity factor estimated to be 41%, rather than 49% in established OSW markets). Other key contributions are from increased WACC, inefficiencies from installation and other activities in a new market, and higher transport and mobilization/demobilization costs due to Romania's location on the Black Sea. We derived this factor by considering each cost item in Table 7.4 in turn, assigning a multiplier relating typical change in efficiency when working in a new market, a multiplier for change in cost base and a multiplier for any other relevant consideration. These factors are beyond the impact of change in basic site characteristics between established market and Romania.

7.3.2 LCOE trajectory in the low growth scenario

Over the period, the LCOE premium in Romania from setting up in a new market reduces. A solid regulatory environment with visibility enables some investment in capacity and learning, but market size limits this. Over time, the WACC drops somewhat due to increased certainty in all aspects of project lifecycle and revenue. We have assumed over time:

- Supply of some towers, most offshore substations (including installation), construction of onshore substations and grid connections, but little other supply of local components;
- Gradually increased localization of project development services; and
- Gradually increased operation services, including some component refurbishment.

Much of the LCOE reduction comes from the use of larger turbines and improvements in operation, maintenance and service strategies. This is mainly due to progress in the global market (relating also to the scale of the global market), rather than in Romania.

7.3.3 LCOE trajectory in the high growth scenario

Over the period, the LCOE premium in Romania from setting up in a new market reduces more significantly than in the low growth scenario. A solid regulatory environment with visibility of a strong, constant pipeline of projects enables investment in capacity and learning. Most towers and foundations are manufactured locally and more OSW services are provided locally, with increasing efficiency. Competition drives innovation and cost reduction. Logistics costs are reduced and, critically, the WACC drops due to increased certainty in all aspects of project lifecycle and revenue.

Compared to the low growth scenario, we have assumed:

- Similar localization of project development services and offshore substation activities;
- Localization of manufacture of foundations and more turbine towers;
- Increased involvement of local suppliers during operation; and
- More local supply of replacement components during operation.

The site conditions are the same as for the low growth scenario.

The largest difference compared to the low growth scenario is increased reduction due to WACC due to further decreased market risk and increased competitive tension between lenders. In other areas, the savings are due to increased learning, turbine rating, competition and international collaboration.

7.4 BACKGROUND: DETAILS OF METHODOLOGY

7.4.1 Definition of levelized cost of energy

At its most simple, LCOE is the cost of the project divided by the energy produced. The technical definition is:

$$LCOE = \frac{\sum_{t=s}^{n} \frac{I_t + M_t}{(1+r)^t}}{\sum_{t=s}^{n} \frac{E_t}{(1+r)^t}}$$

where:

I_t — Investment expenditure in year

M_t — Operation, maintenance and service expenditure in year

E_t — Energy generation in years

r — Discount rate

s — Start year of the project, and

n — Lifetime of the project in years.

We use a WACC method to establish the discount rate. That is, a rate based on the weighted average of the debt and equity portions of the financing, from inception of the project to decommissioning.

7.4.2 Method for cost analysis

The analysis presented in Section 7 is based on a significant body of work peer reviewed through many published reports and private projects with industry clients in Europe, USA and Asia.

In effect, here we have conducted a study of studies, where we access published, but mainly unpublished studies that we have been involved with (or have received in delivery of consultancy projects). This gives a far better data set than is in the public domain.

This is appropriate at this stage because there are no projects operating (or even designed) at this scale in Romania.

Key to the analysis are the following steps.

A. Create Established market baseline for projects installed in 2029, 2032 and 2035, considering larger turbines and larger projects, but deeper water and further from shore over time. We did this using cost models proven over time. A schematic of the inputs and outputs of a typical single BVGA cost model run is shown in Figure 7.3. This step involved 3 cost model runs.

B. Create Romania starting point in the same way but using Romania site conditions for a typical floating and a typical fixed project in each time period. At this stage results are still for established market conditions (and supply chain). This step involved six cost model runs. Note that this same process, with a simplified step C is used for each individual cell in the preparation of the LCOE map derived in Section 6.

C. Convert each to the Romania market (and supply chain) conditions for each of the two OSW scenarios. For each cost element shown in Table 7.4, we established scaling factors to take account of differences in market efficiency, cost base compared to an established market and other considerations. We considered:

- Transitory effects, such as lack of industry inexperience and high regulatory risk. For example, if we applied a cost premium in step 2, we assumed that by 2035 in the high growth scenario, much of that premium had been removed by more rapid learning than in northern Europe during the same period.
- Permanent effects, such as needing to bring installation vessels from established OSW markets. In some of these cases, we assumed a larger early transitory cost penalty which reduced in time, for example as design for typhoon resistance gets more optimized.
- To do this, we used our experience of other new markets and feedback about Romania. A schematic of the inputs and outputs of a single conversion process is shown in Figure 7.4. This step involved 12 conversions, each with a set of scaling factors.

D. Combined the results of the above to derive the LCOE trends shown in Figure 7.2. A schematic showing the source of each trend is shown in Figure 7.5.

FIGURE 7.3 SCHEMATIC SHOWING INPUTS AND OUTPUTS FOR A BVGA COST MODEL RUN

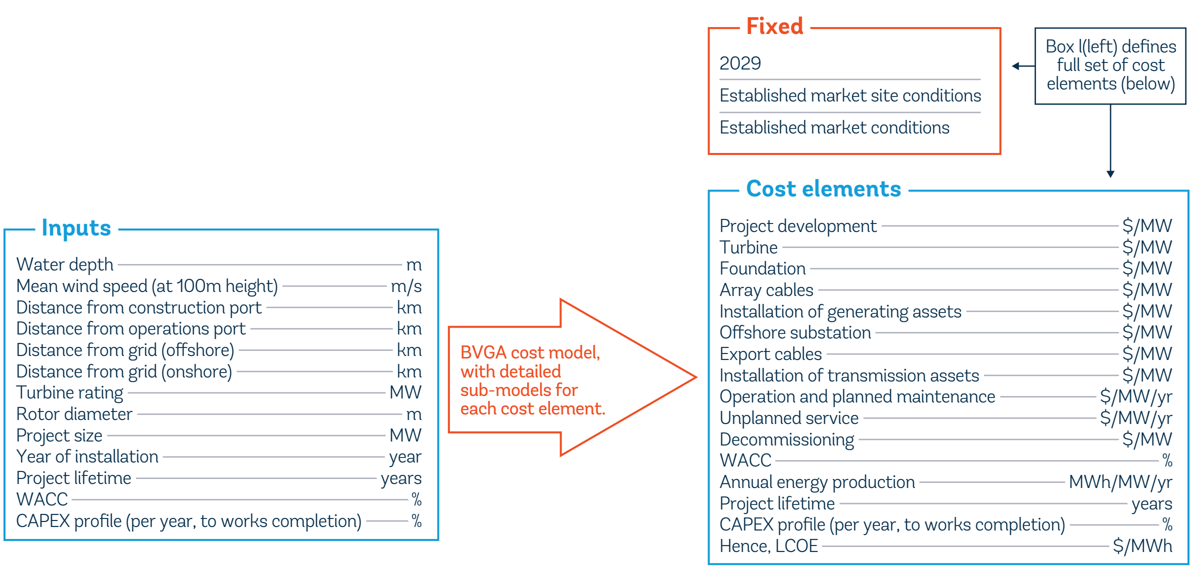


FIGURE 7.4 SCHEMATIC SHOWING CONVERSION FROM ESTABLISHED TO LOCAL MARKET CONDITIONS

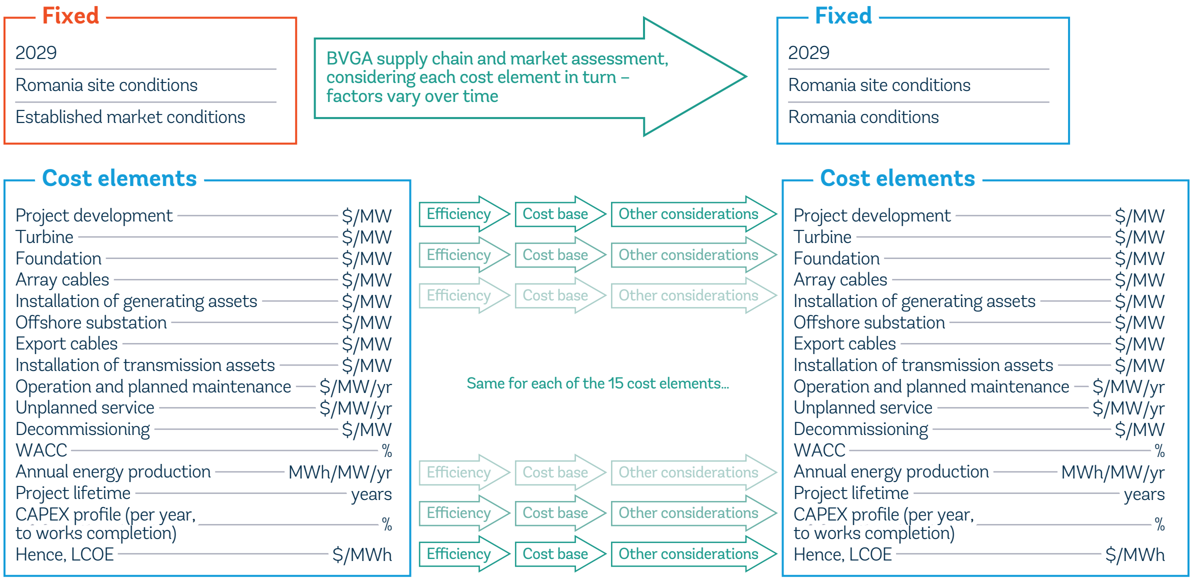
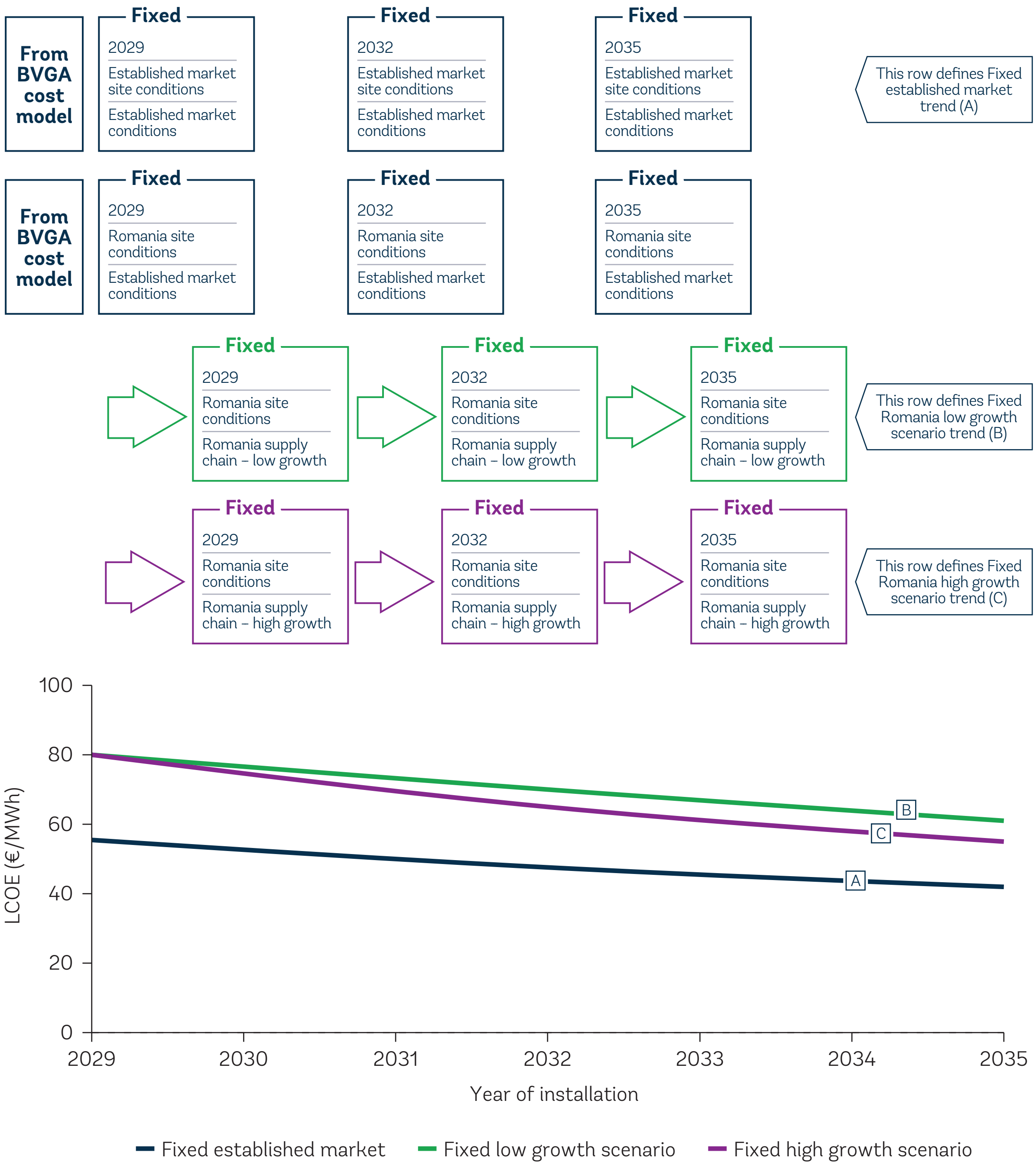


FIGURE 7.5 SCHEMATIC SHOWING DERIVATION OF LCOE TRENDS



Source: BVG Associates.

7.4.3

7.4.4 Cost element definitions

Table 7.4 provides definitions for cost elements.

TABLE 7.4 OFFSHORE WIND COST ELEMENT DEFINITIONS

Element	Sub-element	Definition	Unit
Capital expenditure (CAPEX)	Project development	Development, permitting and project management work paid for by the developer up to works completion date (WCD). Includes: • Internal and external activities such as environmental and wildlife surveys, met ocean surveys, met mast (including installation), geophysical, geotechnical and hydrological services and engineering (pre front end engineering design (FEED)) and planning studies • Permitting services • Further site investigations and surveys after final investment decision (FID) • FEED studies • Environmental monitoring during construction • Development costs of transmission system • Project management (work undertaken or contracted by the developer up to WCD) • Other administrative and professional services such as accountancy and legal advice • Any reservation payments to suppliers. Excludes: • Construction phase insurance • Suppliers own project management.	€/MW
	Turbine	Includes: • Payment to wind turbine manufacturer for the supply of: • Rotor, including blades, hub and pitch system • Nacelle, including bearing, gearbox, generator, yaw system, the electrical system to the array cables, control systems, etc. • Tower • Assembly thereof • Delivery to nearest port to supplier • Warranty • The wind turbine supplier aspects of commissioning costs. Excludes: • Turbine OPEX • Research, design and development (RD&D) costs.	
	Foundation	Includes: • Payment to suppliers for the supply of the support structure comprising the foundation (including floating, mooring and any piles or anchors, transition piece and secondary steel work such as J-tubes and personnel access ladders and platforms) • Delivery to nearest port to supplier • Warranty.	

Element	Sub-element	Definition	Unit
Capital expenditure (CAPEX) (cont.)	Foundation (cont.)	• Excludes: • Turbine tower • Foundation OPEX • RD&D costs.	
	Array cables	Includes: • Payment to manufacturer for the supply of array cables • Delivery to nearest port to supplier • Warranty. Excludes: • OMS costs • RD&D costs.	
	Installation of generating assets	Includes: • Transportation of all from each supplier's nearest port • Pre-assembly work completed at a construction port • All installation work for array cables, moorings, floating hulls and turbines • Commissioning work for all but turbine (including snagging post WCD) • Subsea cable protection mats etc., as required • Offshore logistics such as weather forecasting, additional crew transfer vessels (CTV) and marine co-ordination • Shared wind-farm infrastructure such as marker buoys. Excludes: • Installation of offshore substation / transmission assets.	
	Offshore substation	Includes: • Payment to manufacturer for the supply of offshore substations • Assembly at fabricator's port • Warranty. Excludes: • OMS costs • RD&D costs.	
	Export cables	Includes: • Payment to manufacturer for the supply of onshore and offshore export cables • Delivery to nearest port to supplier • Warranty. Excludes: • OMS costs • RD&D costs.	
	Installation of transmission assets	Includes: • Transportation of all from each supplier's nearest port • Pre-assembly work completed at a construction port before the components are taken offshore • Installation of offshore substations and onshore and offshore export cables	

Element	Sub-element	Definition	Unit
Capital expenditure (CAPEX) (cont.)	Installation of transmission assets (cont.)	• Supply and installation of the wind-farm specific switchgear and auxiliary equipment in the substation that is located on the transmission network, including any wind farm-specific buildings at the onshore substation • Substation commissioning work (including snagging post WCD) • Scour protection (for support structure and cables) • Subsea cable protection mats etc., as required • Offshore logistics such as weather forecasting, additional CTVs and marine co-ordination.	
	Contingency	Construction contingency, and other CAPEX contingency, also construction phase insurance cover, from start of construction until operation start, including all construction risks & third party	Assumed increases LCOE by 5%
Operational expenditure (OPEX)	Operation and planned maintenance	Includes operation and planned (routine) maintenance, operations phase insurance, other OPEX and transmission OPEX. Starts once first turbine is commissioned. Operation and planned maintenance includes: • Operational costs relating to the day-to-day control of the wind farm (including CAPEX on operations base as an equivalent rent) • Condition monitoring • Planned preventative maintenance, health and safety inspections. Operations phase insurance: • Takes the form of a new operational "all risks" policy and issues such as substation outages, design faults and collision risk become more significant as damages could result in wind farm outage. Insurance during operation is typically renegotiated on an annual basis. Other OPEX covers fixed cost elements that are unaffected by technology innovations, including: • Site rent • Contributions to community funds • Monitoring of the local environmental impact of the wind farm. Transmission OPEX includes: • All operations, maintenance and service for the transmission assets.	€/MW/year
	Unplanned service	Unplanned service includes: • Reactive service in response to unplanned systems failure in the turbine or electrical systems • Unplanned service may be either proactive or reactive.	
Decom-missioning (DECEX)	Decommis-sioning	Includes: • Decommissioning, which includes planning work and design of any additional equipment for decommissioning required to meet legal obligations. Includes further environmental work and monitoring. • Removal of the turbine, foundation, mooring and offshore substation. • Removal or cut-off of piles / anchors, array cable and export cable (where applicable). • Removal of the onshore transmission asset (where applicable).	Assumed increases LCOE by 1%

Element	Sub-element	Definition	Unit
Financing cost	WACC	The discount rate is made up of finance cost from debt and equity, weighted by their contributions to give a WACC. It is in real, pre-tax terms.	-
Annual energy production (AEP)	Capacity factor	AEP averaged over the wind farm life at the offshore metering point at entry to offshore substation, as a fraction of AEP if at rated power output all year. Accounts for improvements in early years and degradation in later years. Includes: • Aerodynamic array losses • Blockage effect • Electrical array losses • Losses due to unavailability of the wind turbines, foundations and array cables • Losses from cut-in/cut-out hysteresis, power curve degradation, and power performance loss.	%

7.4.5 Generic definitions

Global assumptions

Real (2023) prices.

Standard wind farm assumptions

Turbines are spaced at nine rotor diameters (downwind) and six rotor diameters (across-wind) in a rectangle.

The lowest point of the rotor sweep is at least 22 m above mean high water spring tide.

The development and construction costs are funded entirely by the project developer.

Meteorological regime

A wind shear exponent of 0.12.

Rayleigh wind speed distribution.

Turbine

The turbine is certified to international OSW turbine design standard IEC 61400-3-1.

Support structure

Ground conditions are good for OSW. There are only occasionally locations with lower bearing pressure, the presence of boulders or significant gradients.

Array cables

The array cable assumption is that a three core 66kV AC cable (132 kV AC for larger turbines) on fully flexible strings is used, that is, with provision to isolate an individual turbine.

Installation

Installation is carried out sequentially by the foundation, array cable, then the pre-assembled tower and turbine together.

A floating vessel is used to install monopiles.

Array cables are installed via J-tubes, with separate cable lay, survey and burial.

A jack-up vessel collects components from the installation port for turbine installation.

Decommissioning reverses the assembly process, taking one year. Piles are cut off at a depth below the seabed which is unlikely to require uncovering and cables are pulled out. Environmental monitoring is conducted at the end. The residual value and cost of scrapping is ignored.

Transmission

Export system costs are incurred as CAPEX and OPEX where appropriate. Transmission use of system charges are not considered.

Operations, maintenance and service

Access is by service operation vessels (SOVs). Jack-ups are used for major component replacement.

8. SUPPLY CHAIN ANALYSIS

8.1 PURPOSE

In this work package, we assessed the supply chain for offshore wind (OSW) in Romania, including an analysis of current in-country capabilities and opportunities for future investment under the two scenarios presented in Section 2.

We focus on fixed (rather than floating) OSW supply chain needs as this will be the dominant project type in Romania, as discussed in Section 2.3. Ports are covered in Section 17.

We also explore potential bottlenecks that could slow the industry in each of the scenarios. This analysis is important as it underpins the work on cost reduction and economic benefits in Sections 7 and 9.

8.2 METHOD

We established a categorization of the supply chain and robust criteria for assessing capability. These are presented in Table 8.1 and Table 8.2. The level 2 categories broadly correspond with the procurement packages used for buying from principal suppliers (also known as tier 1 suppliers) if a developer is multi-contracting.

TABLE 8.1 CATEGORIZATION OF THE SUPPLY CHAIN

Level 1 category	Level 2 category	Description
Project development	Project development	Work by the developer and its supply chain including planning consent, front-end engineering and design, project management, and procurement
Turbine	Nacelle, hub, and assembly	Supply of components to produce the ex-works nacelle and hub and their delivery to the final port before installation
	Blades	Supply of finished blades and their delivery to the final port before installation
	Tower	Supply of tower sections and their delivery to the final port before installation
Balance of plant	Foundation supply	Supply of foundations and their delivery to the final port before installation
	Array and export cable supply	Supply of cables and their delivery to the final port before installation
	Offshore substation supply	Supply of the completed offshore substation platform and foundation ready for installation
	Onshore infrastructure	Supply of components and materials for the onshore substation and the operations base

Level 1 category	Level 2 category	Description
Installation and commissioning[xvii]	Turbine and foundation installation	Work undertaken in the final port before installation and the installation and commissioning of the turbines and foundations, including vessels
	Array and export cable installation	Installation of the cables, including route clearance, post-lay surveys, and cable termination
	Offshore and onshore substation installation	Installation of the offshore substation and civil works for the onshore substation. Includes commissioning of the electrical system
Operation, maintenance, and service	Wind farm operation	Wind farm administration and asset management, including onshore and offshore logistics
	Turbine maintenance and service	Work to maintain and service the turbines, including spare parts and consumables
	Balance of plant maintenance and service	Inspection and repair of foundations, inspection and repair or replacement of cables, onshore and offshore substation maintenance, and service
Decommissioning	Decommissioning	Removal of all necessary infrastructure and transport to port; excludes recycling or re-use

8.2.1 Criteria for assessing capability

We developed a set of criteria for assessing the current and future capability of the supply chain in Romania. They relate to the likelihood that existing companies in Romania can be successful in the industry and the likelihood that new companies can be attracted to invest in Romania. The scoring relates to the general capability of the supply chain at a country level and is not based on a detailed analysis of individual companies. The scoring is based on an appreciation of global OSW supply chain capability and an understanding of the factors that are key to successfully localizing OSW supply chains. Further work is required in due course to undertake a supply chain assessment at a detailed company level.

These criteria were scored for each level 2 category, as shown in Table 8.2. In the analysis, we distinguished between principal suppliers (equivalent to tier 1) and lower tier suppliers. We shared this assessment with key stakeholders (see Section 21) and gathered feedback and additional data, as well as views on bottlenecks, recognizing Romania's place in a regional and global market.

TABLE 8.2 CRITERIA FOR ASSESSING CURRENT AND FUTURE CAPABILITY IN ROMANIA

Criterion	Score	Description
Track record and capacity in OSW	1	No experience
	2	Experience in supplying wind farm ≤300 MW
	3	One company with experience in supplying wind farm >300 MW
	4	Two or more companies with experience in supplying wind farm >300 MW

xvii. The manufacturing of vessels for offshore wind could be an opportunity for the supply chain in Romania, but was not considered in this analysis as not a direct supply item for any given OSW project.

Criterion	Score	Description
Romanian capability in parallel sectors	1	No relevant parallel sectors
	2	Relevant sectors with relevant workforce only
	3	Companies in parallel sectors that can enter the market with high barriers to investment
	4	Companies in parallel sectors that can enter the market with low barriers to investment
Benefits of Romanian supply chain for Romanian projects	1	No benefits in supplying projects in Romania from Romania
	2	Some benefits in supplying projects in Romania from Romania but no significant impact on cost or risk
	3	Work for projects in Romania can be undertaken from outside Romania but only with significantly increased cost and risk
	4	Work for projects in Romania must be undertaken locally
Investment risk in Romania	1	Investment that needs market certainty from OSW for five or more years
	2	Investment that needs market certainty from OSW for two to five years
	3	Low investment ≤€50 million that can also meet demand from other small sectors
	4	Low investment ≤€50 million that can also meet demand from other major sectors with market confidence
Size of the opportunity	1	<2% of lifetime expenditure
	2	2%≤3.5%
	3	3.5%-5%
	4	>5% of lifetime expenditure

8.3 RESULTS

8.3.1 Summary

Table 8.3 summarizes our analysis. Some categories have been considered together to avoid duplication. The sections below discuss our findings in more detail.

Scoring relates to general capability at a country level and not to individual companies.

TABLE 8.3 SUMMARY OF THE ROMANIAN SUPPLY CHAIN ANALYSIS

Category	Track record and capacity in OSW	Capability in parallel sectors	Benefits of local supply	Investment risk in Romania	Size of the opportunity
Project development	2	4	3	4	2
Nacelle, hub, and assembly	2	2	1	1	4
Blades	1	1	2	1	4
Tower	1	3	2	2	3
Foundation supply	1	3	3	1	4

Category	Track record and capacity in OSW	Capability in parallel sectors	Benefits of local supply	Investment risk in Romania	Size of the opportunity
Array and export cable supply	1	1	1	1	3
Offshore substation supply	3	3	2	3	2
Onshore infrastructure	1	4	4	4	2
Turbine and foundation installation	1	2	1	2	2
Array and export cable installation	1	2	1	2	4
Offshore and onshore substation installation	1	4	1	2	2
Wind farm operation	1	3	4	4	3
Turbine maintenance and service	1	3	3	4	4
Balance of plant maintenance	1	4	3	4	3
Decommissioning	1	2	1	2	2

Note: * A local supplier would deliver most of the work for the project in Romania. It includes foreign headquartered companies operating in Romania.

8.3.2 Opportunities

The analysis shows that while there is little direct experience supplying to the OSW industry so far, there is some relevant capability in most parts of the supply chain. The main opportunities lie where:

- There is capability;
- There is logic in supplying Romanian projects from Romania (which is sensitive to the growth scenario); and
- The investment risk is the lowest.

The opportunity is therefore greatest in categories such as project development, supply of onshore infrastructure, towers, foundations and offshore substation, and the operations and maintenance phase.

The OSW industry is highly cost-sensitive and typically views competition on a global basis for many categories of supply. This means that local suppliers will need to work hard to learn and compete, with international collaboration likely key to success.

Like many sectors, the OSW industry globally is aiming to reduce its carbon footprint. For OSW, using green steel for components has the biggest single impact. Romania has a strong steel manufacturing industry, so investing in green steel manufacturing could therefore be great opportunity for Romania. This opportunity is not covered by the modelling in this section.

Many of the jobs created by the OSW industry require further skills development. This provides a good opportunity to encourage a more diverse workforce. Section 10 makes recommendations that can help achieve this.

Table 8.4 shows the likely changes in the supply chain in Romania under the low and high growth scenarios. The high growth scenario creates a stronger logic for Romanian supply and lowers market risk. We anticipate that most strategic investments will happen before 2030, if the timing is as per the low and high growth scenarios.

TABLE 8.4 CHANGE IN ROMANIA SUPPLY CHAIN UNDER LOW AND HIGH GROWTH SCENARIOS

	Activity today	Low growth 2030	High growth 2030
Project development	Limited	↗	↗
Turbine towers	None	↑	↑
Turbine nacelles	Some component supply for export	→	→
Turbine blades	None	→	→
Foundations	None	→	↑
Subsea cables	None	→	→
Installation	Limited	↗	↗
Operation, maintenance, and service	Limited	↗	↗

Key: → = minimal change; ↗ = organic growth; ↑ = growth via significant inward investment)

8.3.3 Potential bottlenecks

Due to supply from overseas and a rapidly growing global market, Romania will compete with other markets for the supply of key items. Should it be more attractive for key global suppliers to serve other markets, then Romania risks delays to projects due to supply bottlenecks. The attractiveness of a market relates to:

- Margin available;
- Long-term potential; and
- Ease of doing business, without additional local certifications and standards to meet beyond the normal international requirements.

Historically, there have been times where key items including wind turbines, subsea cables and jack-up installation vessels have been limited. All areas of the supply chain continue to invest to meet anticipated future demand, but there remains a risk of bottlenecks that are best managed by experienced, globally acting project developers, especially as the supply chain has suffered in recent times due to intense competition between project developers and the impact of commodity price volatility.

8.3.4

8.3.5 Project development

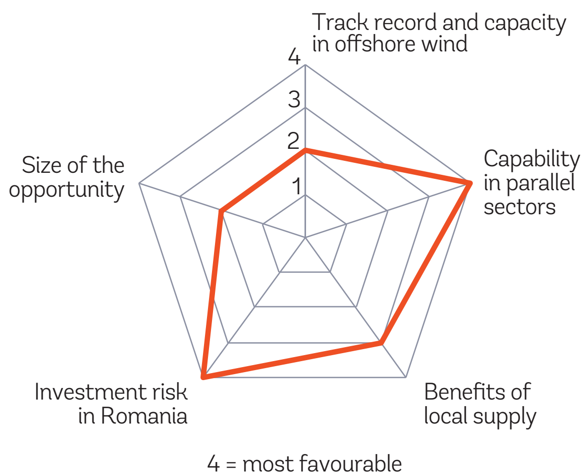
Project development is likely to be led by established OSW developers, potentially with a local partner, and the work is likely to be split between local and global offices of an international partner as well as local offices for local partners, drawing on the:

- Local partner for in-country knowledge and relationships; and
- International partner for its project management, engineering, environmental management, procurement skills, and OSW experience and relationships.

There are no OSW farms in Romania yet, but there is capability in parallel sectors from the development of onshore wind farms, offshore hydrocarbon extraction and other power generation projects.

There are benefits of using a local supply chain during development because these companies will have a good understanding of relevant local regulations and local companies can minimize logistics and labor costs. It is however likely that the local supply chain will need some capacity building and support from international operators when it comes to undertaking Environmental and social impact assessment (ESIA) to Good international industry practice (GIIP) for OSW. The barriers to entry are low, with investments mainly in skills to meet the needs of OSW. These conclusions are summarized in Figure 8.1.

FIGURE 8.1 ASSESSMENT OF SUPPLY CHAIN FOR PROJECT DEVELOPMENT



Source: BVG Associates.

8.3.6 Turbine

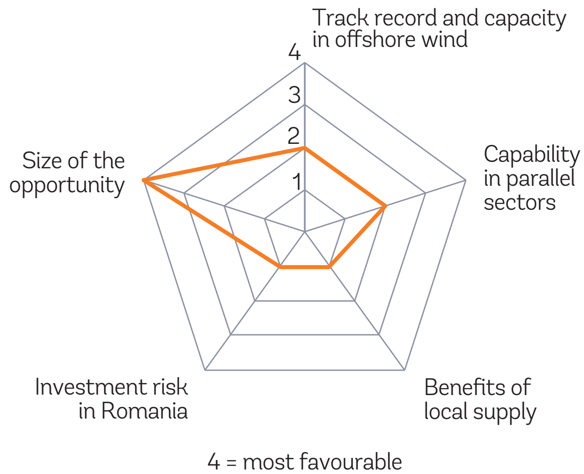
Nacelle, hub, and assembly

Romania has no turbine manufacturing facilities currently, and it is unlikely that there is a business case for investment in the country even in the high growth scenario. While there is some benefit to local supply to minimize transport costs, nacelles, and hubs have complex supply chains and are critical to turbine performance and reliability, and so the barriers to investment are high. It is therefore likely that nacelles and hubs will be imported.

There has been some small component manufacture in country exported for assembly, and this is likely to continue, which could contribute to local content of Romanian projects.

These conclusions are summarized in Figure 8.2.

FIGURE 8.2 ASSESSMENT OF SUPPLY CHAIN FOR NACELLE, HUB, AND ASSEMBLY



Source: BVG Associates.

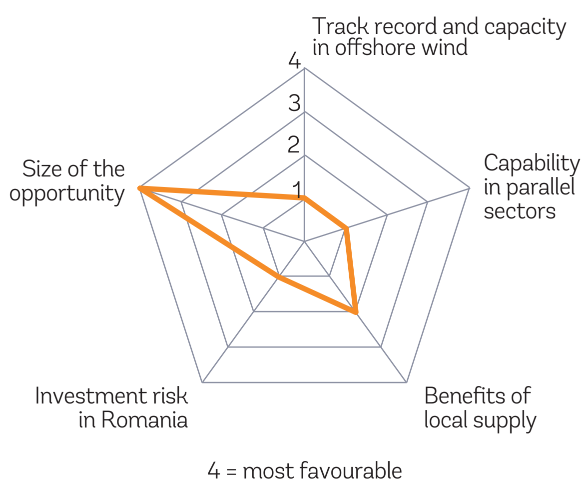
Blades

Romania has no blade production facilities currently. While transport costs of blades are high, and manufacture is relatively easy to localize as its supply chain is mostly materials from commodity suppliers, investment risk is high and there is not much relevant capability in parallel sectors in Romania. Republic of Türkiye has a blade factory already, but it is not suitable for manufacture (and onward transport) of very large blades for OSW.

Typically, an OSW blade manufacturing facility serves only one turbine supplier and is established by (or in close partnership with) the turbine supplier due to intellectual property considerations.

These conclusions are summarized in Figure 8.3.

FIGURE 8.3 ASSESSMENT OF SUPPLY CHAIN FOR BLADES



Source: BVG Associates.

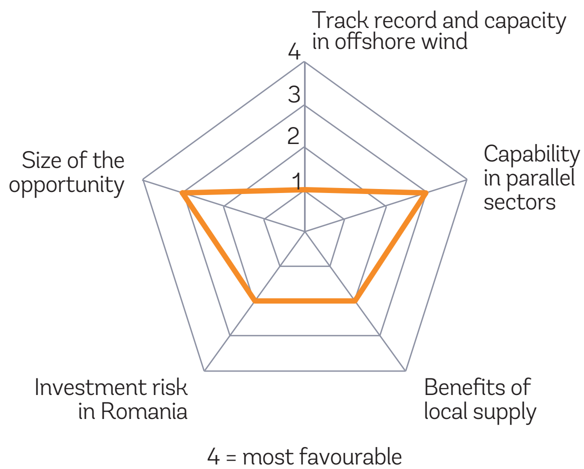
Tower

There are no wind turbine tower production facilities in Romania currently.

There is a logistical benefit to local supply due to high transport costs, and the supply chain for towers is not complex, so there could a business case for a tower production facility in Romania in both scenarios, despite high investment risks. Such a facility could supply any of the wind turbine suppliers in the market, as well as onshore wind projects in Romania and Romania also has a strong steel manufacturing industry, which makes them well places for tower production.

These conclusions are summarized in Figure 8.4.

FIGURE 8.4 ASSESSMENT OF SUPPLY CHAIN FOR TOWERS



Source: BVG Associates.

8.3.7 Balance of plant

Foundation supply

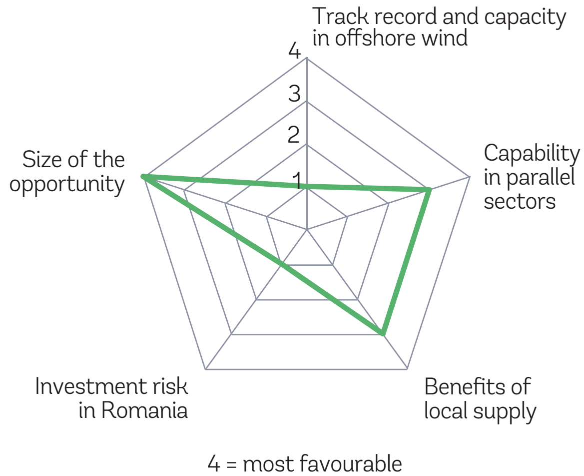
In both scenarios we expect that most of the projects in Romania will use mainly monopile foundations fixed to the seabed.

Although the transport costs for monopile foundations are high, it is unlikely that there is a business case for investment in the rolling equipment needed to manufacture monopiles in the country in the low growth scenario, due to the low volume of foundations needed and the high investment needed for a potential short period of supply. Romania has a strong steel manufacturing industry, so there could be business case for a monopile factory in the high growth scenario, enabling export to other markets (including southern Europe and possibly also northern Europe) as well.

There is a stronger benefit of local supply for jacket foundations as Romania have experience in manufacturing jacket foundations for the oil & gas industry. It is unlikely, however, there will be a high enough demand for jackets even in the high growth scenario to make a business case for investment, unless most of the production was for export, because the most cost effective foundation solution for Romanian water depths is likely to be monopiles.

The conclusions for the supply of foundations are summarized in Figure 8.5.

FIGURE 8.5 ASSESSMENT OF SUPPLY CHAIN FOR FOUNDATIONS



Source: BVG Associates.

Array and export cable supply

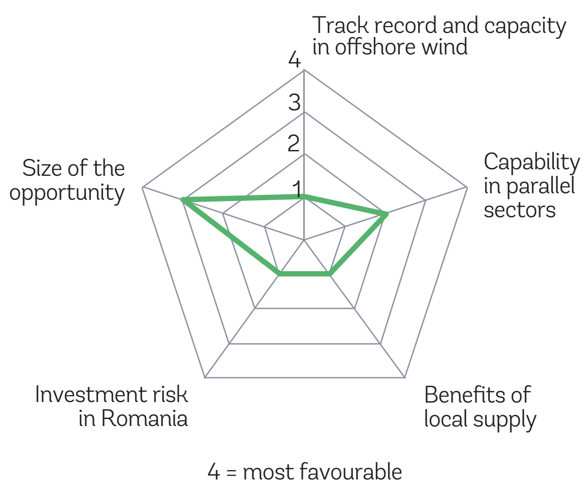
Romania has no subsea cable production capability currently, and cable suppliers with manufacturing facilities currently located in Romania are not located portside.

The logistical benefits are low because in many cases a single cable vessel can transport all the cables for a project from the factory in one or two journeys.

The investment risk for export cables is lower than for array cables, as there is likely to be a market for interconnectors in Romania. Despite this, it is unlikely that there is a business case for investment in Romania in array and export cable supply, driven by the OSW market.

These conclusions are summarized in Figure 8.6.

FIGURE 8.6 ASSESSMENT OF SUPPLY CHAIN FOR ARRAY AND EXPORT CABLES



Source: BVG Associates.

Offshore substation supply

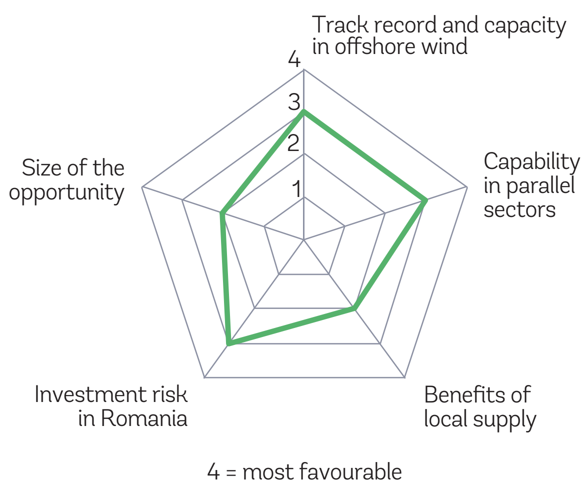
OSW substation supply has synergies with shipbuilding as it requires steel fabrication and systems integration skills. Substations are typically one-off designs manufactured without significant automation and therefore new entrants do not need to make investments to enable efficient volume production. A challenge for new entrants has been the lower profit margins in OSW than in the oil and gas sector.

There is a benefit to the local supply of the substation foundations and topsides, and it is possible that both could be manufactured in Romania, as well as some of the electrical components. Romanian manufacturers have already won the contract to supply two topsides for offshore substations for OSW projects in other markets.

An offshore substation platform for Romania could also draw on the local supply chain for items such as secondary steel, platforms and walkways, and other auxiliary items.

Figure 8.7 summarizes our conclusions.

FIGURE 8.7 ASSESSMENT OF SUPPLY CHAIN FOR OFFSHORE SUBSTATIONS



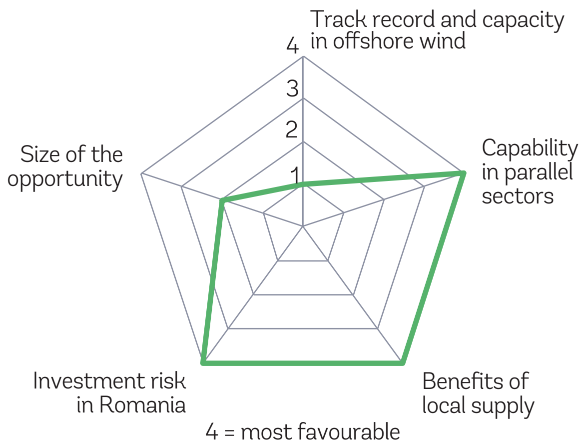
Source: BVG Associates.

Onshore infrastructure

Onshore infrastructure includes the onshore export cable, the onshore substation, and the operations base. There are significant synergies with the rest of the civil engineering sector and this work is typically provided by local companies. No significant investment by local companies is likely to be necessary.

There is no difference between the scenarios. Figure 8.8 summarizes our conclusions.

FIGURE 8.8 ASSESSMENT OF SUPPLY CHAIN FOR ONSHORE INFRASTRUCTURE



Source: BVG Associates.

8.3.8 Installation and commissioning

Turbine and foundation installation

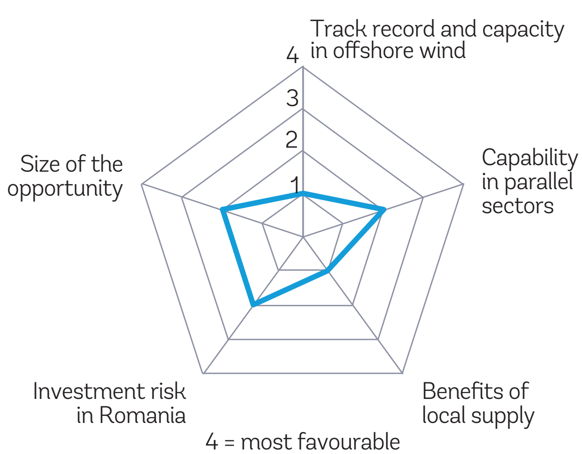
Fixed OSW farms use specialist jack-up vessels built almost exclusively for OSW use to install the turbines. Foundations are usually installed by either a jack-up vessel (which may also be used for turbines) or a floating heavy lift vessel. Romania has no such vessels, so they are likely to be operated by overseas companies, and most of the crew is likely to be provided by these companies, having gained experience in other markets.

The manufacturing of vessels for all aspects of OSW installation and operation could be an opportunity for the supply chain in Romania but was not considered in this analysis as not a direct supply item for any given OSW project.

Regardless of the installation solution adopted for OSW farms in Romania, local ports and services will be used in both scenarios.

Figure 8.9 summarizes our conclusions for fixed OSW farms.

FIGURE 8.9 ASSESSMENT OF SUPPLY CHAIN FOR TURBINE AND FOUNDATION INSTALLATION



Source: BVG Associates.

Array and export cable installation

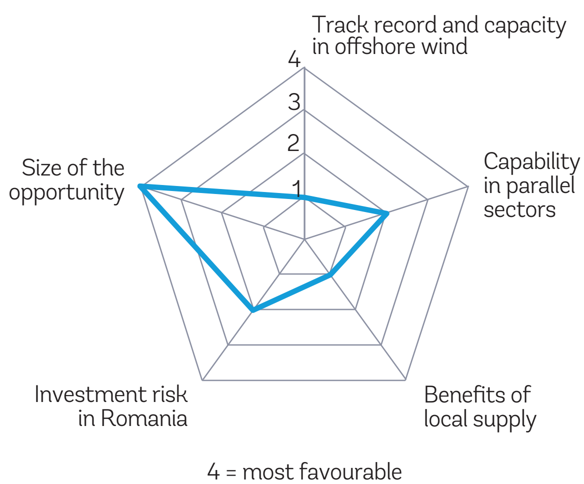
Array and export cable installation may use the same vessels and equipment, but optimal solutions differ. Array cable laying vessels need to be maneuverable, but do not need high carrying capacity. Export cable laying vessels are typically larger to carry the full length of an export cable. Ideally, they can also operate in shallow water for installation up to the shoreline.

OSW cable laying is technically challenging, particularly the process of pulling in and terminating the cable at the base of the turbine and working in shallow waters, and the risks of entering the market are significant. As well as the investment in vessels, inexperienced cable-laying companies have suffered project delays in established OSW markets and the financial consequences can be severe.

With little benefit of local supply and high investment risk, it is unlikely that there is a business case for investment in cable laying vessels operated from Romania. Some of the marine crew and most port services could however be local.

Figure 8.10 summarizes our conclusions.

FIGURE 8.10 ASSESSMENT OF SUPPLY CHAIN FOR ARRAY AND EXPORT CABLE INSTALLATION



Source: BVG Associates.

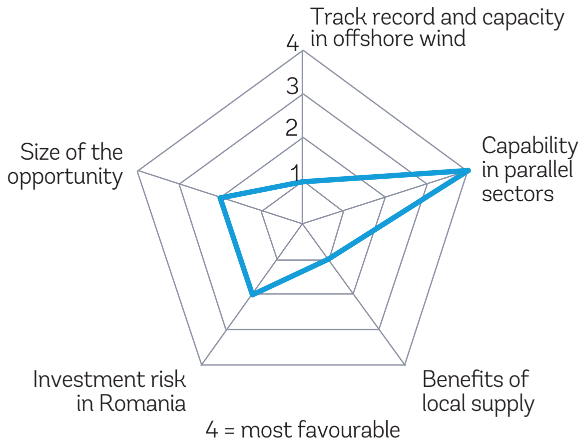
Offshore and onshore substation installation

For fixed projects in shallower water, the offshore substation foundation is often a jacket, but can be a monopile. In these cases, offshore substation installation consists of the installation of the foundation (as above) and then the substation topside. The substation topside is likely to weigh more than 2,000 t and in most cases is transported to the site by barge and then lifted into position by a large, heavy lift vessel. Romania has such a vessel, though the crane capability may need to be increased, depending on eth design of the substation. As the vessel is needed for only one lift, mobilization and demobilization costs dominate, meaning a local vessel is attractive.

For onshore substation installation, there are significant synergies with the rest of the civil engineering sector and Romania has suitable expertise to undertake the work.

Figure 8.11 summarizes our conclusions.

FIGURE 8.11 ASSESSMENT OF SUPPLY CHAIN FOR OFFSHORE AND ONSHORE SUBSTATION INSTALLATION



Source: BVG Associates.

8.3.9 Operations, maintenance, and service

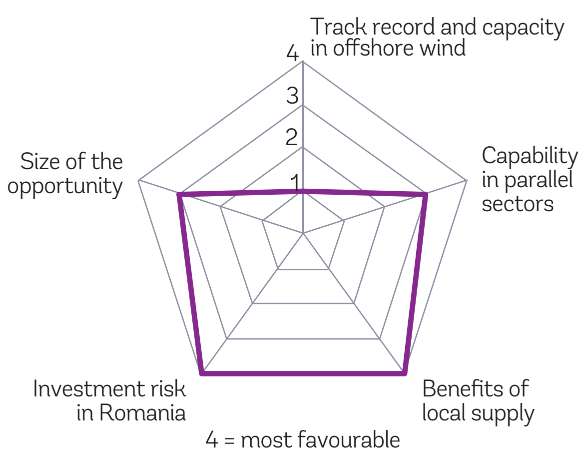
Wind farm operation

Wind farm operation combines asset management expertise from onshore wind and large electromechanical infrastructure assets along with offshore logistics. Romania has some onshore wind industry experience, as well as marine asset operation experience and barriers to entry are generally lower than in many of the capital phase areas described above, revenue streams are long-term and there is a benefit to local supply. It is likely therefore that there will be local asset management combined with global resources used by the wind farm owners and turbine manufacturers.

OSW projects close to shore typically use bespoke crew transfer vessels (CTV), and these could be built and operated locally, normally from the closest small port to the project. Projects further from shore use larger service operation vehicles (SOVs) that will be locally crewed and have a local home port. We anticipate that most projects in Romania will use SOVs.

Figure 8.12 summarizes our conclusions.

FIGURE 8.12 ASSESSMENT OF SUPPLY CHAIN FOR A WIND FARM OPERATION



Source: BVG Associates.

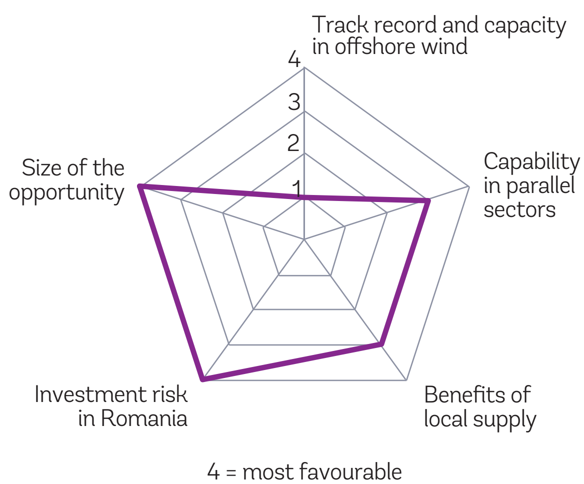
Turbine maintenance and service

Turbine maintenance and service is typically undertaken by the turbine supplier, generally under a service agreement of length up to 15 years, or by experienced international project developers who go on to be lead owners of projects. A local workforce will be used for much of the work, and there is an opportunity for local companies offering inspection services and for technicians (employed by a service company or the project lead owner) during planned maintenance and unplanned service activities in response to turbine faults. The barriers to entry are lower than in many of the capital phase areas described above, and investment will be mainly focused on ensuring a high-quality skills base. In the early days of operation, there is likely to be a number of overseas technicians used, but the numbers will decline as a local team is trained.

Major replacements for fixed OSW projects typically use the same large jack-up vessels used in installation but could potentially use heavy lift vessels in benign conditions. Spare parts and consumables will be a mixture of imported and locally supplied. There may also be opportunity for local refurbishment of some components.

Figure 8.13 summarizes our conclusions.

FIGURE 8.13 ASSESSMENT OF SUPPLY CHAIN FOR TURBINE MAINTENANCE AND SERVICE



Source: BVG Associates.

Balance of plant maintenance and service

Balance of plant maintenance and service covers foundations, array cables, export cables, and substations.

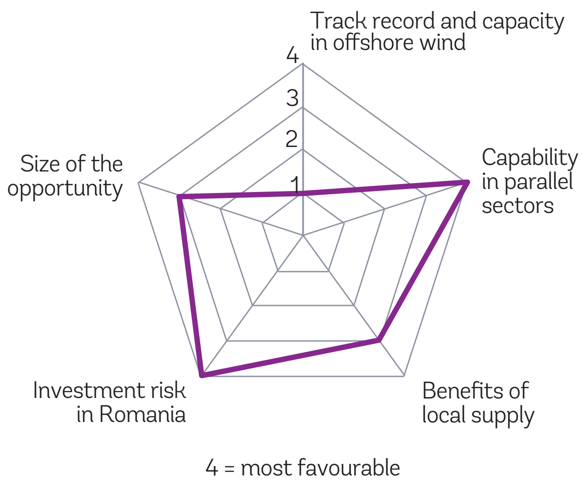
Cable maintenance and service is the most significant, with cable failures the biggest source of insurance claims in OSW, typically due to mechanical damage caused to the cables. It uses similar equipment to cable installation, in some cases with cables replaced in others with cables repaired in situ.

Foundation maintenance and service include inspections for corrosion or structural defects above and below the water line, and cleaning and repairing areas, especially around the water line. This is likely to use a global and local workforce.

For substations, the structural maintenance and service could be done by the local work force, but some of the electrical system component replacements are likely to come from global suppliers.

Figure 8.14 summarizes our conclusions.

FIGURE 8.14 ASSESSMENT OF SUPPLY CHAIN FOR BALANCE OF PLANT MAINTENANCE AND SERVICE



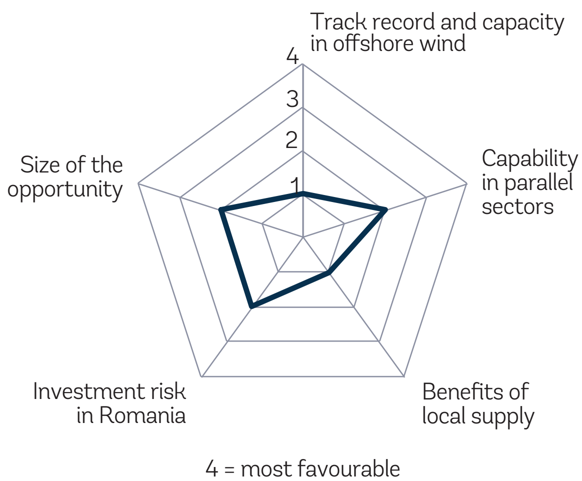
Source: BVG Associates.

8.3.10 Decommissioning

Although some decommissioning has been carried out in established OSW markets, solutions have not yet been optimized. It is most likely that vessels that have been used for installation will also support decommissioning, following similar processes, with some simplifications. Much material can be recycled, offering opportunities in the circular economy. As projects start reaching the end of life, there will also be work to explore extending the life of generating and/or transmission assets. We may see some projects where turbines, foundations and array cables are replaced but the export system is retained for a second life cycle.

Figure 8.15 summarizes our conclusions.

FIGURE 8.15 ASSESSMENT OF SUPPLY CHAIN FOR DECOMMISSIONING



Source: BVG Associates.

8.4 DISCUSSION

Romania has a good port infrastructure that could host local manufacturing. It has supply chain capability relevant to some areas of OSW, including significant experience in steel manufacturing.

Both the low growth and the high growth scenario could lead to some local content, the main difference between the two is that the high growth scenario could lead to investment in a monopile foundations factory ready for the first project in 2029, there is a higher probability of towers being manufactured in Romania than in the low growth scenario and more of the turbine service and maintenance is carried out by local suppliers.

A proactive approach will help increase local readiness for supply and help create the economic benefit discussed in Section 9. Romania has the potential for manufacture of towers under each scenario, and monopiles under the high growth scenario. A proactive approach could support the export of these components to other markets, both regionally, where Bulgaria, Türkiye and Ukraine are considering developing OSW projects, and further afield.

The Government of Romania has the opportunity to develop a somewhat high volume market by providing a robust policy framework and good market visibility. International experience shows this to be an effective way to generate local economic benefits without having to resort to restrictive local content requirements.[xviii] It is also the dominant way to reduce the cost to consumers and create a more sustainable, internationally competitive supply chain.

One route to supporting the OSW supply chain is through the use of criteria beyond just price in competitions, especially for in revenue auctions, later in the project development lifecycle. Other criteria, weighted lower than price, can be used to deliver a range of policy objectives (including supply chain development) without overly disturbing the important focus on levelized cost of energy.[18] World Bank Group's *Key Factors* report Section 3.6 describes New York State's successful approach in this regard, though such an arrangement could not be mirrored directly to a European Union market .9

8.5 RECOMMENDATIONS

Based on this analysis, it is recommended that:

- The Ministry of Energy (MOE), working with the Ministry of Development, Public Works and Administration, the Ministry of Economy and Ministry of Transport and Infrastructure, presents a balanced vision for local supply chain development, encouraging international competition (learning from elsewhere and avoiding restrictive local content requirements that add risk and cost to projects and slow deployment).
- The MOE considers steps to support the expansion of supply chain for OSW, including the use of non-price criteria in auctions.
- The MOE, Ministry of Economy, The Ministry of Education, relevant universities / training colleges and industry (through the Romanian Wind Energy Association (RWEA)) collaborate to enable education and investment in local supply chain businesses, including in training of onshore and offshore workers.

---

xviii. As discussed in Section 2 of the World Bank Group's *Key Factors* report, protectionist practices have not delivered value-adding outcomes.9 They typically drive inefficiency and re not compatible with global OSW businesses managing cost and risk across portfolios of projects.

9. JOBS AND ECONOMIC BENEFIT

9.1 PURPOSE

In this work package, we determine the economic impact of offshore wind (OSW) in Romania, looking at the potential for job creation and direct investment in the country's OSW industry under the scenarios established in Section 2.

The analysis looks at opportunities at different stages of the industry (including manufacturing, installation, operation, and maintenance), both for in-country projects and export.

This analysis is important as it is helpful to understand, long-term, what the economic impact of OSW is and how to maximize this.

The analysis aimed to establish the economic impacts created by wind farms in Romania globally, as well as economic impacts created in Romania.

9.2 METHOD

We considered three types of impact:

- Total impacts from projects in Romania;
- Romania impacts from projects in Romania; and
- Romania impacts from projects overseas.

We modelled direct and indirect impacts. Direct impacts are defined as those associated with project developers and their main contractors. Indirect impacts are defined as those associated with their sub-suppliers.

All cost data is from Section 7, ensuring that the different types of analysis presented are consistent. Section 8 uses the supply assumptions presented in this section.

The scenarios show capacity installed from 2029. This is as early as feasible. Based on experience in other markets, it is more likely that capacity will be installed from the early 2030s, but this does not change the relative impact of the two scenarios. Delays will slow installation but will mean early projects should be able to benefit from marginally lower global prices as technology continues to progress, but lower prices are also linked to fewer jobs, as processes get more efficient.

9.2.1

9.2.2 Total impacts from projects in Romania

We established the total full-time equivalent (FTE) employment years and gross value added (GVA) by year created for each market scenario if there was 100% local content (that is, there is no import of materials, components, and services):

- Low growth scenario (3 GW by 2035).
- High growth scenario (7 GW by 2035).

We used our in-house model that uses multipliers to convert expenditure to FTE years and GVA. More details of our methodology are provided in Section 9.4.

We calculated the impacts from a single 1.2 GW project installed in 2032 in the high growth scenario. We also calculated the total impacts of the pipeline of projects in each scenario, considering the different amounts of localization for different years of installation and in different scenarios.

Charts are to 2040, recognizing that there is further economic benefit for the full lifetime of each project, with more operation, maintenance service (OMS) spend, followed by a one-year peak during decommissioning (not shown).

9.2.3 Romanian impacts from projects in Romania

We established the impacts in Romania by considering the current and potential future capability of the supply chain in Romania and assessed the likely percentage of local content for each scenario. The capability of the supply chain in Romania and opportunities for growth are discussed in Section 8.

9.2.4 Romanian impacts from projects in Romania and overseas

This is the sum of the above and anticipated exports. We estimated the potential based on our understanding of the regional and global market and the supply chain in Romania and how that will develop in each growth scenario.

9.3 RESULTS

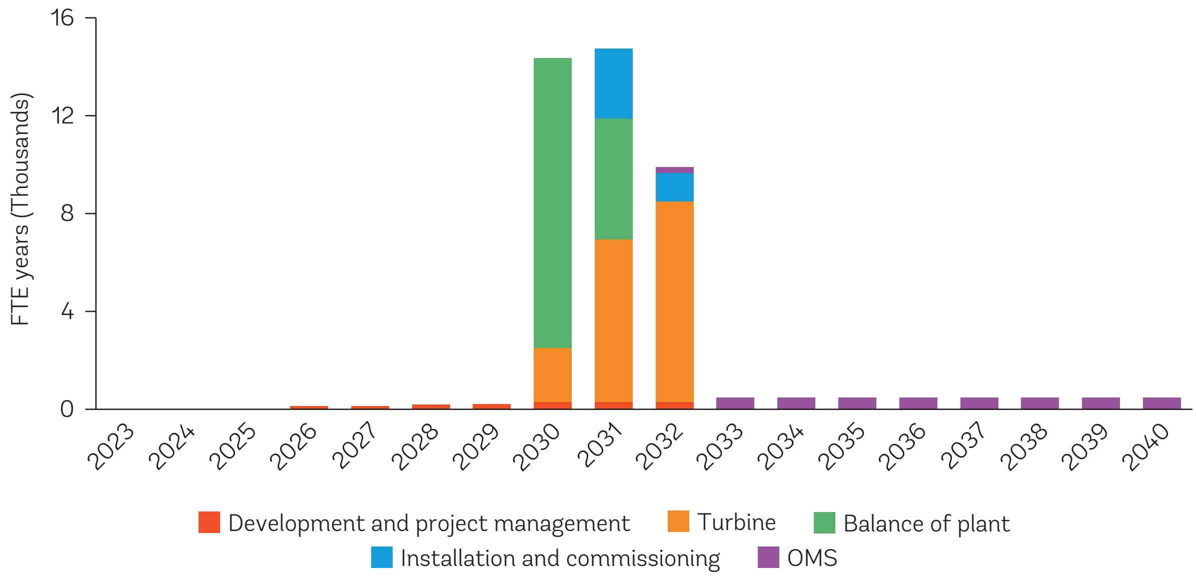
9.3.1 Total impacts from projects in Romania

High growth scenario: single project

Figure 9.1 shows the total FTE years employment created annually for a single 1.2 GW fixed project installed in 2032 in the high growth scenario. It shows that employment peaks in 2031 at about 15,000 FTE years, when there is significant turbine and balance of plant manufacture as well as installation. Total employment for the project is about 54,500 FTE years over the 32-year lifetime of the project.

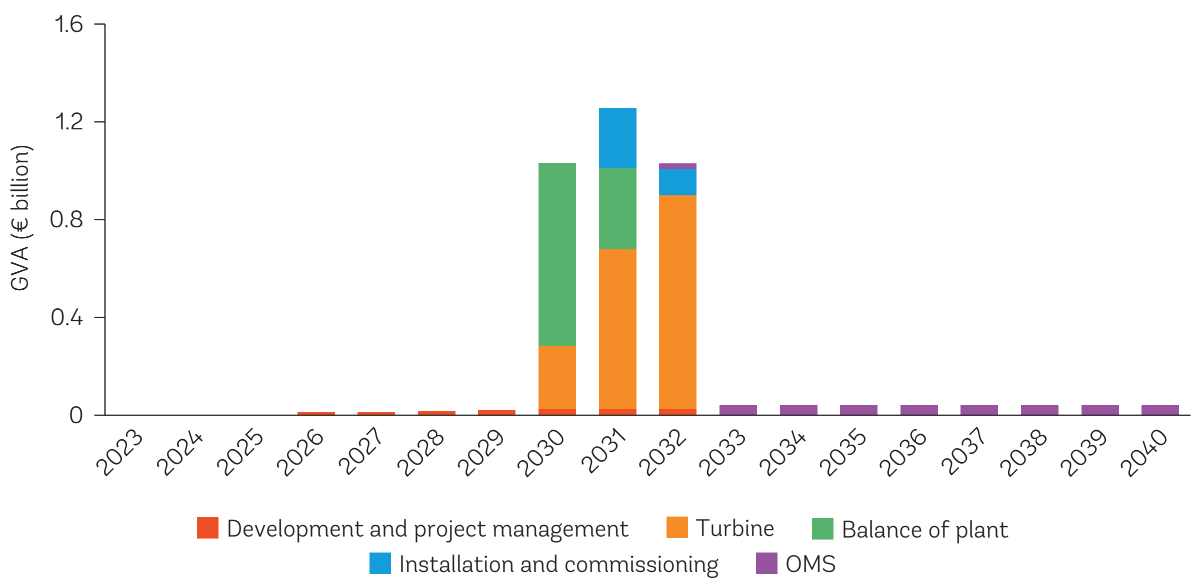
Figure 9.2 shows the GVA generated by this single project. The peak GVA in 2031 is about €1.3 bn. The total GVA over the lifetime of the project is about €4.7 bn.

FIGURE 9.1 TOTAL ANNUAL FTE YEARS EMPLOYMENT FOR A SINGLE 1.2 GW PROJECT INSTALLED IN 2032, SPLIT BY COST ELEMENT



Source: BVG Associates.

FIGURE 9.2 TOTAL GVA FOR A SINGLE 1.2 GW PROJECT INSTALLED IN 2032, SPLIT BY COST ELEMENT



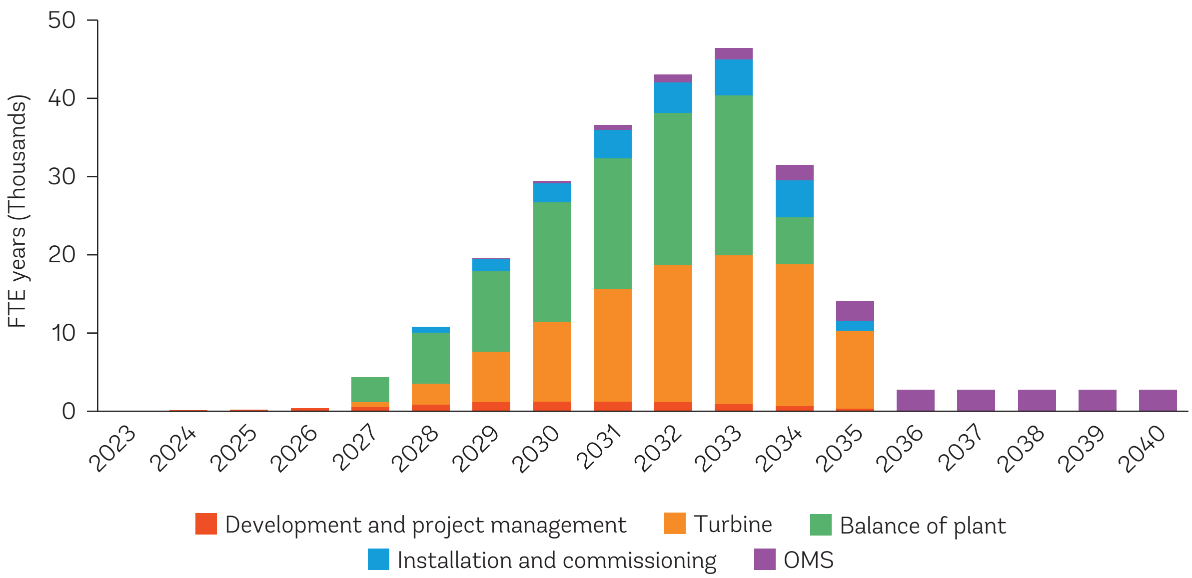
Source: BVG Associates.

High growth scenario

Figure 9.3 shows the global annual FTE years employment and it shows that the number of jobs grow steadily to 2033 where it reaches about 46,000 FTE years. The number of FTE years decrease after that based on the last OSW project entering operation in 2035, although around 2,700 annual FTE years continues for the lifetime of the wind farms. During the lifetime of the wind farms more than 320,000 FTE years are created.

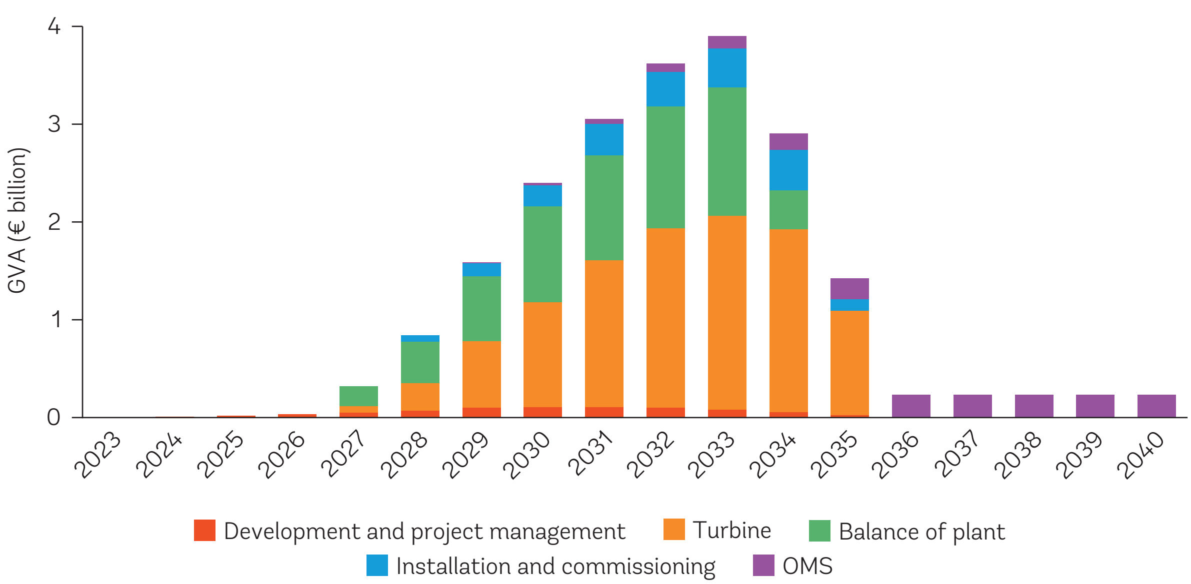
In Figure 9.4, the GVA created by all projects shows a similar pattern, with GVA reaching about €3.9 billion in 2033. During the lifetime of the wind farms about €27 billion GVA is generated.

FIGURE 9.3 TOTAL ANNUAL FTE YEARS EMPLOYMENT CREATED BY ALL THE PROJECTS IN ROMANIA IN THE HIGH GROWTH SCENARIO, SPLIT BY COST ELEMENT



Source: BVG Associates.

FIGURE 9.4 TOTAL GVA CREATED BY ALL THE PROJECTS IN ROMANIA IN THE HIGH GROWTH SCENARIO SPLIT BY COST ELEMENT



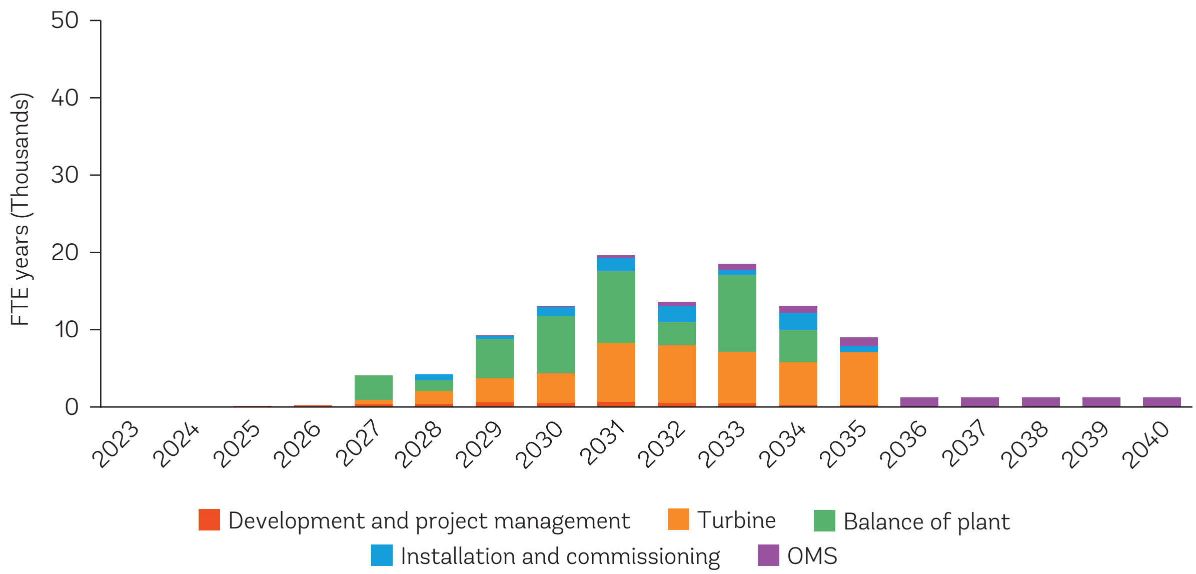
Source: BVG Associates.

Low growth scenario

For the low growth scenario, the pattern is different, as new projects are not installed every year. We can see the peaks of about 19,000 FTEs years created in 2031 and 2033 in Figure 9.5. Over the lifetime of the wind farms, more than 143,000 FTE years are created.

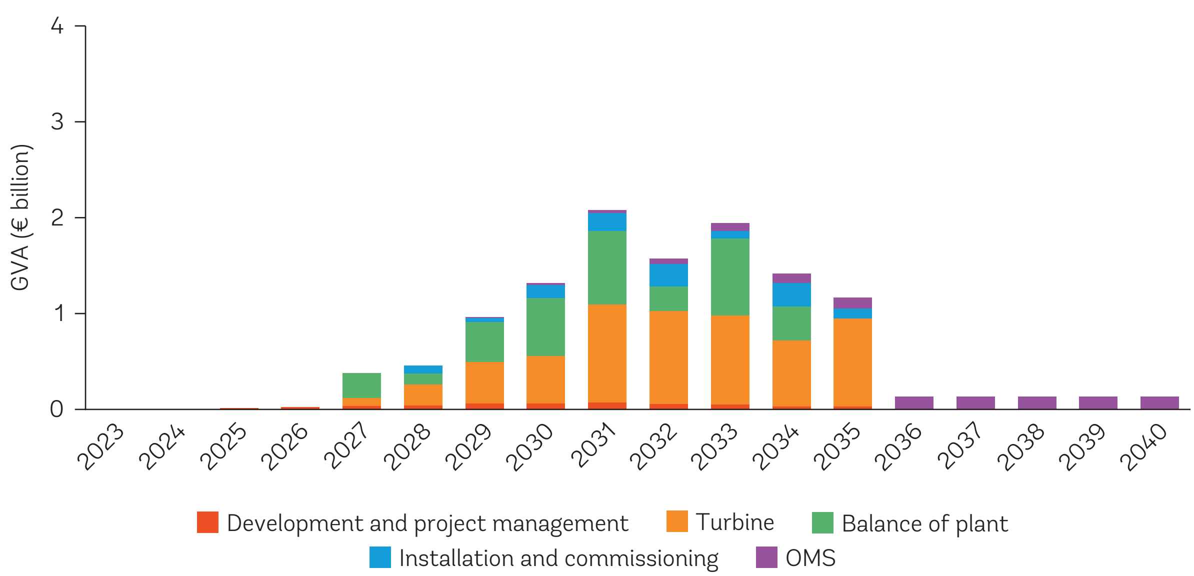
In Figure 9.6 the GVA created by all projects in the low growth scenario shows a similar trend. Over the lifetime of the wind farms about €16 billion is generated.

FIGURE 9.5 TOTAL ANNUAL FTE YEARS EMPLOYMENT CREATED BY ALL THE PROJECTS IN ROMANIA IN THE LOW GROWTH SCENARIO, SPLIT BY COST ELEMENT



Source: BVG Associates.

FIGURE 9.6 TOTAL GVA CREATED BY ALL THE PROJECTS IN ROMANIA IN THE LOW GROWTH SCENARIO SPLIT BY COST ELEMENT



Source: BVG Associates.

9.3.2 Romanian impacts from projects in Romania

Table 9.1 shows how the local content changes over time as investments are made. In both scenarios, we show the assumed local content percentage in 2029, 2032, and 2035. The local content percentages reflect the assumptions about the current and future supply chain in Romania developed in Section 8. The important differences are that the high growth scenario leads to investment in a monopile foundations factory ready for the first project in 2029, that there is a higher probability of towers being manufactured in Romania in the high growth scenario and that more of the turbine service and maintenance is carried out by local suppliers in the high growth scenario. Note that in some cases, the total local content percentage drops from one year to the next. This is due to the change in the relative cost of different OSW project elements over time, rather than any reduction in scope or fraction of supply.

TABLE 9.1 LOCAL CONTENT FOR THE OSW PROJECTS IN ROMANIA COMPLETED IN 2029, 2032, AND 2035

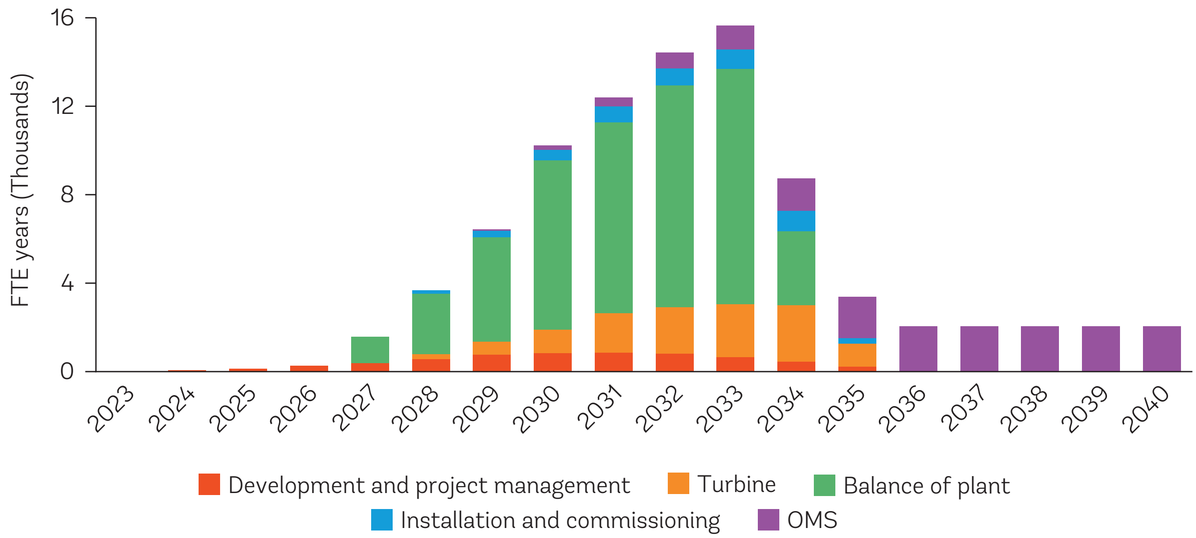
		Low growth			High growth		
	Project development	**60%**	**70%**	**70%**	**60%**	**70%**	**70%**
Turbine	Nacelle, rotor, and assembly	2%	2%	2%	2%	2%	2%
	Blades	0%	0%	0%	0%	0%	0%
	Tower	20%	30%	30%	40%	60%	60%
Balance of plant	Foundation supply	0%	0%	0%	40%	60%	60%
	Array and export cable supply	0%	0%	0%	0%	0%	0%
	Offshore substation supply	60%	75%	75%	60%	75%	75%
	Onshore infrastructure	95%	95%	95%	95%	95%	95%
Installation and commissioning	Turbine installation	15%	15%	15%	15%	15%	15%
	Array cable installation	15%	15%	15%	15%	15%	15%
	Onshore and offshore substation installation	85%	85%	85%	85%	85%	85%
O&M	Wind farm operation	90%	90%	90%	90%	90%	90%
	Turbine maintenance and service	40%	50%	50%	60%	70%	70%
	Foundation maintenance and service	60%	85%	85%	60%	85%	85%
Decommissioning		50%	50%	50%	50%	50%	50%
	Total local content	**26%**	**29%**	**28%**	**35%**	**40%**	**38%**

High growth scenario

Figure 9.7 shows annual FTE years employment created in Romania by all projects. It shows that the number of FTE years peaks at about 16,000 in 2033. Over the lifetime of the wind farms 140,000 FTE years are created, about 44% of the total created globally by the pipeline of projects in Romania.

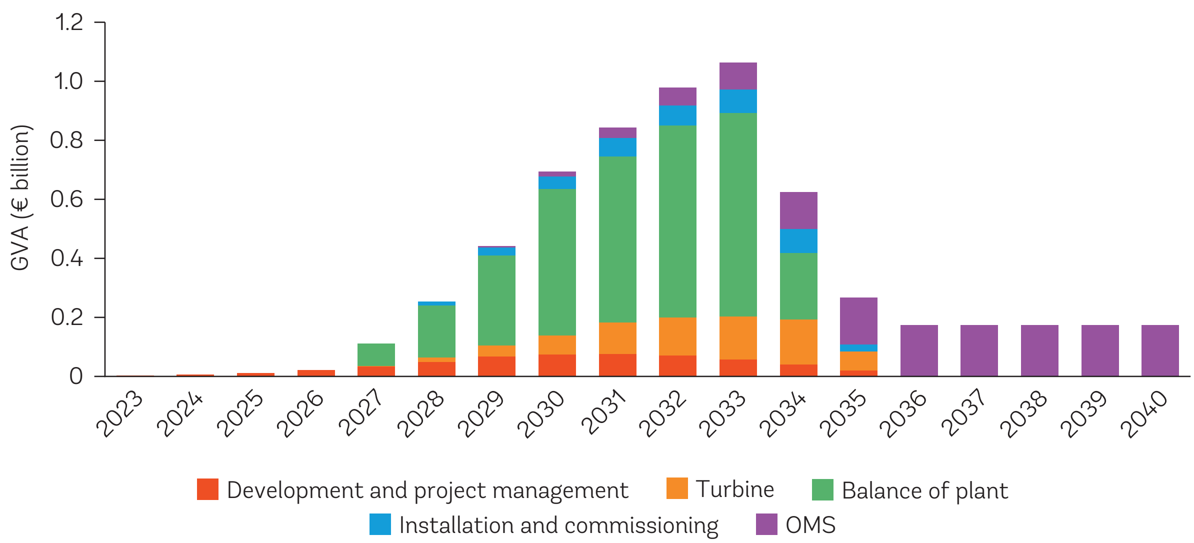
Figure 9.8 shows annual GVA reaching a peak of about €1 billion in 2033. Over the lifetime of the wind farms €11 billion GVA is generated, about 39% of the total generated globally.

FIGURE 9.7 ANNUAL LOCAL FTE YEARS EMPLOYMENT CREATED BY ALL THE PROJECTS IN ROMANIA IN THE HIGH GROWTH SCENARIO SPLIT BY COST ELEMENT



Source: BVG Associates.

FIGURE 9.8 ANNUAL LOCAL GVA CREATED BY ALL THE PROJECTS IN ROMANIA IN THE HIGH GROWTH SCENARIO SPLIT BY COST ELEMENT



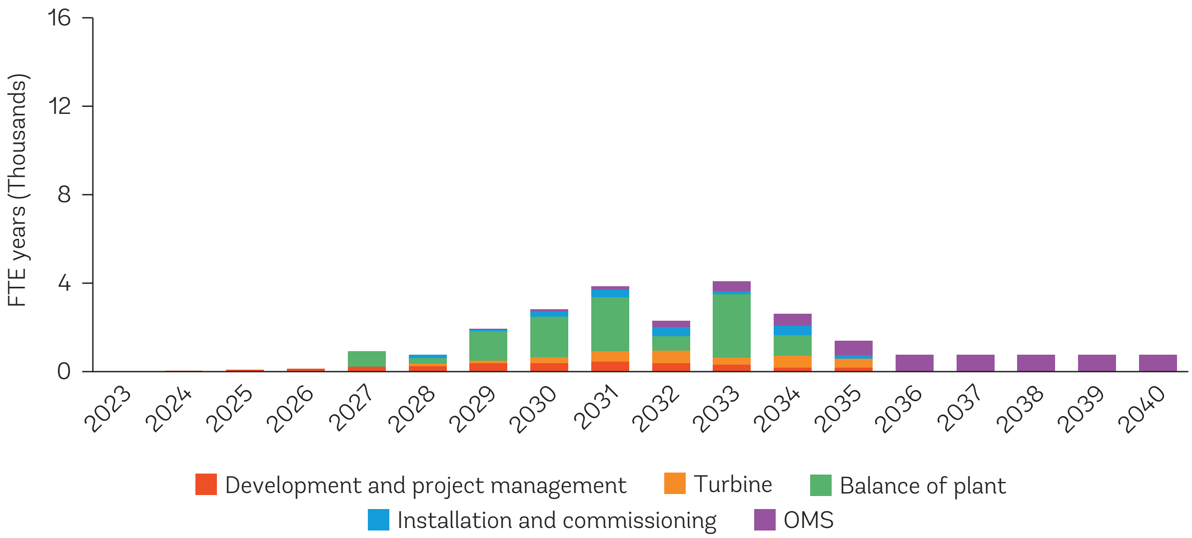
Source: BVG Associates.

Low growth scenario

Figure 9.9 shows Romania annual FTE years employment created by all projects. It shows that the number of FTE years peaks in 2033, with about 4,000 FTE years. The number of FTE years created over the lifetime of the wind farms is about 44,400. To aid comparison with the high growth scenario, the same axis scale is used.

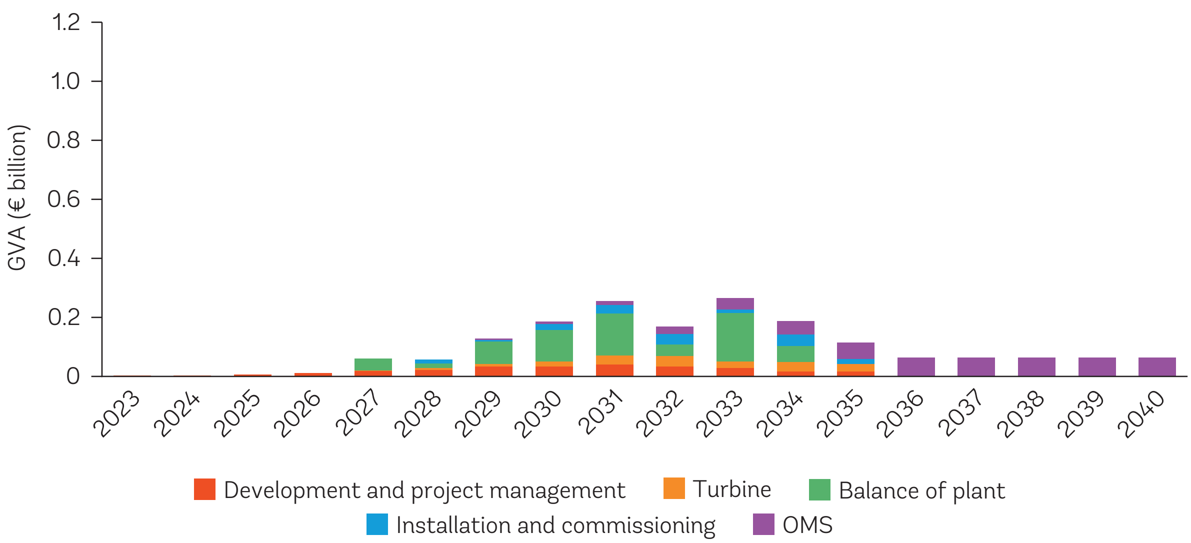
Figure 9.10 shows that annual GVA peaks in 2033 with about €270 million. The GVA generated over the lifetime of the wind farms is about €3.4 billion.

FIGURE 9.9 ANNUAL LOCAL FTE YEARS EMPLOYMENT CREATED BY ALL THE PROJECTS IN ROMANIA IN LOW GROWTH SCENARIO, SPLIT BY COST ELEMENT



Source: BVG Associates.

FIGURE 9.10 ANNUAL GVA CREATED BY ALL THE PROJECTS IN ROMANIA IN LOW GROWTH SCENARIO SPLIT BY COST ELEMENT



Source: BVG Associates.

9.3.3 Romanian impacts from projects in Romania and overseas

In the high scenario, we have assumed that 25% of the towers manufactured are exported to nearby markets, and 40% of towers are for onshore wind. In addition we assume that 50% of monopiles manufactured are for export. This creates an additional 38,000 FTE years of employment between 2029 and 2035, as well as €2.6 million in GVA. These impacts will continue after 2035 as well.

In the low growth scenario, there would also be opportunity to export tower as well as manufacture towers for onshore wind, if a tower factory is invested in.

9.3.4 Investment

Table 9.2 presents the likely large-scale investment needed to deliver the supply chain development described above, with timing to achieve impacts for a first project installed in 2029. Investments are highly indicative, as they depend on where investment occurs and what existing infrastructure can be used.

We have included investment in a 1 GW tower factory in both the low and high growth scenario in Table 9.2, producing 60% of the OSW demand for towers for Romania onshore wind and OSW projects, as well as for export. In Table 9.1 the local content % for the low growth scenario is lower to represent the lower probability of a tower factory being built in this scenario. Viability will depend on relative pricing of towers from a new Romanian facility compared to existing facilities.

Total investment is in the range €250 to €350 million in the high growth scenario, with €100 to €150 million required in the low growth scenario. Smaller-scale investments in the supply chain and investments in ports have not been included, so will be additional. It is not anticipated that any significant investment is needed to manufacture offshore substations or vessels for OSW (for use in Romania or export, so not necessarily directly linked to projects in Romania).

TABLE 9.2 POTENTIAL LOCAL SUPPLY CHAIN INVESTMENTS RELATING TO OFFSHORE WIND IN ROMANIA

Investment	Low growth scenario	High growth scenario	Timing	Amount
Tower factory	New 1 GW factory to produce up to 60% of Romanian OSW demand (up to 15 towers per year), Romania onshore wind demand and export.	New 1 GW factory to produce up to 60% of Romanian OSW demand (up to 40 towers per year), Romania onshore demand and export.	Investment decision 2026, to supply first project installed in 2029	€100-150 million
Monopiles	Imported	New 1.5 GW factory for up to 60% of Romania demand (up to 40 foundations per year) and export (same volume).	Investment decision 2025, to supply first project installed in 2029 (foundations installed in 2028)	€150-200 million

9.3.5 Prerequisites

Based on experience in other markets, there are a number of prerequisites to such investment:

- Confidence in a strong visible future pipeline of projects to compete for;
- A commercial and financial environment that enables investment, whether inward investment or indigenous; and
- A sufficient level of commitment to buy a reasonable amount of supply over a long enough period.

This last point can be a frustrating barrier, as project developers often only have limited visibility of their own projects and seek to keep competitive tension in their supply chain, so tend not to give much commitment. Often, commitment can only be for 'the next project' and then there is not enough time for the supplier to build the new manufacturing facility and then manufacture components, because the developer wants to construct the project as soon as possible. This may be addressed through state intervention.

9.4 BACKGROUND: DETAIL OF METHOD

Conventional modeling of economic impacts for most industrial sectors relies on government statistics, for example those based on industry classification codes and use input-output tables and other production and employment ratios.

Industry classification code data can be appropriate for traditional industries at a national level. The development of new codes for a maturing sector, however, takes time. This means that conventional industry classification analyses of OSW need to map existing data onto OSW activities, which is not easy and a source of error. Analyses using industry classification codes also have to rely on generalized data.

OSW is ideally suited to a more robust approach that considers current and future capability of local supply chains because OSW projects tend to:

- Be large and have distinct procurement processes from one another; and
- Use comparable technologies and share supply chains.

It therefore enables a realistic analysis of the local, regional and national content of projects even where there are gaps in the data.

The methodology used here was developed jointly by BVGA and Steve Westbrook of the University of the Highlands and Islands, UK, and has been used for a series of major clients.

The methodology's first input is the cost per MW of each of the supply chain categories at the time of wind farm completion.

The remaining expenditure is analogous to the direct and indirect GVA created. GVA is the aggregate of labor costs and operational profits. We can therefore model FTE employment from GVA, provided we understand some key variables. In our economic impact methodology, employment impacts are calculated using the following equation:

$$FTE_a = \frac{GVA - M}{Y_a + W_a}$$

Where:

FTE_a = Annual FTE employment

GVA = Gross value added

M = Total operating margin

Y_a = Average annual wage, and

W_a = Non-wage average annual cost of employment.

To make robust assessments, therefore, we consider each major component in the OSW supply chain and estimate typical salary levels, costs of employment, and profit margins, bringing together specific sector knowledge and research into typical labor costs for the work undertaken in each supply chain level 2 category.

FTEs relate to full time equivalent job years, with part-time or part-year work considered appropriate. A full-time job would normally be at least 7 hours per day over 230 working days of the year. If an individual works significantly more than this over a year, FTE attribution would be more than 1 FTE (for example, 1.5 FTEs if working long hours over 7 days per week).

FTEs are by workplace rather than by residence and will include migrant/temporary resident workers.

Where work in a local area (for example, on an assembly site) is carried out by people who have moved temporarily from elsewhere in Romania ,or overseas and live in temporary accommodation while working on site, their daily expenditures on accommodation, food, and drink, leisure and the like create employment impacts locally and within Romania more widely. These impacts have been considered in the indirect impacts because these payments are likely to be covered through subsistence expenses rather than personal expenditures.

The GVA to gross earnings ratio for a business can be relatively high where it is charging for use of expensive plant, equipment, boats, etc. If a specialist vessel, for example, has been built in Romania for offshore renewables work, the prior employment and earnings impacts from this could be additional to what it has been possible to capture in the analysis carried out for this report.

In this report, GVA and earnings impacts have not been discounted prior to aggregation.

9.4.1 Definitions and assumptions

The economic analysis was structured around theoretical projects. We have assumed that all these projects are fixed projects.

For each of the theoretical projects, we made judgements of local content for each of the supply chain categories defined in Section 8. Project costs in 2029, 2032, and 2035 were taken from the LCOE modelling described in Section 7. To simplify this analysis, we assumed that there is no real term increase in salaries and that changes in cost for the projects between 2029 and 2035 are due to changes to technology and industry learning. As a result, the analysis is likely to underestimate the GVA.

To model economic impacts years between 2029 and 2035, we interpolated costs and local content based on the three years; 2029, 2032 and 2035.

10. GENDER ASPECTS

10.1 PURPOSE

This work package presents the status of gender equality in Romania and reviews the policies and legislation that affect the creation of a diverse offshore wind (OSW) workforce. We also look at learning around gender diversity from the development of OSW in other countries to highlight possible ways of eliminating or lowering common barriers to gender equality. We recommend a proactive approach to ensure the OSW industry that evolves in Romania is gender equal.

10.2 METHOD

This section contains the results of the desk-based research and stakeholder engagement carried out to understand:

- The current position of men and women in the Romanian workforce and education system;
- The prevailing legal and regulatory environment around gender equality issues in Romania;
- Gender discrimination and diversity targets; and
- How other countries have approached gender equality issues in the wind industry.

This enabled the creation of policy recommendations that can help remove barriers to the equal participation of women in Romania's OSW industry.

10.3 RESULTS

As OSW establishes itself as a global industry it is important that it can address the gender, diversity and inclusion challenges of our time. Research has established that more jobs are held by women in the renewable energy sector (32%) than in oil and gas (22%).[19] Analysis suggests that OSW performs poorly compared to the rest of the renewable energy sector when it comes to gender, with a global average rate of female employment of 21%, and with 26% female employment in the best performing nations, People's Republic of China and Taiwan, China.[20] Poor gender diversity is a structural threat to the health of the OSW industry. Multiple studies have shown that a diverse workforce is beneficial to the growth, innovation, resilience, and sustainability of all industries. A diverse workforce also gives the biggest opportunity to attract the best talent into the industry workforce.[21]

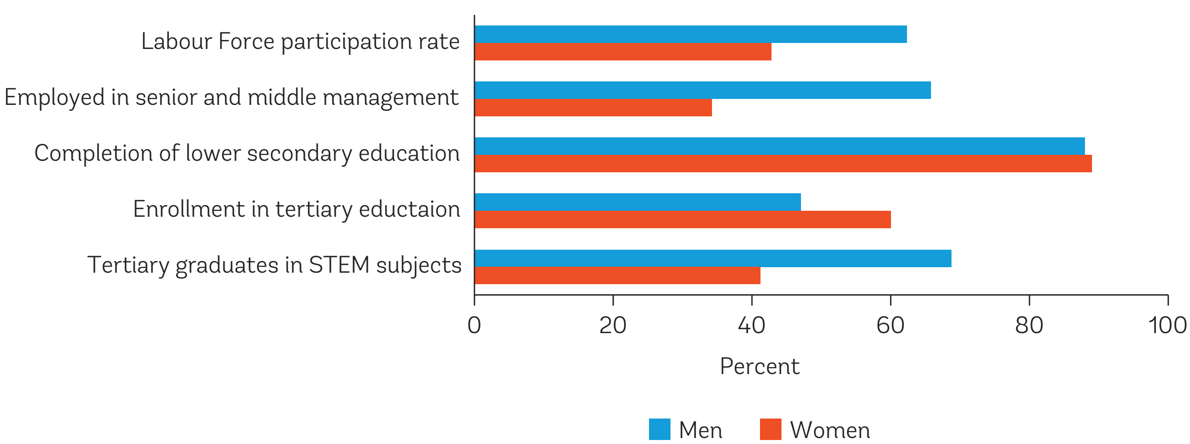
The pursuit of gender equality is mandated by existing legislation and soft-law treaties to which Romania is a signatory. The 2015 Paris Agreement states that nations should "respect, promote and consider" their obligations toward gender equality and the empowerment of women as they reduce their emissions. Romania is also committed to the UN's 17 Sustainable Development Goals (SDGs). Gender aspects play an important role in SDG 5 (Gender equality) and SDG 8 (Decent work and economic growth). The development of the OSW industry in Romania will also benefit women as consumers by providing affordable, sustainable energy to the grid, which will help meet SDG 7 (Affordable and clean energy). Romania has also ratified the UN Convention on the Elimination of all Forms of Discrimination against Women (CEDAW) which commits signatories to implement provisions to achieve equal opportunities for women and report on progress in this area[22].

Under EU law, the Equal Treatment Directive (2006/54/EC) mandates the implementation of the principle of equal opportunities and equal treatment of men and women in employment, including equally pay for equal work and equal access to opportunities.[23] There are two further important pieces of legislation – the Pregnancy Directive (92/85/EEC), which protects pregnant and breastfeeding women and women who have recently given birth, and the Work-life Balance Directive (2019/1158/EU), which provides legislative and non-legislative measures that enhance rights to leave and flexible working arrangements for parents.[24,25]

Domestically, the country's Gender Equality law (Law No. 202/2002) establishes the legal framework for equal opportunities for women and men and defines measures for achieving them.[26] This law has been subject to several amendments. Companies with more than 50 people are mandated to appoint equal opportunity experts to develop equality action plans with the support of human resources (HR) and Trade Unions. These plans should clearly state policies that prevent harassment, allow for promotion and pay increases without discrimination, set up a complaints process, and reconcile professional life with family life. Companies must implement projects, training programs, and information campaigns for their employees about gender discrimination. Gender equality measures are implemented the National Agency for Equal Opportunities for Women and Men, with the Ministry of Education responsible for monitoring compliance within the academic sphere. There are also clear civil remedies and criminal penalties covering sexual harassment in employment[27].

According to the World Economic Forum's Global Gender Gap Report 2022, Romania is ranked only 90 overall out of 146 listed countries, but is the third highest scoring Eastern European Country after Slovakia (67) and Hungary (88).[28] Figure 10.1 shows that a gender gap around educational attainment at secondary and tertiary level has been closed. The data highlight that significant gender gaps exist around other key metrics, including the workforce participation, the number of women relative to men in the senior roles and science, technology, engineering and mathematics (STEM) attainment rates. STEM attainment is highly relevant to accessing many higher-paid jobs within OSW.

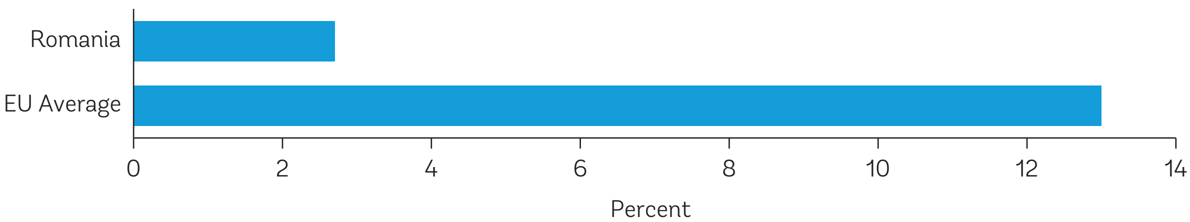
FIGURE 10.1 EMPLOYMENT GENDER METRICS IN ROMANIA



Source: World Economic Forum.

Romania performs well for wage equality, however, with a gender pay gap that is five times lower than the EU average, as shown in Figure 10.2.

FIGURE 10.2 GENDER PAY GAP IN ROMANIA RELATIVE TO EU NEIGHBORS



Source: Eurostat.

10.4 DISCUSSION

Experience from the development of OSW in Northern Europe shows that strong equality laws alone will not ensure that a gap does not emerge over time between the number of women and men employed in the industry and the types of role they occupy. The Global Wind Energy Council (GWEC) Women in Wind Program and the International Renewable Energy Agency (IRENA) have found that women make up 21% of the global wind energy workforce and that 65% of all women working in the sector perceive gender-related barriers.[29] Just 8% of senior management positions in wind energy are taken up by women, who generally occupy roles in administration and non-STEM occupations within the sector.

Early experience from the UK shows how OSW can suffer from even more acute gender imbalance. The UK installed its first OSW project in 2000 and by 2018 had 7.5 GW of installed OSW capacity with 7,200 people directly employed in the sector. Women, however, made up just 16%of that workforce, despite the UK having robust equality legislation in place. This highlights that external policies alone are not enough to foster a gender equal industry. Since 2018, the Government and industry in the UK have moved to address this gender disparity as part of the UK Offshore Wind Sector Deal signed in 2018.[30] An aspirational target of ensuring women make up at least 33% percent of the OSW workforce by 2030 has been set. Meeting this target will be challenging, but educational institutions and OSW industry programs have been established to eliminate the significant barriers that exist to prevent women from either joining or staying in the OSW. These barriers include:

- Sociocultural norms that drive men and women to pursue different educational and employment opportunities;
- Hiring practices that unconsciously or inadvertently discriminate against women;
- A lack of gender targets within the industry;
- Workplace conditions and policies that discourage women;
- A lack of networking spaces and opportunities for women in a male-dominated sector; and
- A lack of awareness about these barriers in a male-dominated sector.

Since the publication of the Offshore Wind Sector Deal, the UK has incorporated gender equality requirements in a scored 'supply chain plan' assessment which developers must pass as a before they can participate in revenue auctions to aid progression towards its 33% target for women employed.

10.5 RECOMMENDATIONS

Based on the above analysis, it is recommended that:

- OSW project developers and suppliers collaborate to encourage women into the sector and get involved in gender equality working groups. Women's rights organizations in Romania, such as the Women's Association of Romania, the Association for Liberty and Equality of Gender and Centrul Filia, and industry bodies, such as Global Wind Energy Council (GWEC) and Global Women's Network for the Energy Transition (GWNET), should be included in these working groups.
- The Ministry of Labour and Social Solidarity and industry set diversity targets and establish framework to measure progress.
- OSW project developers and suppliers collaborate to publish a best practice guide for industry stakeholders and ensures opportunities for women in OSW are well-promoted. The best practice guide should discuss using gender decoders and gender-balanced language to ensure hiring practices are unbiased and creating spaces and opportunities for women to network within the OSW sector.
- The Ministry of Energy (MOE) considers introducing diversity requirements into leasing and revenue frameworks.

11. ENVIRONMENTAL AND SOCIAL CONSIDERATIONS

11.1 PURPOSE

In this work package we describe and rate the environmental and social considerations relevant to offshore wind (OSW) in Romania.

11.2 METHOD

The assessment presents the environmental and social considerations relevant to the development, installation and operation of OSW projects. The rating shown in Table 11.1 has been used to show the potential impact of OSW on key receptors.

Further detailed studies, surveys and consultations will be required to be undertaken by Government, stakeholders, and project developers in relation to the environmental and social considerations. This will be required at both a country-wide and at a project-specific level. These studies and surveys should include the consideration of cumulative impacts between projects.

TABLE 11.1 RAG SCALE FOR ENVIRONMENTAL, SOCIAL AND TECHNICAL CONSIDERATIONS

Scale values	Description
(R) Red	OSW development has the potential to have significant impact or influence on the environmental or social consideration.
(A) Amber	OSW development has the potential to have an impact or influence on the environmental or social consideration.
(G) Green	OSW development is unlikely to have an impact or influence on the environmental or social consideration.

These categories are defined based on a combination of our knowledge and professional judgement of considerations relevant to OSW in other markets, and through limited early engagement with some relevant stakeholders in Romania. Beyond this roadmap, further work is needed to provide a full view of environmental and social considerations. Best practice would mean inclusion of stakeholders from neighboring countries in such work.

Key Romanian stakeholders that have a concern for the environmental and social considerations relating to the development of OSW include:

Government Institutions/Agencies:

- Local, provincial, regional, and national government units and community leaders, including:
  - Danube Delta Biosphere Reserve Authority;
  - Ministry of Environment, Water and Forests;
  - Ministry of Labour and Social Protection;
  - National Agency for Fishing and Agriculture; and
  - National Agency for Protected Natural Areas.

Non-governmental organizations(NGOs)/Academes/Private Entities:

- Businesses and project developers with relevance or potential interest to OSW project in Romania.
- NGOs with relevance or interest to OSW project in Romania such as Agreement on the Conservation of Cetaceans of the Black Sea, BirdLife Romania, Mediterranean Sea and Contiguous Atlantic Area, Mai Bine, Mare Nostrum, Romanian Ornithological Society, REPER 21 and the World Wildlife Fund Romania.
- Romanian academic organizations with relevance or interest in OSW such as Dunărea de Jos University of Galați, Danube Delta National Research and Development Institute, National Research and Development Institute for Marine Research, National Research-Development Institute for Marine Geology and Geoecology - GeoEcoMar Bucharest and Politehnica Bucharest University.
- Communities, and fisherfolk that may be affected.

Consideration has also been given to the World Bank Environmental and Social Framework (ESF).[31] It consists of 10 core environmental and social standards (ESS) listed below. These core standards, along with good international industry practice (GIIP)[xix]. have been used to evaluate the environment and social risks posed by OSW development in Romania setting to refine project outcome.

- ESS1: Assessment and Management of Environmental and Social Risks and Impacts.
- ESS2: Labor and Working Conditions.
- ESS3: Resource Efficiency and Pollution Prevention and Management.
- ESS4: Community Health and Safety.
- ESS5: Land Acquisition, Restrictions on Land Use, and Involuntary Resettlement.
- ESS6: Biodiversity Conservation and Sustainable Management of Living Natural Resources.
- ESS7: Indigenous Peoples/ Traditional Local Communities.
- ESS8: Cultural Heritage.
- ESS9: Financial Intermediaries.
- ESS10: Stakeholder Engagement and Information Disclosure.

xix. Good International Industry Practice (GIIP) is defined as the exercise of professional skill, diligence, prudence and foresight that would be reasonably expected from skilled and experienced professionals engaged in the same type of undertaking under the same or similar circumstances globally. World Bank ESS Standards are technical reference documents which provide examples of approaches that are based upon Good International Industry Practice. Equator Principles (a financial industry benchmark for determining, assessing and managing environmental and social risk in projects) and IFC Performance Standards call upon these guidelines for establishing acceptable levels of performance.

11.3 RESULTS

The key environmental and social considerations are discussed in Table 11.2. As stated above, further detailed studies, surveys and consultations will be required to be undertaken before any invasive project works, including consideration of cumulative impacts between projects.

TABLE 11.2 KEY ENVIRONMENTAL, SOCIAL AND TECHNICAL CONSIDERATIONS

Consideration	Category	Rating	Definition and potential OSW impact (without mitigation)	Romania-specific considerations, mitigation measures and impact on projects of mitigation
A. Protected Areas and Key Biodiversity Areas (KBAs)	Environ-mental	R	Environmentally designated sites of regional, national, and international significance which are considered as high-risk areas. This includes identified freshwater and/or marine KBAs. OSW development during pre-construction and construction stages can cause displacement and habitat changes and pose a threat to marine species and surrounding biodiversity due to noise and vibration levels, and reduced water quality during construction.	Almost all of the coastline of Romania and large sea areas around the Danube Delta are Protected Areas and have been excluded from the potential wind energy areas, and a 5 km buffer has been assumed.[xx] We assume export cables will not cross these areas. Both these measures add to levelized cost of energy (LCOE) for OSW in Romania. Project-specific mitigation may relate to projects bordering the buffer zone.
B. Natural Habitats	Environ-mental	R	Coastal and marine habitats such as wetlands and deltas. Construction in coastal areas and marine ecosystems can lead to biodiversity disturbance and possibility of local increased erosion caused by scouring around new structures and water pollution during construction. Wastes anticipated for the project include domestic wastewater, solid wastes (hazardous and non-hazardous), oil and lubricants during construction. Indirect effects include interruption or changes to natural coastal processes such as tidal flows and sediment movement.	Key habitats have been excluded. The key coastal construction activity will be bringing ashore the export cables. Surveys are important to establish key local receptors, then relevant mitigation measures can be taken, including limiting the season of activity and use of temporary solutions such as newt fencing. Horizontal directional drilling can be used as an alternative to cable trenching for crossing short stretches of sensitive habitat.

xx. We have assumed that a 5 km buffer is appropriate but there might be non-soaring bird species of concern that do cross the sea area, including passerines, ducks and shearwaters.

Consideration	Category	Rating	Definition and potential OSW impact (without mitigation)	Romania-specific considerations, mitigation measures and impact on projects of mitigation
C. Sensitive marine species	Environ-mental	R	Includes dolphins, sharks, whales, and other marine species sensitive to survey, construction and operational activities. Includes various endangered species. Noise, acoustic vibration, and light produced during OSW construction can impact sensitive marine species causing changes in feeding and breeding patterns through habitat disruption. Increased sediment loading during construction and operation could cause smothering of habitats and species. Operational sources include mechanical and aerodynamic noise.	Black sea dolphins and other species have seasonal behavior patterns that need to be considered, especially in the design of foundation installation methods and the timing of installation programs, to avoid times when receptors are most sensitive. Monopiles are likely to be the most used foundation type in Romania. Typically, these are driven into the seabed using piling hammers, but in some cases, drills and vibro-piling solutions can be used. Gravity-base for alternative foundations can also be used, but at a cost premium. Much work has been done to reduce the piling noise and to minimize its propagation to receptors, including through the use of bubble curtains or temporary solid barriers put in place round foundations during installation. Use of such solutions adds to installation cost. Typically, effects of operating projects are believed to be much less significant.
D. Bats and birds	Environ-mental	R	Habitats for resident and migratory bird species, particularly intertidal feeding grounds and high-tide roost sites which support populations of threatened species. Offshore foraging sites and migration of bats. OSW poses risk of injury or death from turbine collision, habitat displacement, disruption of feeding grounds, and changes in breeding patterns during construction and operation.	We have found little data especially regarding migratory birds, but recognize the international importance of the Danube Delta, especially for avian life. This is why we recommend an early Strategic Environmental Assessment with focus on avian flightpaths, especially for the Yelkouan Shearwater.[xxi] This could have a significant effect on potential wind energy areas. Studies show that many birds navigate OSW projects

xxi. The Yelkouan Shearwater has been seen in large numbers from the coast, but no spatial data on their movements around Romania exists. Habitat suitability modelling, combined with boat surveys and coastal counts, show the coast of Romania to have good suitability for Yelkouan Shearwater with areas in the non-breeding season overlapping with the proposed OSW areas. Surveys in these areas should therefore be targeted for Yelkouan Shearwaters. More information is available at: https://www.sciencedirect.com/science/article/abs/pii/S096706451630193X?via%3Dihub

Consideration	Category	Rating	Definition and potential OSW impact (without mitigation)	Romania-specific considerations, mitigation measures and impact on projects of mitigation
D. Bats and birds (cont.)		R		successfully, but casualties have been seen and the impact of disruption is not fully understood. In some cases, turbines on some projects have been temporarily stopped, either at defined times of year or based on real-time avian tracking. Such measures impact LCOE, so a better solution is to only construct projects where such measures are not needed.
E. Artisanal and commercial fishing grounds	Social	A	Comprises commercial fishing areas, and small-scale fisheries for individual households or communities. In many countries, larger fishing vessels are not permitted to enter OSW farms, driving changes to fishing areas and practices, though changes in risk perceptions are in some cases softening such restrictions.	Romania is a minor EU producer of fishery products. Romania's fishing fleet is mostly small-scale (vessels less than 12 meters in length). In 2020, Romania had 175 registered vessels, with the majority (133) being less than 12 meters. Five vessels are between 18 and 29 meters. This suggests the majority of fishing in Romania is artisanal and is unlikely to be at the distances from shore relevant for OSW or excluded from within OSW project areas. For owners of larger vessels, consultation is likely to lead to satisfactory outcomes, which may include: Site adjustment to avoid interference with the most important commercial fishing grounds and their biologically linked habitats, such as spawning or nursery areas; Use of compensation schemes, including retraining, community investment, or disruption payments; and Agreements on multiuse areas.
F. Aquaculture	Social	G	Areas for coastal aquaculture and mariculture of fish, shellfish, and seaweed in the country. OSW construction such as piling may cause noise / vibration impacts to the marine environment. Civil works increase the potential for water pollution that could result in potential economic displacement through reduced yields.	In 2020, Romania had an aquaculture production of 12,200 tons, with over 30 species cultivated, the most important belonging to the Cyprinidae family, particularly common carp, as well as bighead, silver, and crucian carps. The majority of aquaculture is inland, freshwater aquaculture with limited mariculture production.

Consideration	Category	Rating	Definition and potential OSW impact (without mitigation)	Romania-specific considerations, mitigation measures and impact on projects of mitigation
F. Aquaculture (cont.)		G		Established aquaculture sites should be avoided by developers to minimize disturbance. This is easy due to the anticipated location of OSW projects. OSW projects may provide new opportunities for aquaculture due to the availability of fixed structures, refuges, power and communication. Pilot programs are running in some markets.
G. Landscape and seascape	Social	G	Any significant viewpoints (landscape, seascape, or visually significant landforms/structures) that will be affected by the visual impact of wind turbines and associated facilities, such as transmission lines and substations. Impacts can relate to the presence of infrastructure but also flicker or shadow effects changing as turbine rotors rotate.	Protected landscape and seascape in the country that could be impacted by OSW development include the Danube Delta and Vama Veche - 2 Mai Marine Reserve. Stakeholder engagement and avoiding protected landscapes and seascapes through marine spatial planning is key to addressing this consideration. Wind Energy Areas are mostly at least 30 km from shore, sufficient to minimize concerns.
H. Historical and cultural areas	Social	A	Shipwrecks and heritage sites that have significance to local culture or local setting. OSW construction can pose risks to potential offshore artifacts, which may have cultural or tourist value. Visual considerations are also relevant.	The are no marine or coastal UNESCO cultural heritage sites in Romania. There are known shipwrecks within the Romanian waters of the Black Sea. Early identification of important heritage sites through marine spatial planning is recommended to minimize harm and local conflict. It is possible, however, that important sites and finds may arise during the ESIA process and from stakeholder engagement. Protection of underwater archaeology and historical settings will be secured through the permitting process, and local siting of turbines and subsea cables within wind farms can be adjusted relatively easily to avoid sensitive sites. Wind Energy Areas are mostly at least 30 km from shore, sufficient to minimize concerns.

Consideration	Category	Rating	Definition and potential OSW impact (without mitigation)	Romania-specific considerations, mitigation measures and impact on projects of mitigation
I. Tourism areas	Social	A	Tourism areas consist of beaches, hotels, natural areas, cultural/heritage buildings and locations spots for water activities such as diving, surfing, recreational fishing, boating, sailing and cruise ships. Construction activities can cause disruption. Visual considerations are also relevant. Early OSW projects can create new local tourism opportunities.	The main coastal tourist areas in Romania include Constanța, Jupiter, Mamaia, Mangalia Neptune, Vama Veche and Venus. These sea resorts rely on the tourist economy that is supported by the scenery and activities found on the Black Sea. International experience suggests that OSW developers avoid areas with important tourism activities, but it is relevant to note that early OSW projects have created local tourism opportunities via boat trips and visitors centers. Public consultation is key to managing this consideration.
J. Ports and shipping routes	Technical	R	Ports and shipping routes for a range of vessel sizes. Construction activities can cause temporary disruption, and larger vessels are not permitted to enter OSW farms, potentially driving changes to navigation routes. The presence of structures at sea can risk collision. Road traffic due to associated onshore works (grid connection and transmission and port upgrades) can impact locally.	The Port of Constanța, including the Midia and Mangalia area, and the Port of Sulina are Romania's main sea ports. There a number of major ports along the Danube River, with major shipping routes originating at Constanța. Exclusion zones and minimum safety zones are required during construction and operational stages to mitigate impacts. Consultation with the Ministry of Transports and Infrastructure and the Romanian Navel Authority is key to managing this consideration. At present, we have assumed a minimum distance of 12 km between potential wind energy areas to allow for shipping.
K. Military exercise areas	Technical	A	This comprises military bases, firing ranges, exclusion zones (including due to radar) and military no fly zones. Potential impacts are as directly above, plus OSW projects can affect radar and defense systems due to the presence of large, moving structures at sea (as rotors turn).	There are naval bases in the coastal cities of Constanța, Mangalia and Tulcea. The 57th Air Base is located at Mihail Kogălniceanu International Airport which is 20 km from the coast. Consultation with the Ministry of National Defence, coordination with coast guard, and clearance application for OSW development are keys to managing this consideration. It is likely to lead to exclusion zones, and site-specific restrictions.

Consideration	Category	Rating	Definition and potential OSW impact (without mitigation)	Romania-specific considerations, mitigation measures and impact on projects of mitigation
L. Aviation	Technical	A	This comprises local and international airports, flightpaths and related radar systems. Potential impacts are risk of collision plus OSW projects can affect radar, as above.	Mihail Kogălniceanu International Airport, located outside Constanța, is the only airport within 20 km of the coast and could potentially be a consideration. The location and design of projects can be adapted to minimize the impact on aviation services. Advanced sensor systems can also be employed to reduce radar interference. Consultation with the Romanian Civil Aeronautical Authority (RCAA) is key to managing this consideration.

11.4 DISCUSSION

This section describes and rates relevant environmental and social considerations. Section 6 describes how information about the location and sensitivity of receptors should be used in defining the location of OSW projects in Romania. Guidance and standards for environmental and social impact assessment (ESIA) aligned with GIIP and lender requirements are important to:

Minimize environmental and social impacts;

Enable financing of projects; and

Avoid damage to the reputation of the industry, slowing inward investment opportunities and future growth prospects.

11.5 RECOMMENDATIONS

Based on this analysis, it is recommended that:

The Ministry of Environment, supported by the Ministry of Finance addresses any shortfalls in Romanian ESIA requirements compared to EU Regulations, GIIP, and lender standards.

The Ministry of Energy and the General Secretariat of Government lead in helping Government departments and other key stakeholders to grow capacity and knowledge needed to process the planned volume of OSW projects (through all frameworks).

New permitting entity explores access to (and benefits of use of) existing environmental data from impact assessment of oil and gas activities, held by Authority for Mineral Resources (NAMR) in order to increase efficiency of OSW environmental impact assessment.

12. HEALTH AND SAFETY

12.1 PURPOSE

The management and regulation of health and safety (H&S) is a vital aspect of developing a sustainable and responsible offshore wind (OSW) industry. The purpose of this section is to undertake a high-level review of H&S guidance and law in Romania. The review will show the extent to which current legislation and best practice aligns with OSW activity. It will also recommend ways of ensuring Romania can develop an OSW industry that conforms with international H&S requirements and best practice.

12.2 METHOD

Our assessment has been based on our existing knowledge of OSW H&S issues, primary research in relation to H&S frameworks in Romania and engagement with relevant stakeholders.

12.3 RESULTS

12.3.1 General guidance and law

In Romania, the Ministry of Labour and Social Solidarity is the competent authority in the H&S field. Its main responsibilities are:

- Drawing up national policy and strategy;
- Drawing up drafts of normative acts in order to implement the national strategy; and
- Monitoring the enforcement of the legislation.
- The Romania Labour Inspectorate checks compliance with H&S legislation and grants permits through the local territorial labor inspectorates.
- Romanian H&S legislation hierarchy has a three layer structure:
- Constitution and Labour Code
- The Law on Safety and Health at Work and the Methodological Norms for its application.32 This provides the main legal framework for H&S. It sets out the following obligations of the employer:
  - To carry out (and be in possession of) a labor H&S risk assessment;
  - To decide on the protective measures to be taken and, where appropriate, the protective equipment to be used;
  - To keep records of occupational accidents; and
  - To draw up for the competent authorities, reports on labor accidents suffered by its employees.
- A larger base of Government Decisions that have more detailed provisions. Generally, these are transpositions of different EU Directives on H&S matters such as types of hazards, and protective or work equipment.

12.3.2 Oil and gas

For Romania's oil and gas sector, H&S requirements are set out in the Law No 165/2016 on the Safety of offshore oil operations (Law 165). The specific H&S rules for offshore extraction include measures to prevent labor accidents and illnesses specific to offshore oil and gas extraction work. Law 165 is complementary to the Law on Safety and Health at Work.33

In the absence of OSW specific regulations, it is logical that Law 165 is a robust starting point for OSW H&S.

To determine any gaps in the current framework and make it fit for OSW, it is important to understand the various H&S documents that are often applied to OSW activities in established OSW markets. Table 12.1 provides a non-exhaustive list of the main guidance. In addition, there are many international standards including EN, ISO and IEC standards that cover specific areas such as engineering design and processes.

Table 12.1 Main health and safety legislation and guidance documents relevant to offshore wind

Project Stage/Area	Document	Summary	Applicable to Romania Projects
Design Safety/ Emergency Response Inspection Emergency Response	DNVGL-ST-0145, Offshore Substations (OSSs) for Windfarms.[34]	General safety principles, requirements and guidance for platform installations associated with offshore renewable energy projects (substations).	Yes (international standard applied globally).
Design Inspection	DNVGL-ST-0119, Floating Wind Turbine Structures.[35]	Principles, technical requirements and guidance for design, construction and inspection of floating wind turbine structures.	Yes (international standard applied globally).
Design Construction	DNVGL-ST-0126, support Structures for Wind Turbine.[36]s	General principles and guidelines for the structural design of wind turbine supports.	Yes (international standard applied globally).
Design Construction	DNVGL-ST-0437, Loads and Site Conditions for Wind Turbines.[37]	Principles, technical requirements and guidance for loads and site conditions of wind turbines.	Yes (international standard applied globally).
Design	IEC 61400, Wind Turbine Generator Systems.[38]	Minimum design requirements for wind turbines.	Yes (international standard applied globally).
Design Operation Maintenance	EN 50308: Wind Turbines – Protective Measures – Requirements for Design, Operation and Maintenance.[39]	Defines requirements for protective measures relating to H&S of personnel (commissioning, operation and maintenance).	Yes (international standard applied globally).
Various	G+ Good Practice Guidelines and Safe by Design Workshop Reports.[40]	Good practice guidance intended to improve the global H&S standards within OSW farms and workshop reports that explore current industry design and investigate improvements.	Yes (international standard applied globally).
Health & Safety	RenewableUK Health & Safety Publications[41]	Various H&S guidelines for OSW farms including Emergency Response guidelines.	UK specific but may be applied internationally.

Project Stage/Area	Document	Summary	Applicable to Romania Projects
Safety/ Emergency Response Arrangements	Safety of Life at Sea Regulations (SOLAS).[42]	Sets minimum safety standards for life saving appliances and arrangements.	Yes (international standard applied globally).
Helideck Design	ICAO Heliport Manual.[43]	Criteria required in assessing the standards for offshore helicopter landing areas.	Yes (international standard applied globally).

12.4 DISCUSSION

Romania does not currently have any H&S regulation in place specifically for the OSW industry. OSW specific considerations will need to be incorporated into existing oil and gas regulation or new regulation, based on the findings of the project Wind Harmony as appropriate.xxii This should be managed by the Authority for the Regulation of Offshore Oil Operations in the Black Sea (ACROPO).

The evolution of OSW in other markets has shown that project developers can make effective use of international regulations, standards and guidelines in conjunction with any overarching national frameworks in place for the instead of drawing up a whole set of H&S rules.

12.5 RECOMMENDATIONS

Based on this analysis, it is recommended that:

- The Ministry of Labour and Social Solidarity adapts the existing framework of labor code and regulations to be suitable for OSW, adopting international industry standards where appropriate.
- ACROPO develops H&S regulations specifically designed for application to the OSW industry, which should be based on existing regulations in established EU markets, and include reference to the international design and operational standards adopted in established OSW markets.
- ACROPO ensures H&S regulations have a firm focus on the behavioral aspects of H&S and ensure that ongoing behavioral training forms a core element of compliance. Behavioral training forms an integral part of modern OSW H&S practices in established OSW markets.
- ACROPO encourages companies active in OSW and oil and gas activities in Romania to collaborate on knowledge sharing. This will allow the OSW industry to build upon existing experience in oil and gas by using established facilities and personnel to train OSW workers, were possible.

xxii. The project Wind Harmony has worked on harmonizing the different H&S requirements for OSW.

13. LEASING AND REVENUE FRAMEWORKS

13.1 PURPOSE

In this work package, we provide an overview of the proposed framework for leasing and revenue for offshore wind (OSW) in Romania, key considerations for the Government to consider and recommendations for next steps. We also provide recommendations for other early work needed to establish a viable, confident OSW industry.

13.2 METHOD

Balanced, transparent, and efficient processes for granting project leases and for procurement of large volumes of energy are required for Romania to deliver the volume of OSW discussed in the two scenarios in Section 2.

World Bank Group's *Key Factors* report Sections 3.2 and 3.6 discuss different ways of organizing leasing and revenue frameworks and the different options available regarding energy procurement.[9]

We considered two of the models discussed in the *Key Factors* report, a one-competition model and a two-competition model, as used in a number of other markets.

A one-competition model (as used in Denmark and Netherlands, for example) would require significant capacity building and resource within Government to do early-stage development work, and this was seen as a challenge to address within the timeframe discussed. It would also risk the progress slowing down while developers wait for Government to carry out the necessary activities and would leave little room for developers to input into project design decisions.

A two-competition (as used in UK and US, for example) would not work well in a smaller market like Romania, where there would likely not be enough liquidity of leased projects to make the revenue auction competitive, and not enough future auctions for developers who lost in the first auction to have confidence in the value of their assets.

Taking the learning from this and significant discussion with industry and the MOE about the best frameworks model to adopt for Romania, we concluded that a hybrid model would be best solution for Romania, which has parallels with the current solution for oil & gas in Romania. The hybrid solution is similar to a one-competition model, but with developers (rather than Government) leading the early stage development work and being compensated for this if they do not win the revenue auction. This reduces competitive and policy risk for developers, but it does leave the risk that a developer secures the exploration license but that the site could be won by another developer in the revenue auction. In this case, costs are reimbursed, but the opportunity value is lost.

Section 13.3.2 outlines this model, and the stages and milestones to deliver.

13.3 RESULTS

13.3.1 Seabed rights

According to Romanian legislation, the seabed is part of the state's heritage. As a consequence, in order to secure the right over a block of seabed, an applicant needs to enter into a concession agreement.

This is where the grantor (on public land this is the local authority,), transfers, for a maximum period of 49 years, to the concessionaire, the right and obligation to exploit public property, in return for a royalty. It is a requirement that the concession agreement is awarded through a tender procedure with criteria:

- The level of the royalty;
- The economic and financial capacity of the applicant;
- Environmental protection; and
- Specific considerations relevant to the nature of the concessioned asset.

13.3.2 Proposed leasing and revenue frameworks for Romania

Following analysis of the suitability of framework model options, industry engagement and government consultation, a hybrid model is recommended for leasing and revenue, which has parallels with the current solution for oil and gas in Romania. The proposed hybrid model would include the following steps:

1. Early government activity and Strategic Environmental Assessment (SEA)
2. Site exploration competition
3. Revenue auction

It is recommended that the Ministry of Energy (MOE) drafts details in law and secondary legislation, working with a transaction advisor as required before consultation with industry and other relevant stakeholders, to ensure that key considerations are addressed and equitable compromises found, where needed. All aspects, including with respect to transmission, need to be in compliance with national and European provisions in the field of competition and state aid. The above steps apply to both the low growth and high growth scenarios (with further rounds of competitions in the high growth scenario), and are described in more detail below.

Early government activity and Strategic Environmental Assessment

- Potential OSW energy areas are established based on economic analysis and using available environmental and social data. See Section 6.
- The Government retains an Independent Engineer and Transaction Advisor and undertakes a SEA on the potential OSW energy areas and a basic technical review to confirm windspeeds, other metocean conditions (such as wave climate and sea currents) and geotechnical conditions.
    - A key consideration would be bird migration and the Appropriate Assessment would likely need baseline survey data.

- It designates three 1 GW sites.
- In parallel with the above the Government progresses the OSW law.
- The Government establishes how OSW fits within Romania's broader energy strategy, including through a least cost generation analysis, considering temporal patterns for generation by onshore wind, solar and OSW. Currently, it is unclear how much energy could be generated at lower cost than OSW by more onshore wind and solar projects. A further consideration is how Romanian OSW fits within a wider European context, recognising that levelized cost of energy (LCOE) in Romania is expected to be significantly higher than in established OSW markets. This also brings consideration of security of supply and international interconnect costs.
- The Government establishes an OSW capacity vision to 2035 and beyond as part of a decarbonized energy mix, considering plans also for decarbonizing the transport sector and domestic and industrial heat sectors), explaining how and why OSW is important.
- The Government sets OSW installed capacity targets for 2030 and 2035 in the next revision of the National Energy and Climate Plan (NECP), showing a clear plan for delivery of first projects, including the timetable for private-sector competitions.

Site exploration competition

- The Government initiates a site exploration license competition.
- It uses pre-qualification criteria in line with good industry practice, enabling a suitable range of entrants (including utilities, energy companies and investment funds) and meeting legal requirements, for example:
  - **Financial / Commercial.** Evidence that the bidder has the required capital to deliver the project. This ensures both that immediate payments can be made (any deposit or bond required up-front to secure an exclusive exploration license), as well as ensuring that the capital to bring the project through development (typically to financial investment decision) is available and that the project will not be abandoned due to lack financial resource.
  - **Legal.** Evidence the bidder passes certain thresholds for compliance with local regulations and ethics and understands the process it is signing up to. This minimises risk of reputational damage to the Government competent authority and de-risks the competitive process and increases the likelihood of a project being developed well and on time.
  - **Technical / capability.** Evidence that the bidder has both the experience and capability to develop a and deliver the project. This combines track record and evidence of a credible plan and ability to deliver, potentially in a market with supply chain bottlenecks. This further increases the chances of a project being developed well and on time.
  - **Commitment.** Evidence of commitment to Romania-specific policy objectives, for example:
    - Combining experience of local conditions and international OSW good practice, through collaboration between local and international players.
    - To deliver first OSW capacity operating in the early 2030s at a cost minimised for consumers
    - To meet environmental protection obligations, and
    - To support local supply chain to compete in an open market and invest in local workforce development.

- In introducing commitment criteria, it is important to establish how these are assessed and how developers are then made accountable. One important consideration is at what stage the commitments are made. For example, in the UK, supply chain commitments are made quite late in the process (when project developers know much about their project and the supply environment) and as part of prequalification for the revenue auction and accountability is relatively weak. In New York State, commitments are made earlier and accountability is higher, with commitments scored along with an electricity price element as part of the auction. Further discussion is provided in Section 3.6 of the *Key Factors* report.[9, xxiii] Specific solutions should be developed in conjunction with the proposed transaction advisor.Based on the criteria above the Government decides on a shortlist of consortia and issues guidance, including a timeline for the revenue auction for the sites and an outline of how the winning consortia will be compensated under different scenarios. These include:

  1. If the Government decides not to award a revenue contract: the site exploration consortium will be reimbursed in full for their exploration expenses up to that decision.
  2. If another developer wins the revenue auction: the winning developer will reimburse the site exploration consortium for their development expenses.
  3. If the site exploration consortium wins the revenue auction: they will include their expenses into the project.

- The Government runs the site exploration competition among short-listed consortia to undertake full feasibility work at the site.
  - The site data from the feasibility work will be made available to all bidders in the revenue auction and will therefore need to be consistent with international norms and provide enough information for other developers to be able to bid.
  - Competition criteria will include those that are legally required, as described above:
    - Royalty payment (that could potentially be capped);[xxiv]
    - The economic and financial capacity of the applicant;
    - Environmental protection; and
    - Specific considerations relevant to the nature of the concessioned asset. [xxv]

- Government awards exploration licenses for 3 GW, and the successful site exploration consortia gets site exclusivity to carry out the detailed feasibility work within a reasonable timeframe, recognizing that activities in a new market can sometimes take longer than initially expected.

Revenue auction

- Once the feasibility work has been carried out, the Government opens a data room with all the data defined as required by Government and provided by the holders of the exploration licenses.[xxvi]The Government initiates pre-qualification for developers interested in bidding on

---

xxiii. As discussed in the *Key Factors* report, restrictive local content requirements add risk and cost to projects and slow deployment. This is because new suppliers often have much to learn before supplying offshore wind projects in volume and restrictions typically limit competition.

xxiv. We understand that some form of royalty payment is legislated in Romania, Many (but not all) markets have some sort of one-off or ongoing payment at this stage. One relevant consideration is that additional cost to project developers typically will be recouped via eventual per MWh bid prices, meaning that royalty payments eventually act rather like a tax paid by consumers. For this reason, there is logic to implement a small, capped royalty payment, but for this not to be excessive. Specific solutions should be defined in conjunction with the proposed transaction advisor.

xxv. We understand that this criterion is legislated in Romania. It would be reasonable to focus this on local benefit commitments, as discussed above. Specific solutions should be defined in conjunction with the proposed transaction advisor.

xxvi. Example datasets are available, for example relating to OSW auctions in the Netherlands, where information is made public. Specific details (to be communicated prior to the site exploration competition) should be defined in conjunction with the proposed transaction advisor.

the site(s) and selects a shortlist. Pre-qualification criteria will be defined in conjunction with the transaction and will be generally in line with the pre-qualification criteria for the site exclusivity competition, covering deliverability, environmental protection and local economic benefit and any other policy objectives relevant at the time.

- The Government runs auction for 3 GW among shortlisted companies, and selects a winner for each site. The competition criteria should be dominated by per MWh price, but could also include non-price criteria (see Section 8.4).
- The winner(s) compensates the site exploration consortia where applicable.
- If any of the sites do not proceed beyond this point, then the Government compensates site exploration consortium.
- The winner(s) progresses the development of the site to operation.

Note that in the early stage of OSW markets, public financial support has been required. In time, as costs reduce, the subsidy-free corporate PPAs have become an option. Although Romania is not likely to host a large offshore wind market, keeping this route to market open is a relevant consideration.

Figure 13.1 shows a best estimate timeline for the above process in the high growth scenario, based on typical timing from other markets. The purpose of the timeline is to serve as a guide, which is different from the optimistic scenarios presented in Section 2, and used to calculate LCOE is Section 7 and the economic benefits in Section 9. It will be important to establish an agreed timeline once frameworks and responsibilities are better defined. This is especially relevant considering possible use of the Modernisation Fund, as discussed in Section 19.

FIGURE 13.1 BEST ESTIMATE TIMELINE FOR LEASING AND REVENUE FRAMEWORKS IN THE HIGH GROWTH SCENARIO

2023-2024 — Early Government activity

- Government sets OSW capacity target
- Government appoints Independent Engineer and Transaction Advisor to undertake a Strategic Environmental Assessment
- Government designates sites or areas.
- Government progresses OSW law

2025 (Competition) — Site exploration competition

- Governments shortlists consortia based on pre-qualification criteria
- Government publishes timeline for auction and guidance on compensation for winning consortia.
- Government runs site exploration competition
- Government awards exploration licenses and site exclusivity to carry out detailed feasibility work to winning consortia.

2025-2027 — Feasibility work

- Winning consortia carry out detailed feasibility work

2027 (Auction) — Revenue auction

- Government opens data room with data from feasibility work
- Government initiates pre-qualification and selects a shortlist of developers for the revenue competition
- The Government runs auction and selects a winner for each of the sites
- The Government provides compensation to site exploration consortia per rules established

2027-2029 — Project development

- The winning developer(s) progresses the site development to reach FID

2029-2032 — Project construction and operation

- The winning developers construct the projects, and the projects reach operation

13.4 RECOMMENDATIONS

Based on this analysis, it is recommended that:

- The MOE introduces a new, clear and investor-friendly OSW law and associated regulation relating to OSW frameworks, involving other public stakeholders, as required. All aspects, including with respect to transmission, need to be in compliance with national and European provisions in the field of competition and state aid.
- The MOE establishes a long-term official Government-industry forum involving local and international project developers and key suppliers, to work together to address the new OSW law, the recommendation throughout the roadmap and other considerations, as they arise.
- The MOE proposes that The National Energy Regulatory Authority (ANRE) is given responsibility to grants seabed rights relating to OSW.
- The MOE establishes how OSW fits within Romania's broader energy strategy, including through a least cost generation analysis, considering temporal patterns for generation by onshore wind, solar and OSW.
- The MOE publishes its vision for OSW to 2035 and beyond as part of a decarbonized energy mix, considering plans also for transport and heat, explaining how and why OSW is important.
- The MOE sets OSW installed capacity targets for 2030 and 2035 in the next revision of the NECP, showing clear plan for delivery of first projects, including the timetable for private-sector competitions.
- The MOE considers avoiding regulatory barriers for developers with regard to signing corporate power purchase agreements as an alternative route to market than winning a revenue competition.

14. PERMITTING

14.1 PURPOSE

A transparent and efficient process for granting permits is required for Romania to deliver the volume of offshore wind (OSW) discussed in Section 2.

In this work package we assess the existing regulatory and permitting frameworks in Romania and identify any gaps which need to be addressed to ensure they are capable of underpinning and guiding the future development of a sustainable OSW industry, based on EU Regulations, good international industry practice and other lender standards.

14.2 METHOD

There is currently no legislation in force that applies to OSW projects specifically, so we have mapped out the current key legislation that applies to energy generation projects, specifically highlighting laws that apply to offshore oil and gas operations.

We also mapped the permitting process that applies for construction projects in Romania, especially ones that apply to similar industries, such as oil and gas and onshore wind.

Further work will be required by Government to consult on, design, and implement a permitting framework for OSW projects that meets the needs of Government, stakeholders, developers, and investors.

14.3 RESULTS

14.3.1 Key legislation

The existing legal and regulatory framework for energy in Romania is covered by several laws on energy, electricity, the use of energy, environment and construction. A non-exhaustive list of relevant Romanian laws is provided below:

- Law 123/2012 on electricity and natural gas, published in the Official Gazette no. 485 dated 16 July 2012[44];
- Law No 165/2016 on the safety of offshore oil operations (Law 165)[45]; and
- Law No 256/2018 on certain measures necessary for the implementation of petroleum operations by holders of petroleum agreements relating to offshore and onshore oil blocks (Law 256)[46].

A non-exhaustive list of legislation related specifically to permitting is provided below:

- Law 292/2018 on assessing the impact of certain public and private projects on the environment, published in the Official Gazette no. 1043/10.12.2018 (Law 292)[47];

- Law 265/2006 for the approval of the Government Emergency Ordinance no. 195/2005 on environmental protection, published in the Official Gazette np. 586/ 06.07.2006 (Law 265)[48];
- Law no. 50/1991 on the authorization of the execution of construction works, as further amended and supplemented, published in the Official Gazette no. 933/13.10.2004 (Law 50)[49];
- Law no.17/1990 on the legal regime of inland maritime waters, the territorial sea and the contiguous area of Romania, republished in the Official Gazette no. 252/8.04.2014 (Law 17)[50];
- Law no. 395/2004 on maritime hydrographic activity published in the Official Gazette no. 941/14.10.2004 (Law 395)[51];
- Law 107/1996, with subsequent amendments and completions and Order 828/2019 on the procedure and powers of issuance, amendment and withdrawal of water management permits, including the procedure for assessing the impact on water bodies (Law 107);[52]
- Government Ordinance no. 57/2002 on scientific research and technological development published in the Official Gazette no. 643/30.08.2002 (GEO 57)[53]; and
- Government Decision no. 967/2004 for approving the Regulation for organization and functioning of the National Research-Development Institute for Marine Geology and Geo-ecology - GEOECOMAR Bucharest, published in the Official Gazette no. 619/ 8.07.2004 (GD 967).

Specifically for OSW, over the last years, there were two legislative initiatives in the Parliament, in 2020 and in 2022, but these have not progressed.

In addition to national legislation listed, significant EU legislation is relevant.

14.3.2 Resources

In Romania the main public entities that are responsible for the energy industry policy and regulatory framework are:

- **The Competent Regulatory Authority for Oil and Gas Operations at Black Sea (ACROPO).** A central administration body that has been set up especially for the offshore petroleum operations, based in Constanța, as a result of the transposition of the Directive 2013/30/EU for the offshore oil and gas safety operations.
- **The Ministry of Energy (MOE).** The competent authority at national level responsible for the development of energy efficiency policies and legislation in the energy industry.
- **The Ministry of Environment, Water and Forest:** Government department responsible for the conservation, management, development, and appropriate use of the environment and natural resources within the country.
- **The National Agency for Mineral Resources.** An administrative body functioning under the Romanian Government, is in charge with managing the mining and oil and gas resources, including awarding concessions, monitoring, exploration and exploitation activities in the designated sectors, providing regulatory framework and other permits for conducting operations.
- **The National Energy Regulatory Authority (ANRE).** An autonomous administrative authority with legal personality, under parliamentary control, independent in decision-making, organizational and functional terms. ANRE drafts, approves and monitors the application of mandatory regulations at national level, necessary for the functioning of the electricity, heat and gas sector in conditions of efficiency, competition, transparency and consumer protection. The above are likely to have a role in the permitting process for OSW.

14.3.3 Permitting

There are currently no specific regulations detailing the permitting process for OSW projects. Below is therefore an outline of the process for obtaining permits for other construction works in similar industries, such as offshore oil and gas platforms and onshore wind projects. The process for grid connection is discussed separately in Section 15.7.

Figure 14.1 shows the five steps of this permitting process.

FIGURE 14.1 OUTLINE OF CURRENT PERMITTING PROCESS FOR OFFSHORE WIND

Stage 1

Obtaining necessary documents to get Building Permit

The following documents must be obtained:

- Urbanism certificate from the local municipality
- Permit from the National Agency for Environmental Protection;
- Permit from the National Administration "Apele Romane";
- Permit from the Constanta Maritime Hydrographic Directorate;
- Permit from the Romanian Naval Authority;
- Permit from the Romanian Border Police
- Permit from the Ministry of Foreign Affairs
- Permit from the General Major State
- Approval from the Competent Regulatory Authority for Offshore Petroleum Operations in the Black Sea;
- Technical authorisation documentation;
- Order for declassification and the certificate of archaeological clearance issued by the Ministry of Culture;
- Declaration on bearing the costs of repairing environmental damage.

Stage 2

Obtaining design and connection approvals from the TSO

- A grid connection request will be submitted to Transelectrica.
- The technical project will be discussed with a company that will put together a solution study.
- The solution study will be further submitted to Transelectrica.
- The TSO will issue the grid connection approval (ATR).

Stage 3

Obtaining Establishment Authorisation

- Allows the establishment of a new electricity production unit.
- Issued by ANRE at a late stage in the development process, typically after the ATR.

Stage 4

Obtaining Conformity Certificate

- Technical conformity certificate issued by the grid operator
- Prerequisite for generation license

Stage 5

Final approval and commissioning

- After the project is constructed, the project will enter in a process of approval of the construction and commissioning. The final approval will be granted by a committee formed by a representative of Transelectrica, a representative of the local municipality, a representative from the investor side and representatives of any other authorities that might need to approve the connection with Transelectrica.
- A generation license for commercial operation of electricity generation capacities and energy storage related to the generation capacity must be obtained before after commissioning (of first turbine) and before commercial operation.

The Building Permit

All construction works carried out in Romania must be performed based on a Building Permit (BP) obtained by the beneficiary following the securing of a real right over the land where the construction will be erected. This can be an ownership right, a superficies right, an easement right or a concession right over public owned land, which would likely apply for the seabed.

The first procedural step is for the beneficiary of the construction to obtain the urbanism certificate (UC) from the local municipality, which includes a list of all endorsements and approvals that must be in place before submitting the application for the BP. The beneficiary must obtain all endorsements and approvals mentioned in the UC. Usually, these endorsements are issued by the National Agency for Environmental Protection, the National Administration for Romanian Waters and the local authorities (or the Ministry of Agriculture and Rural Development if it relates to agricultural land), although other authorities may also be involved in the initial endorsement process, depending on the location of any neighboring constructions (if any), the grid connection solution, and other particularities of the project.

In the absence of specific OSW regulations, it is likely that Law 256 will be taken as a logical starting point for authorizing works on OSW plants. Currently, Law 256 provides for an authorization issued by the MOE, as a derogation from the standard procedure. Under Law 256, the following documents are required for the building authorization:

- Permit issued by the National Agency for Environmental Protection;
- Notification for starting the works, or the permit issued by the National Administration "Apele Române";
- Permit issued by the Constanța Maritime Hydrographic Directorate, where applicable;
- Permit issued by the Romanian Naval Authority, for the part of the works carried out in the territorial waters of Romania;
- Permit issued by the Romanian Border Police, for the works to be located in its area of competence;
- Order for total or partial declassification and the certificate of archaeological clearance, as the case may be, issued by the Ministry of Culture; and
- Permit issued by the Ministry of Foreign Affairs, in the case of perimeters located in sectors where the delimitation between the maritime spaces of Romania and the maritime spaces of neighboring States has not been carried out.

Provided a project has a grid connection permit (ATR), the BP needs to be secured within 24 months following the ATR date and within 18 months following the signing of the grid connection agreement.

The environmental permit

The environmental permit agreement includes the specific requirements needed to ensure a high degree of environmental protection during the project construction, including the organization of the site, and during the development of the project, and during decommissioning.

The establishment authorization (set-up authorization)

This allows the establishment of a new electricity production unit (required for new electricity production units with an installed capacity higher than 1 MW). This authorization is issued by ANRE within 30 days from the submission of all the required documents and payment of the corresponding fee (0.32% from the total value of the investment for maximum charge capacity between 1 MW < 10 MW, 0.1% maximum charge capacity between 10 < 100 MW and 0.05% for maximum charge capacity higher than 100 MW).

The establishment authorization is required in an advanced stage of the development process, and typically is requested after the issuance of the grid connection permit, however it is not conditional on the BP.

The validity term will be established by ANRE according to the schedule of construction works and commissioning, considering the terms specified in the supporting documentation.

Conformity certificate

This is the technical conformity certificate issued by the grid operator, which is a prerequisite for the generation license, and acknowledges the compliance of solar/wind projects with an installed capacity above 1 MW with the technical requirements for grid connection.

Generation license for commercial operation of electricity generation capacities and energy storage facilities related to the generation capacity

This must be obtained from ANRE after the plant is commissioned and before the commencement of commercial operations. The license is issued by ANRE within 60 days of submission of the complete documentation and payment of the corresponding fee. The validity term of the license is 25 years. The generation license may only be extended if the validity period is less than the maximum duration allowed according to the law. We understand that it will be possible to apply for the license after the first turbine is commissioned and amend this later. This will allow each turbine to start generating soon after its installation, in line with normal industry practice, rather than waiting to start generating after the whole project is installed. Waiting adds significantly to the levelized cost of energy, as equipment will have been paid for, but is not yet generating.

At least 60 days before the fulfilment of the maximum validity period, the holder may apply for a new license.

14.4 DISCUSSION

There is currently no OSW-specific permitting process in Romania, and this should be developed based on the current permitting process, and good international industry practice (GIIP) for OSW development.

A one-stop shop entity leading the process can help simplify, and under EU Directive 2014/89 on establishing a framework for maritime spatial planning, it is recommended to create a single administrative entity, which can clarify responsibilities and levels of authorization (e.g. national vs. regional) in order to simplify decision-making processes. This is currently under consideration by the Government.

The purpose of a one-stop shop is to simplify and expedite the permitting process by providing a single point of contact for project developers, thereby reducing administrative burdens and enhancing efficiency. Typically, an effective one-stop shop will do this by providing:

- **A single point of contact:** Offering developers assistance and guidance throughout the permitting journey, expediting progress, resolving queries, and providing updates on applications, eliminating the need to engage with multiple agencies separately.
- **Centralized Coordination:** Bringing together government departments, agencies, and stakeholders, facilitating communication and collaboration to enable smooth progress and avoid delays.
- **Streamlined procedures:** Consolidating requirements, helping to simplify and harmonize the process through clear guidelines, standardized documentation and a streamlined application process. This reduces duplication of effort and time-consuming interactions with and between different regulatory bodies.

- **Regulatory expertise:** Holding knowledge of the permitting landscape , helping both developers and consultees regarding applicable laws, regulations, environmental considerations, and other criteria that need to be addressed during the permitting process.
- **Stakeholder engagement:** Facilitating stakeholder engagement, ensuring that concerns and viewpoints are considered, and promoting transparency and public participation in the permitting process.
- **Timelines and deadlines:** Establish clear timelines and deadlines for each stage of the permitting process. By setting reasonable and achievable targets, it helps maintain project momentum and provides developers with certainty regarding the progress of their applications.

See WBG's *Key Factors* report for more details, including examples.[9]

Note that the one-stop shop does not take responsibility for decisions, rather smooths the process for stakeholders to provide feedback and for responsible bodies to make decisions.

14.5 RECOMMENDATIONS

Based on this analysis, it is recommended that:

- The Government General Secretariat establishes a one-stop-shop permitting entity in order to simplify the decision-making process and interface for project developers and enables the use of digital services for submitting applications and similar.
- The new permitting entity develops an OSW specific process based on the current permitting process, also ensuring that it meets GIIP to help de-risk projects and facilitate access to international finance.

15. TRANSMISSION INFRASTRUCTURE

15.1 PURPOSE

In this work package, we summarize the existing transmission network and planned transmission upgrades as well as changes in transmission network management that may be required to support development of offshore wind (OSW) under the scenarios presented in Section 2. We also summarize the current grid connection process for new plants.

15.2 METHOD

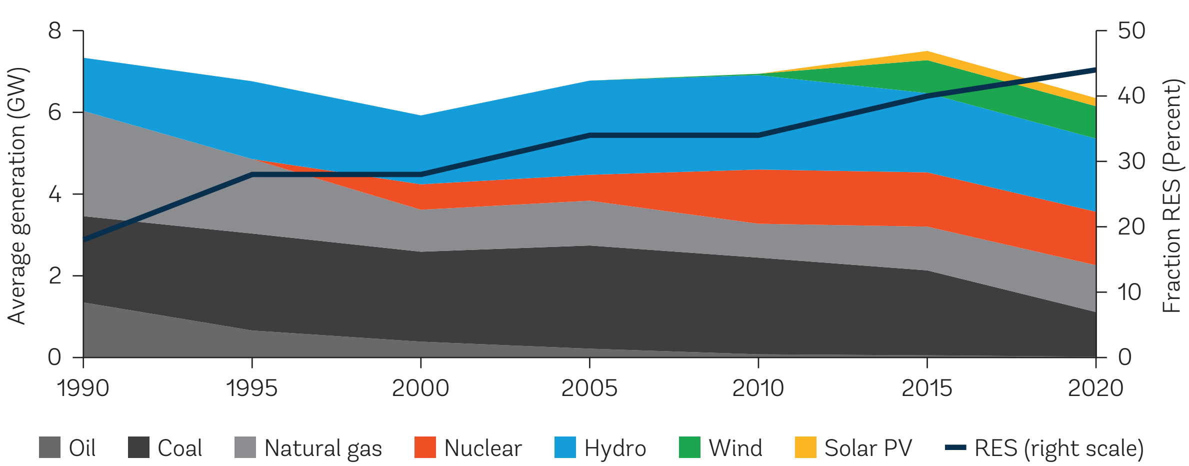
Our assessment has been based on sources as cited within this section along with industry knowledge from which suggestions have been made for the upgrading of the transmission network to facilitate the development of OSW projects in Romania. It is recognized that parts of the proposed transmission network development may pass close by to environmentally sensitive areas. This will need to be considered and incorporated during the future planning and detailed option appraisals for the future transmission network upgrading works but should not fundamentally change the principles suggested.

Environmental and social aspects have only been considered at a headline level and would need to be incorporated fully during future more detailed option appraisal.

15.3 OVERVIEW OF GENERATION

Romania's electricity supply has transitioned from being dominated by fossil fuels to well over half coming from low carbon technologies by 2020 (45% Renewable Energy supply (RES)), as shown in Figure 15.1.

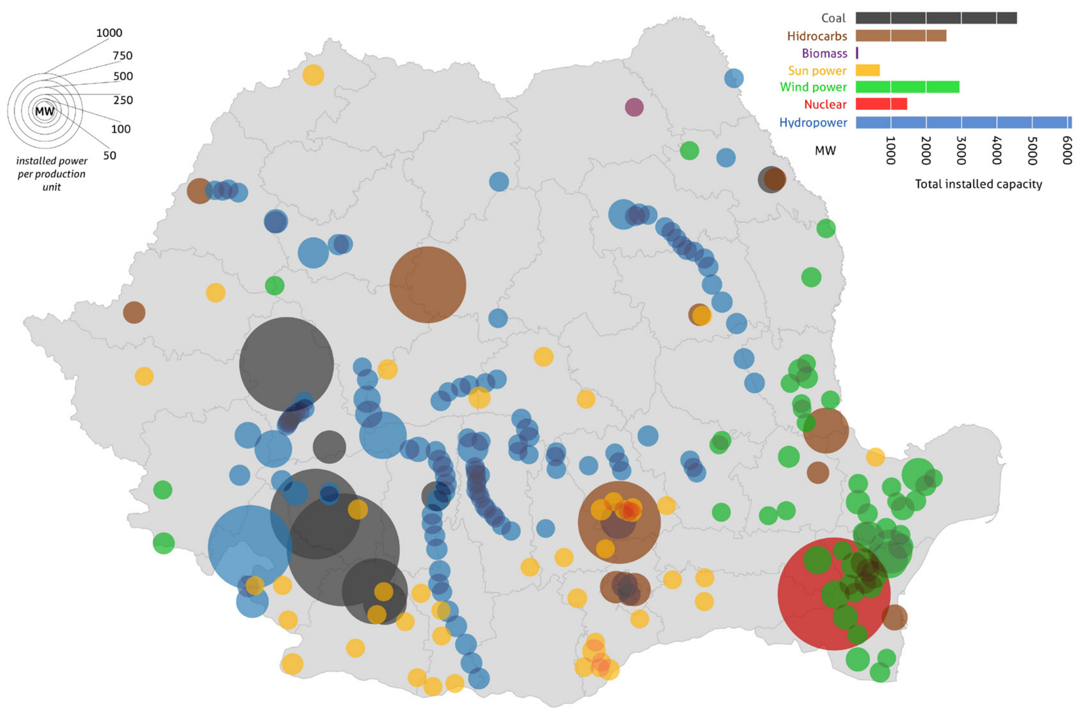
FIGURE 15.1 THE START OF ROMANIA'S ENERGY TRANSITION: THE CHANGE IN ELECTRICITY GENERATION IN ROMANIA FROM 1990 TO 2020



Source: IEA Electricity Information[54]

Figure 15.2 shows the location of power generation by type, with large coal plant to the south west and the largest generation plan, 1.3 GW nuclear with onshore wind to the south east. Future OSW would be located further to the south east.

FIGURE 15.2 POWER PLANTS



Source: Transelectrica, via Adrian_Judu[55]

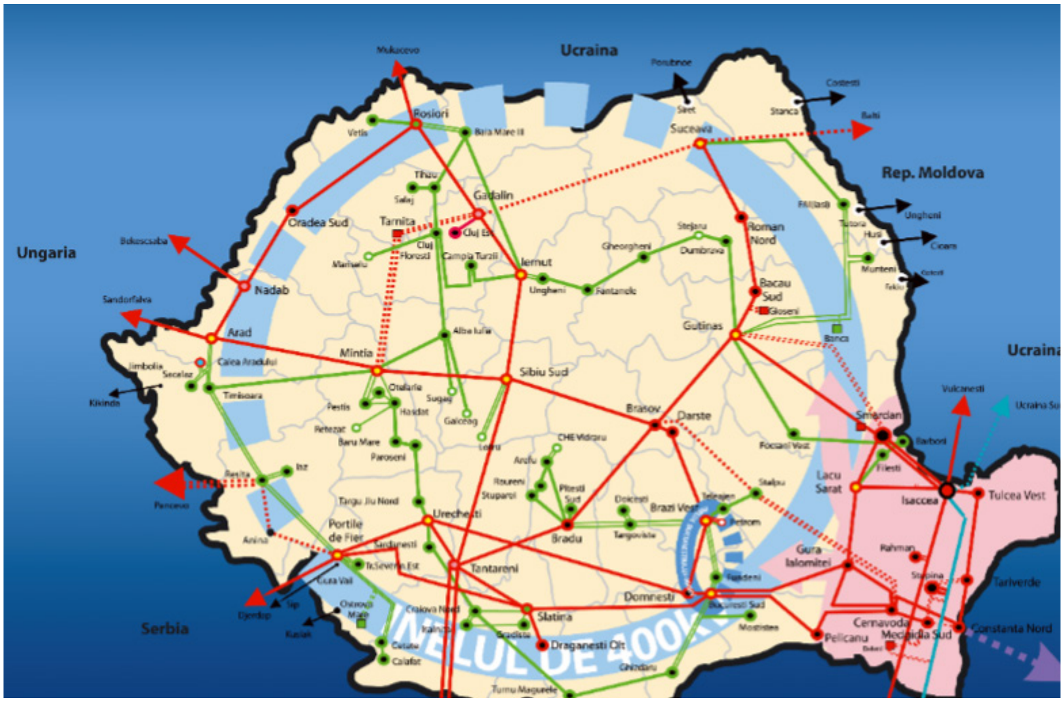
In its *National Energy and Climate Plan* (NECP), Romania has a target of 31% renewable energy in gross final energy consumption and 49% RES share in electricity supply by the end of 2030. Since publication, the Government has announced that these targets will be 'significantly increased' to around 34% in the next revision of the NECP, taking benefit of significant funding through the *National Resilience and Recovery Plan*[7] (NRRP) and the Modernisation Fund. The expectation is that the vast majority of new RES will be from wind and solar.

At the end of 2022, Romania had about 3.4 GW onshore wind operating and in its *RET Development Plan* for the period 2022-2031[56], Transelectrica anticipates this increasing to 5.3 GW by the end of 2031 in its Reference scenario (with similar capacity of solar and up to about 50% more combined wind and solar capacity under its Favourable scenario). With such increases, it has significant focus on managing variable renewable energy. The latest plan references OSW but does not reference specific capacity allocated to OSW.

15.4 OVERVIEW OF THE CURRENT TRANSMISSION NETWORK AND FUTURE PLANS

The Romanian transmission network is operated by Transelectrica. The current status is presented in Figure 15.3. It consists of about 9,000 km overhead lines above 110 kV, about 45% of this length is rated at 220 kV, just over 50% at 400 kV and just under 2% at 750 kV. Romania has interconnects with Ukraine, Moldova, Bulgaria, Serbia and Hungary. Planned upgrades are shown with dashed lines. Transelectrica has a long-term vision to establish a 400 kV high voltage direct current (HVAC) loop around Romania, also shown.

FIGURE 15.3 THE TRANSMISSION NETWORK IN ROMANIA



Source: Transelectrica.[57]

The RET Development Plan also discusses Romania's part in establishing three multi-state new priority corridors for energy which open further eventual opportunities for OSW in Romania.[58] These corridors are:

- **NSI East Electricity.** Interconnections and internal lines in the north-south and east-west directions to complete the internal market and for the integration of production from renewable sources. Member States concerned: Austria, Bulgaria, Croatia, Czechia, Cyprus, Germany, Greece, Hungary, Italy, Poland, Romania, Slovakia and Slovenia.
- **SE offshore.** Development of the offshore electricity grid, development of the integrated offshore electricity grid, including, where appropriate, the development of the hydrogen grid and related interconnectors in the Mediterranean, Black Sea and waters adjacent, for the transport of electricity or hydrogen from offshore renewable energy sources to consumption and storage centers or for the intensification of cross-border exchange of energy from renewable sources. Member States concerned: Bulgaria, Croatia, Greece, Italy, Cyprus, Romania and Slovenia.
- **HI East.** Hydrogen infrastructure and gas infrastructure reconfiguration enabling an integrated hydrogen backbone, directly or indirectly (through interconnection with a third country), which connects countries in the region and addresses their specific hydrogen infrastructure needs, supporting the creation of an EU-wide network for hydrogen transport. Target Member States: Bulgaria, Czechia, Germany, Greece, Croatia, Italy, Cyprus, Hungary, Austria, Poland, Romania, Slovakia and Slovenia.

More recently, the governments of Azerbaijan, Georgia, Hungary and Romania, with EU support, entered into an agreement under which the four countries committed to developing a subsea link in the Black Sea that will, among other things, transfer electricity from future OSW projects in Azerbaijan's part of the Caspian Sea. This opens further opportunities for OSW in Romania. [59]

15.5 CONSIDERATIONS WITH INCREASED DEPLOYMENT OF VARIABLE RENEWABLE ENERGY

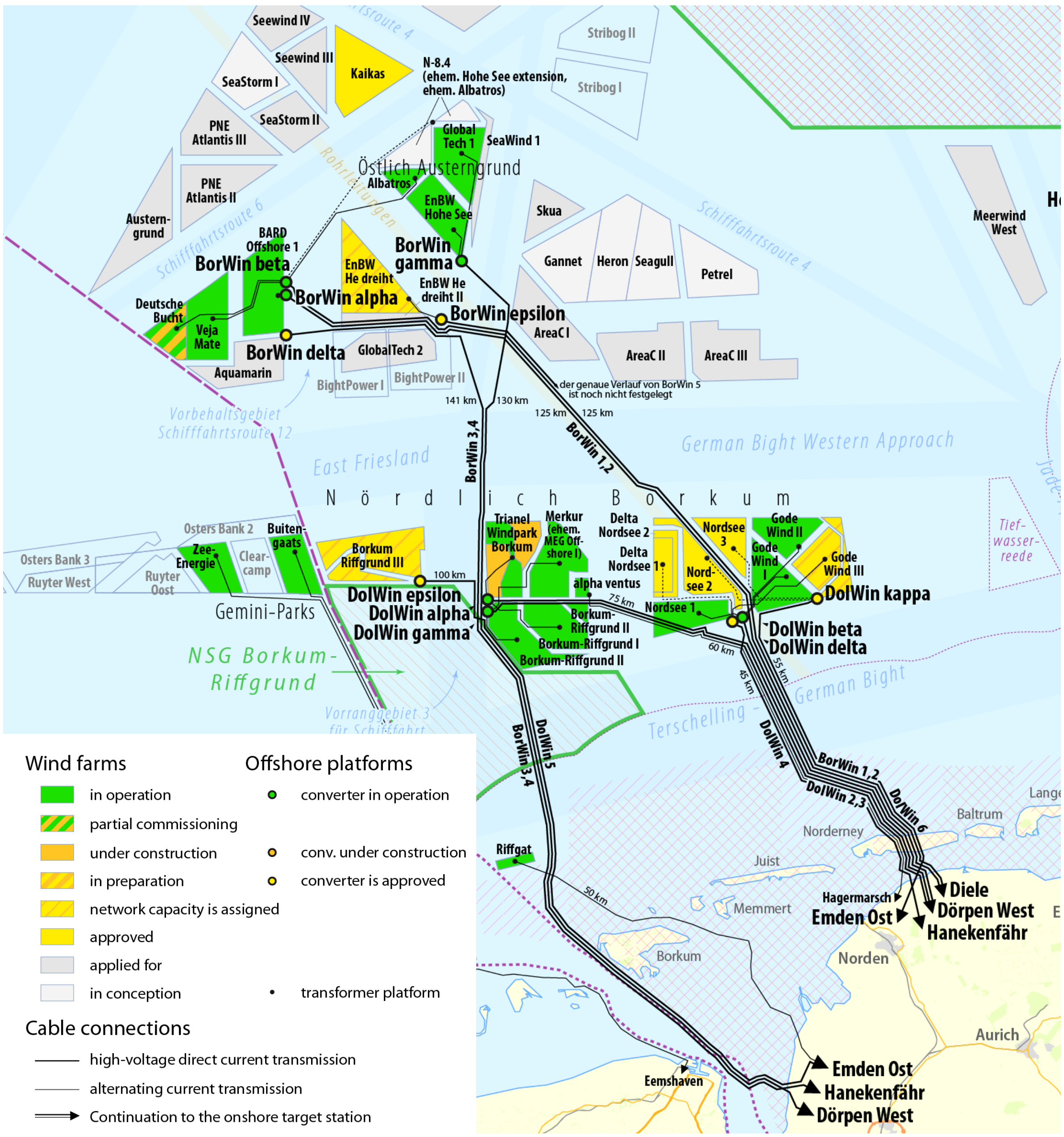
Key considerations are:

- **The need for substations and transmission upgrades.** Inevitably as new power plants are brought online, new substations and transmission line upgrades will be needed. New transmission infrastructure will also be required to bring renewable energy (RE) (including OSW) and other power from areas of remote generation.
- **Inclusion of suitable energy storage systems.** The inclusion of suitable and strategically placed energy storage systems in the transmission network will enhance the grid robustness and resilience to handle increased RE sources through peak load management, frequency regulation and reduction of the required spinning reserves.
- **Grid harmonics.** A wind turbine contains variable-speed generator technology with a power converter, which emits harmonic currents. In addition, they impact the resonance frequencies of the grid due to the presence of large amounts of capacitance in subsea cables and capacitor banks. At the point of connection, harmonic compensation must be considered.
- **Reactive compensation.** Connection of OSW by onshore and subsea cables also gives rise to voltage increases during energization and low load situations, needing reactive compensation locally through SVCs.
- **Dispatching and wind farm control.** Increased wind capacity warrants the use of forecasting systems to estimate the variable infeed. Dispatch procedures and reserve calculations may need to be changed to consider variations in output. Where the amount of conventional generation is low, system stability can be a major issue. A mix of wind farm control and other control technologies are therefore required to ensure security of supply which could otherwise lead to periods of wind farm curtailment which if uncompensated will lead to an unacceptable investment risk.
- **System frequency and inertia.** Following the disconnection of a generator, the frequency of the transmission and distribution system will decrease. The frequency drop and rate of change depends on the contribution to system inertia from the offline generator, duration of fault, available inertia from other generators on the network and network demand. With the increased penetration of wind, the overall system inertia will decrease. To balance this, however, inertial and frequency response can also be provided by wind power by balancing controls between maximizing performance, reliability, and stability provision to the transmission network. OSW farms can control active power to respond to grid frequency events to assist in overall grid stability. A similar performance to conventional generators can be achieved by using controlled inertial response technology. Wind farm capabilities can also provide flexibility to transmission and distribution network operations through inertial response which can assist system reliability. In many power systems, ancillary service markets have been developed and provide incentives towards developing technologies which provide support to transmission system reliability.

15.6 OFFSHORE EXPORT SYSTEM

In most markets so far, individual OSW projects have been connected to the closest onshore substation with sufficient capacity, potentially after local transmission network upgrades. In some markets, where a strategic approach has been taken and where projects are located close together, offshore hubs have been established to take power from a number of OSW projects. The best example of this is in Germany, as shown in Figure 15.4. See also *Key Factors* report Figure 3.11.[9]

FIGURE 15.4 EXTRACT OF MAP OF OFFSHORE WIND PROJECTS AND INTEGRATED HUB EXPORT SYSTEMS IN THE GERMAN BIGHT



Source: Wikimedia Commons[60]

Should Romania seek to develop OSW projects close together, then an offshore hub option should be considered. Pros and cons of the two options are presented in Table 15.1. It is understood that should an export connection be required for a single OSW project in Romania, then this radial system would be constructed, owned and operated by the OSW project owner. If an integrated hub serving more than one OSW project was required, then regulations require that this would have to be operated by Transelectrica. For such a model to be successful, it is likely that the hub would need to be constructed using public money, with each project owner paying a fraction of the cost when it was ready to connect. The hub could be connected directly to the round-Romania link via an HVDC connection. Germany has led in the adoption of integrated offshore hubs serving mutiple projects, so is a good basis for exploring this option. It is suggested that any refinements to process in this area follows good practice established in other markets.[9,61]

TABLE 15.1 PROS AND CONS OF INTEGRATED HUB EXPORT SYSTEM COMPARED TO RADIAL SYSTEM

Pros	Cons
• Overall, lower cost (as long as all planned projects are built within a reasonable timeframe). • Likely lower environmental impact.	• Risk to first developer that system is not constructed in time to connect its project. • Risk to owner that it receives delayed/incomplete income if OSW projects are delayed/cancelled.

15.7 GRID CONNECTION

There is currently no OSW specific process, but the current process for connecting new energy generation capacity is outlined below:

New electricity production capacities may be connected to the grid under the terms and conditions of the grid connection permit, aviz tehnic de racordare (ATR). The connection to the grid of new generation facilities is regulated by The National Energy Regulatory Authority (ANRE) Order no. 59/2013, approving the regulation on connection of users to electricity networks in the public interest (Order 59).[62] This order regulates a procedure for the connection to the public power grid of the new capacities:

- Preliminary request for information (optional): The applicant can request that the grid operator (transmission or distribution operator) provide information regarding the conditions to connect to the power grid. The grid operator must provide general information regarding the necessity of a location notice, general options for the grid connection, the steps and estimate duration of the grid connection process, the requested documents, and the costs of the procedure.
- The request for the grid connection: The request regarding the connection to the public grid shall be submitted to the:
  - Distribution operators acting in the respective geographical area or other owners of electricity networks of public interest, if the electricity produced is less than 50 MW; or
  - The transmission and system operator if the electricity produced exceeds 50 MW. The request must contain the applicant information and technical details about the project and must be submitted together with several documents, including the Urbanism certificate (UC),

the location of the energy unit, the title over the land (e.g. property title, right of use, lease agreement).

- The connection solution: The grid operator determines the connection solution based either on:
  - A solution study (studiu de solutie). Assesses two connection options and is drafted for capacities that will be connected to a grid with a nominal voltage of 110 kV or higher; or
  - A solution report (fisa de solutie). Assesses one connection option to the grid and is drafted for capacities under 30 kVA.

- ATR: The ATR includes the connection solution and represents the offer of the grid operator to the request for connection submitted by the applicant. The ATR is issued by the grid operator in accordance with the approved solution study and contains all the technical and economic conditions for the connection to the grid. If the ATR requires network consolidation works upstream of the connection point, the user has to provide the grid operator with a financial security, as indicated in the ATR (up to 20% of the value of the respective works, although it is typically set as a percentage of the ATR tariff, which in practice ranges from 5% to 10%). This must be provided within 12 months from the issue date of the ATR, to ensure that the ATR is valid beyond the 12 months period. In principle, the ATR is valid until the date of issue of the grid connection certificate agreed through the ATR.
- Grid connection agreement: Upon receipt of ATR, applicants may require the relevant grid operator to execute the grid connection agreement, subject to the submission by the applicant of the documents indicated in the Order 59, including ATR, written approvals of the owners of the land affected by the execution of the connection works, and Trade Registry excerpt regarding the applicant. The grid operator is compelled to submit to the applicant the draft grid connection agreement within 5 business days from submission of the indicated documents.
- Connection to the grid: After the grid connection agreement has been concluded, the grid operator is obliged to find solutions to all tasks related to the connection of the project and implement them in accordance with the terms set out in the agreement, including:

  1. Design to the connection point;
  2. Obtaining consent/authorization for the execution of the connection installation;
  3. Build, acceptance and commissioning the connection installation;
  4. Necessary reinforcement works in the installations upstream of the connection point in order to fulfil all the technical conditions for ensuring the capacity of the electricity network to supply/prevail the power approved by the technical connection permit, at the quality parameters corresponding to the standards in force; and
  5. Energize the user installation.

The grid operator is obliged to submit the certificate of grid connection to the user after the grid connection installation has been commissioned. The certificate of grid connection specifies the technical requirements the project has to fulfil when being connected to the grid and which are outlined by law. The grid operator is obliged to connect the project to the grid after issuing the certificate of grid connection and after the grid user concludes the contract on transport, distribution and/or delivery of electricity.

OSW project connections, which may be at a scale of 1 GW or more, are likely to require significant transmission network upgrades that need to be planned and delivered over a few years. The ATR process can be used for OSW, but timing and risk management need to be considered. As discussed in Section 18, due to the high capital cost and long lead time to construct and OSW project, robust terms are needed in the grid connection agreement, with compensation for the developer if reinforcement is delayed. Likewise, a developer should be held to account for timely delivery of the wind farm.

15.8 INTEGRATION OF OFFSHORE WIND IN THE TWO SCENARIOS

With current plans and network management rules, Transelectrica suggests that 3 GW of additional wind capacity could be added in the region of Dobrogea, or off the coast, by 2030. Beyond this, further upgrades would be required. It is likely that 3 GW of additional onshore wind capacity will be added in this timeframe, requiring new plans for OSW. Softening of the network management rules, by not modelling such extreme scenarios but in turn using more sophisticated models, is likely to enable integration of more capacity, but not up to 7 GW. In general, with higher capacity factors than onshore wind and solar, OSW is considered closer to baseload generation. Continually improving wind forecasting also eases management.

Upgrading the part of the 400 kV loop from western Muntenia to Bucharest will be key for the transfer of large volumes of energy from OSW to the location of greatest demand. Also critical would be a link from Dobrogea, home of much of Romania's existing wind and nuclear capacity into this loop. Relevant also are the plans for international interconnects discussed in Section 15.4 that could progress in relevant timescales.

A pipeline of OSW projects can be more helpful in facilitating strategic transmission network upgrades than onshore renewables, as projects have larger scale and longer (7-10 year) development timescales.

The planning and financing of transmission network upgrades will be critical as they typically can take more than ten years to plan, design and implement but will allow the connection of OSW projects and is therefore a key recommendation for this study.

Project developers seek clarity regarding transmission network upgrade plans and transparency and rational risk and cost sharing regarding grid connection agreements. Other countries manage this through clear responsibilities and robust processes agreed with relevant stakeholders, including OSW project developers. See World Bank Group's *Key Factors* report for good practice.[9]

Depending on the scale and eventual locations of projects, the development of international interconnects and export options cost analysis, it may be advantageous to use either a radial or an offshore hub model. Early assessment of options is needed, so that agreements with developers can be made in parallel with site exploration, enabling construction in time for first generation from OSW projects.

15.9 RECOMMENDATIONS

Based on this analysis, it is recommended that:

- Transelectrica develops a 2050 vision for a nationwide electricity transmission network for a decarbonized energy system, with milestone plans for 2030 and 2040 and consideration of finance. This is a topic much wider than OSW, considering all electricity, transport and heat, and should include viability of subsea between Ukraine, Romania, Bulgaria and Türkiye and also with Azerbaijan, providing balancing between the relevant states. Transelectrica incorporates Ministry of Energy's (MOE)'s OSW development vision into its next ten-year plan, published in 2024, and considers offshore hubs and the potential impact of international interconnects so that timely export and transmission solutions can be delivered.

- Transelectrica undertakes power systems studies to understand the potential impacts of large volumes OSW on the future transmission network and ESIAs in line with good international industry practice (GIIP) and lender requirements to understand the environmental and social implications of transmission network upgrades, feeding these into marine spatial planning activities.
- Transelectrica, MOE, distribution system operators (DSOs) and other relevant balancing parties agree a softening of the network management rules to better reflect the probabilistic nature of variable output renewables, including OSW, whilst remaining with EU regulations.
- ANRE amends the template grid connection agreement (and any auxiliary regulations) to incorporate compensation terms in the grid connection agreement to apply if transmission network reinforcement is delayed and this impacts export of energy.
- Transelectrica, potentially with WBG support, considers low cost solutions for the financing of transmission upgrades and the use of concessional finance.

16. HYDROGEN

16.1 PURPOSE

In this work package, we explore the role of offshore wind (OSW) as a basis for producing hydrogen (or other derivatives), the levelized cost of hydrogen (LCOH) manufactured this way and how hydrogen from OSW could contribute to the national strategy. The ability to store significant volumes of energy as hydrogen (or derivatives) is a potentially significant enabler for increased offshore wind production in Romania and other markets.

It is likely hydrogen, whether from Romanian OSW or elsewhere, will be a small but significant part of the energy mix in Romania, with its use focused on hard to abate areas, such as industrial steel production and as feedstock for industrial processes. Green steel, manufactured by using green hydrogen rather than coking coal, will become the norm over the next 10 to 15 years, and Romania's steel making capability will need to convert.[xxvii]

16.2 METHOD

The LCOH from electrolysis is sensitive to the costs of electricity. To provide comparison with competing technologies, it is assumed that electrolyzers are linked directly to OSW projects, not receiving any power from the transmission network.

Hydrogen could be produced at individual wind turbines, centrally at the offshore substation, close to the grid connection point, close to a large demand or elsewhere on the transmission network. We anticipate that the most economically attractive location will be close to the grid connection point.

It is assumed that Proton Exchange Membrane (PEM) electrolyzers are used in all cases, due to their ability to ramp up and down production quickly in response to changing output from OSW.

The LCOH depends on three key factors:

- The LCOE of the electricity used;
- The cost of the hydrogen infrastructure including:
    - DEVEX;
    - Electrolysis stacks;
    - Compression and balance of plant;
    - Commissioning and installation ;
    - Operational and maintenance costs, and
    - Decommissioning.; and
- The capacity factor of the hydrogen plant (average output compared to maximum output).

xxvii. Green hydrogen is defined as having been produced from low carbon renewable energy sources. Grey hydrogen is defined as having been produced from natural gas, or methane, typically through a steam reforming. Blue hydrogen is defined as having been produced through a process where the carbon generated is captured and stored through industrial carbon capture and storage (CCS).

The LCOE for the input electricity from OSW for projects installed in different years is taken from Table 7.2. Each cost element listed above is modeled with cost reductions over time due to the global learning rate in hydrogen manufacture. We have looked at two cases:

A. Rated input power of the hydrogen plant matches the rated output of the wind farm and that the primary use of the electricity from the wind farm is for producing green hydrogen.

B. Rated input power of the hydrogen plant is much lower than the rated output of the wind farm. Priority is given to power the electrolyzers, then additional power is fed into the transmission network. This means that the electrolyzers can run at (say) 90% capacity factor.

Two other cases may be relevant:

C. Power from the transmission network is used to keep the hydrogen plant at full capacity, whenever OSW output is insufficient. Depending on the origin of that energy, this would mean that the hydrogen would no longer be green. In this case, LCOH would be lower but the amount depends on the pricing dynamic of the wholesale market.

D. Smaller electrolyzers could be placed in conjunction with wind farms to make use only of energy that otherwise would be curtailed, but this would result in lower utilization. LCOH would again depend on the pricing dynamic and operation of the wholesale market.

We have not considered storage and transport of hydrogen, with the presented cost covering the cost of hydrogen production only.

16.3 RESULTS

Table 16.1 shows the Indicative levelized cost of green hydrogen generated solely from OSW for Case A, such that when wind is low, the electrolyzers are not at full capacity. Table 16.2 is for Case B, where the rated output of the electrolyzers is lower, so although they are still only using energy from OSW, their capacity factor will be higher. In case B, LCOH is approximately 15% lower.

TABLE 16.1 INDICATIVE LEVELIZED COST OF GREEN HYDROGEN GENERATED SOLELY FROM OFFSHORE WIND

Year of installation	From OSW in Romania low growth scenario (€/kg)	From OSW in Romania high growth scenario (€/kg)	From OSW in established market (€/kg)
2029	5.5		4.0
2032	4.9	4.7	3.5
2035	4.4	4.1	3.2

TABLE 16.2 INDICATIVE LEVELIZED COST OF GREEN HYDROGEN GENERATED SOLELY FROM OFFSHORE WIND WITH A CAPACITY FACTOR OF 90%

Year of installation	From OSW in Romania low growth scenario (€/kg)	From OSW in Romania high growth scenario (€/kg)	From OSW in established market (€/kg)
2029	4.8		3.5
2032	4.2	4.0	3.5
2035	3.8	3.4	2.8

16.4 HYDROGEN POLICY IN ROMANIA

Romania has a national hydrogen strategy in preparation for publication in 2023. A range of national and European documents refer to hydrogen:

- The *National Resilience and Recovery Plan* contains a plan to deliver a new gas distribution network in the Otlenia region, able to carry 20% hydrogen on upon its construction in 2026 and with plans to be converted to use 100% green hydrogen in 2030.[7]
- The *National Resilience and Recovery Plan* sets a target of electrolyzers with a total capacity of 100 MW by end of 2025.[7]
- *Recommendations for Romania's Long-Term Strategy: Pathways to climate neutralit",* published by EPG in 2022, modelled future energy scenarios for Romania and found that under 10% of final energy demand in all scenarios comes from the direct use of hydrogen.[63]
- The European Commission's 2020 Hydrogen Strategy sets targets of 6 GW of installed capacity of electrolysis by 2024 and 40 GW by 2030 across Europe.[64]

The European Commission has approved a €149 million Romanian scheme to support renewable hydrogen production under the Recovery and Resilience Facility.[65] There are two key uses for hydrogen produced in Romania:

- Decarbonizing hard to decarbonize sectors:
  - Hydrogen can be used in industrial processes as a feedstock, high heat applications such as direct reduced iron (DRI) steelmaking and large transport applications such as freight and aviation.
    - The Dobruja region is of particular interest for a domestic hydrogen cluster due to:
      - Proximity to OSW areas and significant onshore renewable energy development;
      - Existing demand for hydrogen from steel production plants and refineries; and
      - Proximity to the port of Constanța for construction, supply chain and as a potential route to hydrogen export. [66]
- Export into a future cross border hydrogen market:
  - Romania is part of two EU-wide planned hydrogen projects, under Article 34(1) of Regulation (EU) 2019/943, which covers a 10 year plan for coordinated energy network development at an EU level.[67]
    - HI East. Priority corridor no. 10 for hydrogen and electrolyzers: Central and South-East European Hydrogen Interconnections. This targets Bulgaria, Czechia, Germany, Greece, Croatia, Italy, Cyprus, Hungary, Austria, Poland, Romania, Slovakia and Slovenia and aims to deliver a hydrogen backbone network to interconnect these countries and reconfigure existing network infrastructure to be suitable for hydrogen transmission.
    - SE offshore. Aims to support the development of offshore electricity networks infrastructure, interconnection and hydrogen infrastructure in the Mediterranean and Black Sea, with a specific focus on offshore renewables and storage. This project targets Bulgaria, Croatia, Greece, Italy, Cyprus, Romania and Slovenia.

16.5 DISCUSSION

Hydrogen produced by OSW will need to compete directly with hydrogen produced by other generation sources, such as onshore wind and solar, as well as blue hydrogen, made from steam methane reformation with carbon capture.

Wider interconnection of energy systems within Europe and a developing pathway towards cross border hydrogen trading creates further competition for domestic hydrogen, although export opportunities also exist, it is likely that neighboring countries will have a lower LCOH.

Based on the above, hydrogen production from OSW alone is unlikely to be cost competitive with a similar situation in established OSW markets or compared to hydrogen production from other renewable sources in locations with excellent resource and sufficient alternative power to keep the hydrogen plant at a high capacity factor.

A domestic source of hydrogen could be important, however, should international supply be limited at any time.

16.6 RECOMMENDATIONS

Based on this analysis, it is recommended that:

- The Ministry of Energy (MOE) finalizes and publishes domestic hydrogen policy to give clarity to industry, OSW project developers and other hydrogen industry stakeholders. This includes hydrogen as a storage solution to enable a greater share of variable renewable energy sources in the Romanian electricity mix.
- The MOE encourages coordination between Transelectrica, Transgas, and other stakeholders to create legislation, regulations, standards, tariffs, transport, storage, import, export and trading arrangements for hydrogen.
- The MOE explores how LCOH and interconnection policy in other nearby countries will impact the requirements for domestic hydrogen production.
- The MOE supports international efforts to establish a certification of origin framework for green hydrogen to allow meaningful competition with blue and gray hydrogen markets.
- The MOE investigates small scale green hydrogen production as a flexible load that can be utilized to absorb intermittent renewable generation from a range of sources, not just OSW.

17. PORT INFRASTRUCTURE

17.1 PURPOSE

In this work package, we assess Romania's port infrastructure against offshore wind (OSW) industry requirements.

We focus on conventional fixed OSW supply chain needs and focus on ports to support coastal manufacturing and construction. In general terms, there are a limited number of available ports in Romania, and the main port focused on in this roadmap is Constanța, including the Mangalia and Midia area.

Ports that support project operation over the 25 or more years of generation typically have much lower requirements and any investment is easier to justify over the long operating life of an OSW project.

We look at the Romanian port capabilities and gaps and provide recommendations how best to address potential bottlenecks. This is important as good ports are critical for safe and efficient construction of OSW projects.

17.2 METHOD

We started by establishing port requirements for construction of conventional fixed OSW looking towards 2035. As the industry continues to develop quickly, a 15-year horizon for investment in ports is a reasonable timescale.

We then used team and stakeholder knowledge, including from local contractors, to assess existing ports in locations relevant to OSW, categorizing ports as:

- Suitable with little or minor upgrades (cost less than €5 million);
- Suitable with moderate upgrades (cost between €5 million and €50 million); or
- Suitable only with major upgrades (cost greater than €50 million).

We then shared this assessment with key stakeholders and gathered feedback and additional data.

A map of manufacturing and construction ports relevant to OSW is provided in Figure 17.1.

17.3 PORTS OVERVIEW

Romanian ports play an important role as a portal for imports and exports around the Black Sea and through the Bosphorus Strait. There are sea ports on the river Danube, the Danube-Black Sea canal and on the Black Sea itself, to the south of the Danube wetlands.

Danube ports relevant to manufacturing include Galați (where shipbuilder Damen and steel supplier Mittal have large facilities) and Tulcea (where shipbuilder STX Europe has facilities).

Black Sea ports include Constanța (the largest port on the Black Sea) with a total quay length of 30 km, and its satellite ports, Mangalia (to the south; mainly used for shipbuilding) and Midia (to the north, mainly used for crude oil).

The Bosphorus Strait is a 30 km waterway that narrows to about 700 m. With high traffic volumes and significant currents and two significant changes of direction at narrow points, it has an air draft limit of 58 m, which is typically too low to permit the transit of large wind turbine installation vessels with legs raised in the normal transit position. Given the reasonable water depths at the bridges, it may be possible to partially submerge the jack-up legs. Water depth maps suggest that vessels with legs of less than 100 m in length could physically transit, but local marine authorities would need to be consulted. This access restriction would likely exclude new-build jack-up vessel which have legs in excess of 120 m, but older vessels (retrofitted with cranes capable of lifting next generation turbines) could be used. Mobilizing such vessels to the Black Sea could come at a high cost, which we have included in our levelized cost of energy estimates. We have not limited the size of turbines that can be used in Romania, however.

The new Istanbul Canal provides another option to access the Black Sea from about 2027. It will have similar air draft restriction as the Bosphorus Strait, however, and does not have adequate water depth for partial submersion of the jack-up legs.

17.3.1 Location of potential OSW suppliers

It is possible that wind turbine foundations will be manufactured in Romania, including using Romanian-manufactured steel. Likewise, offshore substation topsides could be fabricated and assembled with electrical components. Separately, Romanian shipbuilders may be used for vessel manufacture, but this may not necessarily be aligned with Romanian OSW projects.

Due to the relatively small scale of the Romanian OSW market, it is unlikely that any wind turbine blade manufacture or nacelle assembly will be established locally. Both have complex supply chains and high investment barriers, and need a larger pipeline of projects to justify investment than even the high growth scenario provides. Likewise, it is unlikely that new subsea cable facilities will be established in Romania unless a large Black Sea market for such power cables (also for interconnectors) establishes, as existing suppliers typically seek to extend facilities rather than establish new. The above activities could be based in Black Sea or Danube-based facilities.

17.3.2 Operation ports

Ports that support project operation over the 25 or more years of generation typically have much lower requirements and any investment is easier to justify over the long operating life of an OSW project. Many wind farms to date have used crew transfer vessels (CTVs) to transfer crews from shore to turbines each day, with vessels being about 25 m in length and capable of hosting a crew of 10-20. CTVs are designed to move personnel and small quantities of cargo safely and efficiently between the wind farm and port and will berth in port following each shift. CTVs are limited in their capabilities and operating conditions, but modern CTVs have walk-to-work systems allowing for turbine access in harsher weather conditions. CTVs can service wind farms up to 50 km from shore. As the industry has matured and wind farms are often located further from shore, service operation vessels (SOVs) have been used more. SOVs are about 90 m in length and can host a crew of 80-140. Being significantly larger than CTVs, SOVs enable crews to live at sea for 2 weeks at a time and provide walk-to-work access to turbines, improving the utilization of technicians by reduced time spent transiting between port and site. While SOVs require larger berths in ports, they will spend far less time in port overall. In Romania, where projects are likely to be located between 50 and 100 km from shore, either operational strategy may be used.

- A port to support CTV operation needs about 3 ha of onshore space for the O&M base, storage facilities, and car park. There must be berthing space for 2-3 CTVs of length 25 m with a draft of 4 m. The port must have an entrance width of at least 12 m. A port to support CTV operation is typically the closest such port to the site.
- A port to support SOV operation needs equal onshore requirements to a CTV port. It must be able to berth at least one SOV of length 90 m with a draft of 8 m. The port must have an entrance width of at least 18 m. A port supporting SOV operation can be further from site, as the vessel only visits every 2 weeks or so.

17.4 CONSTRUCTION AND MANUFACTURING ASSESSMENT CRITERIA

The criteria used to assess both construction and manufacturing ports are defined in this section and are summarized in Table 17.1.

Construction ports must accommodate the delivery of materials, foundations and storage space for components. These ports must be capable of facilitating full or partial assembly of turbines and foundations prior to load out and transport to the wind farm site. Load out of components normally occurs in batches of four or more turbines or foundations at a time, depending on the capacity of the vessel used.

The main difference between construction and manufacturing port requirements is space. Manufacturing facilities require large areas for warehouses and storage space for components before onward transportation. In some cases, manufacturing ports may facilitate construction activities through co-location or clustering. The feasibility of this solution depends on storage space and quayside access constraints, ensuring each process can continue simultaneously without hinderance.

17.4.1 Manufacturing port requirements

As discussed in Section 8, it is likely that projects will use monopile foundations for turbines which could be manufactured in Romania. The minimum space required for a monopile foundation manufacturing yard to serve 400 MW per year is approximately 15 ha. 30 ha is needed to deliver up to 1 GW annually. A similar amount of space is required for jacket foundations for turbines. In Table 17.1 we have specified a range of 20 to 30 ha of space for a quayside manufacturing port catering for at least one component.

Offshore substations (OSSs) tend to be large but are often built as single units or two units at a time and require about 6-8 ha. Substations use less serial manufacturing processes, so are more similar to one-off oil and gas fabrications.

17.4.2 Construction port requirements

Construction ports will often receive components in batches which are temporarily stored before load-out for installation. The minimum storage space for a construction port is specified as 13 ha. For larger-scale projects, up to 20 ha may be required.

Quay length requirement is between 350 and 400 m, which will accommodate up to two mid-sized installation vessels or feeder barges. The channel is required to be 60 m wide and 10-12 m deep to permit access of installation vessels. Above-water clearance may need to be more than 60 m to allow for overhang of blades and other components in a horizontal configuration.

Quaysides need bearing capacities of up to 50 metric tons/m² for load-out to adjacent vessels while storage areas need a capacity of at least 25 metric tons/m².

Quayside cranes can be used to lift turbine components and foundations in port areas. Suitable cranes have capacities between 500 and 1,000 metric tons for turbine components and between 1,400 and 2,200 metric tons for medium to large monopiles. Lifting is often completed by installation vessels or temporary land-based cranes during load-out, so the importance of this criteria has been reduced in our analysis. Self-propelled modular transports (SPMTs) facilitate the onshore transport of cargo between storage and quayside areas. Mobile and crawler cranes are also used for materials handling but as ports can temporarily hire this equipment, weightings were applied to reduce the significance of this criteria.

Ports also need workshop areas, personnel facilities and good onshore transport links, which are included in Table 17.1 under 'other facilities'.

TABLE 17.1 CRITERIA FOR ASSESSING ROMANIAN PORT CAPABILITIES

Port criterion	Value
Storage space (ha)	13-20 for marshalling and preassembly 20-30 for manufacturing, per facility
Quay length (m)	350-400
Quayside bearing capacity (metric tons /m2)	50
Storage area bearing capacity (metric tons /m2)	25
Channel depth (m)	10-12
Channel width (m)	60
Crane capacity – turbine components (metric tons)*	500-1,000
Crane Capacity – foundations (metric tons)*	1,400 – 2,200
Overhead Clearance (m)	140
Other facilities	Workshops, skilled workforce, personnel facilities, road and rail links

Note: *Lifting capacities may be provided by vessel cranes during load out.

17.5 RESULTS

We assessed five potential ports. A summary is provided in Table 17.2 in order of relevance. Note that assessment is only against criteria – it does not consider availability or commercial considerations. A map of the port locations is provided in Figure 17.1.

We found that Port of Constanța is best suited for both construction and manufacturing activities, with many terminals that meet the above requirements. The channel entrance is more than adequate at approximately 200 m, and the cruise terminal has a depth of 13.5 m, making it suitable for berthing installation vessels. Minimal investment will likely be required, although the bearing capacity of the relevant quays may need to be increased to support both construction and manufacturing activities.

We consider the Port of Constanța – Mangalia area (Mangalia) to be the next best option, assuming the existing Damen shipyard can be repurposed for OSW. The shipyard covers about 70 ha and has about 1 km of berthing space. The channel entrance is over 100 m wide, however, the depth of the berths is only 9 m, meaning dredging would be required to make suitable for larger installation vessels.

Of the considered ports, the Port of Constanța – Midia area (Midia) was the least suitable option. The existing petrochemical area is about 170 ha, and the adjacent marine terminal is about 18 ha, which is adequate for construction but likely not enough for manufacturing. Both areas have berthing space for two installation vessels. The port entrance is about 150 m wide, however, the entrance depth is stated to be only 5.6 m. With over 2 km from port entrance to quayside, significant dredging would be required to permit access for installation vessels.

Manufacturing may best be suited to an inland port on the Danube where much of the country's steel manufacturing is located. Two such ports are Galatia and Tulcea. Galati is the second largest port in Romania, and the largest on the Danube, but it currently only has about 4 ha of open area which is insufficient for new tower or foundation manufacturing. There are large brownfield areas around the port that would need to be redeveloped to permit manufacturing, such as the 80 ha space adjacent to the New Basin Terminal. The minimum water depth between Galati and the Black Sea is about 7 m, making Danube ports unsuitable for hosting construction so barges would likely be used to transport the manufactured components to a Black Sea port such as Constanța. The Port of Tulcea has similar limitations to Galati but with even less available area – the port area is about 10% that of Galati and has only 1 ha of available open space. There is an adjacent greenfield area that would need to be redeveloped if the port is top host manufacturing activities, but this area is not controlled by the port.

At this stage, we have not assessed port availability and interest in OSW. Any potential port facility upgrades or expansions would require full environmental and social impact assessment (ESIA).

TABLE 17.2 PORT ASSESSMENT SUMMARY

Port	Suitability for construction	Suitability for manufacturing	Comments, including on potential upgrades
Constanța	Suitable for construction	Suitable for manufacturing	Likely requires little to no upgrades to be used for construction or manufacturing, assuming the suitable terminals are commercially available, other than an improved bearing capacity. This makes is Constanța preferable from an environmental perspective.
Mangalia	Suitable for construction after minor investment	Suitable for manufacturing after minor investment	Likely requires some dredging of the channel between berths and open sea, assuming the existing Damen shipyard can be repurposed for OSW activities. Bearing capacity upgrades are also likely required. Note also that the Marine Protected Area and Special Protected Area Marea Neagră extends into the port area,
Midia	Suitable for construction after major investment	Suitable for manufacturing after major investment	Likely requires significant dredging to permit access to installation vessel. The existing petrochemical area would need to be repurposed if the port is to host component manufacturing. The marine terminal could be used for construction activities but available lay down area may be somewhat constrained. Bearing capacity upgrades are also likely required.

Port	Suitability for construction	Suitability for manufacturing	Comments, including on potential upgrades
Galati	Unsuitable for construction	Suitable for manufacturing after major investment	The water depth of the Danube eliminates the possibility of construction. Large areas of the port's brownfield land would need to be redeveloped, with suitable bearing capacity, to build new manufacturing facilities, though water depth at some times of year could still be an issue.
Tulcea	Unsuitable for construction	Unsuitable for manufacturing	The water depth of the Danube eliminates the possibility of construction. The port is too small and has no suitable areas to redevelop for new manufacturing facilities. It is also unsuitable from an environmental perspective as all traffic would have to pass through the Danube Delta.

FIGURE 17.1 POTENTIAL OFFSHORE WIND MANUFACTURING AND CONSTRUCTION PORTS IN ROMANIA

Source: BVG Associates.

17.6 DISCUSSION

Overall, Romania has good options for both construction and manufacturing on the Black Sea. The Port of Constanța is especially suitable for both activities, with minimal upgrades required aside from likely bearing capacity improvements. Constanța is large enough to host construction and multiple manufacturing facilities simultaneously which would simplify logistics during construction as components would not need to be double handled. Ports could potentially also be used for projects developed in Türkiye, Bulgaria and Ukraine.

While it may make sense to locate manufacturing near Romania's steel manufacturing industry in the Danube ports, neither port assessed has much available open space. Galati does have large brownfield areas that could be redeveloped for manufacturing facilities, from which components could be transported to a construction port on the Black Sea.

The ongoing situation in Ukraine is also a concern for OSW development in the Black Sea. In the short-term, Romanian ports are busier and the time before there is stability in the region is uncertain.

17.6.1 Low growth scenario

The anticipated pattern for installation of a commercial-scale OSW project in the low growth scenario is:

- Year 1: Local manufacture of offshore substation, installation of offshore substation and turbine foundations (imported) and installation of array cables and export system (imported and not being staged at port). This requires approximately 18 ha and 400 m quay length for a 1 GW project.
- Year 2: Local manufacture of 60% of towers, installation and commissioning of turbines (imported) and the start of operation. This requires approximately 26 ha and 400 m quay length for a 1 GW project.

This means that a port being used for installation of just one project only has to have space for each of these activities, separately, but a port being used for installation of projects in consecutive years has to have space for both of these activities, simultaneously (requiring approximately 44 ha and 400 m quay length for an installation rate of 1 GW per year). With multiple projects being executed in parallel, berthing space must be planned and utilized efficiently to ensure deliveries are not delayed and installation vessel operation is not interrupted.

In the low growth scenario shown in Section 2, Peak port demand is in 2033 (0.75 GW of foundations, substations, and cables, and 0.5 GW of turbines), and requires approximately 34 ha and 400 m quay length. This could be provided entirely by Constanța, or by a combination of Constanța and either the Mangalia or Midia area with additional investment. The use of multiple ports may require further space usage for extra handling / storage.

17.6.2 High growth scenario

The anticipated pattern for installation of a commercial-scale OSW project in the high growth scenario is:

- Year 1: Local manufacture of offshore substation and 60% of foundations, installation of offshore substation and turbine foundations and installation of array cables and export system (imported and not being staged at port). This requires approximately 26 ha and 400 m quay length for a 1.5 GW project.
- Year 2: Local manufacture of 60% of towers, installation and commissioning of turbines (imported) and the start of operation This requires approximately 32 ha and 400 m quay length for a 1.5 GW project.

In the high growth scenario, peak port demand is in 2035 (1.5 GW of foundations, substations, and cables, and 1.5 GW of turbines), and requires approximately 58 ha and 400 m quay length, although 600 m of quay length would reduce risk.

- Again, this could be provided entirely by Constanța, assuming such as large area could become commercially available for OSW construction, with the Mangalia and Midia area supplementing supply.
- Midia has the space to deploy the full 3 GW per year only if the existing petrochemical area can be repurposed.
- Using Mangalia or Midia to supplement supply would require additional investment compared to using Constanța, only.

17.7 RECOMMENDATIONS

Based on this analysis, it is recommended that:

- The Ministry of Energy (MOE) creates an inter-ministerial group with the Ministry of Finance, the Ministry of Economy and the Ministry of Transport and Infrastructure that creates and promotes a plan for port use for OSW manufacturing and construction, interfacing with current activity to develop the Naval Strategy. Consideration should be given to lead times for the upgrades to ensure suitable facilities are ready in time for project deployment. Activities to develop the plan include:
    - Engaging with relevant ports to determine interest and availability to deliver manufacturing and construction activities and identify the specific upgrades required to facilitate each activity.
    - Working with relevant ports and potential tower and foundation manufacturers (both Romanian and overseas) to explore the feasibility of local manufacture (for Romanian offshore and onshore wind markets and export), bringing in project developers if results are positive. For manufacture starting in 2027 (for a project to be completed in 2029), investment decisions would likely be required in 2025, most likely before revenue auction results.
    - Careful consideration should be given to environmental and social considerations and robust ESIA analysis for any potential developments.
- The MOE considers prioritizing investments through the Resilience and Recovery Fund, or similar, into port infrastructure and supply chain for OSW, in the context of the green transition and the commitments to build renewable energy.
- The MOE works with the Ministry of Transport and Infrastructure to encourage the publication of a simple OSW ports prospectus, showing port capabilities against physical OSW requirements, and use this to encourage dialogue with project developers.
- Project developers explore any transport restrictions when entering the Black Sea for likely future wind turbine installation vessels.

18. RISK AND BANKABILITY

18.1 PURPOSE

The purpose of this work package is to define project and market elements which impact the bankability of offshore wind (OSW) projects in Romania. Our focus is the risks that have the potential for high commercial impact which may be perceived as a barrier by international or local investors.

We have considered a project developer's market risks associated with construction, commencement of commercial operations, and generation of revenue. Project risk relating to supply and technology are important, but not directly relevant to this roadmap. Broader financial market risks are addressed in Section 19. Risks to the Government are covered in the SWOT analyses in Sections 3 and 4.

18.2 METHOD

Developing an OSW project involves different risks and considerations to onshore wind and solar project development. There are however benefits in taking elements of onshore renewables frameworks as a basis for the OSW frameworks, where relevant.

We have looked at specific activities or commercial arrangements that have the greatest potential for impact to future cash flows of a project, for example, local grid capacity and skills level of local labor force for OSW.

We have assumed that a new OSW law is put in place, in line with Section 13.

Throughout, our guiding principle has been that risk should be placed where it can be best managed. There are some risks, such as higher than expected operating costs, which investors should bear as they are well placed to manage them. If risks are placed with investors that are outside of their control, such as regulatory or policy risks, they will require an increased rate of return for bearing them. In the limit, they will decide not to invest and to allocate their capital to other international investment opportunities. As a result, in some cases it can be more efficient for these risks to be placed on the Government or directly on customers, as this will result in a lower cost to customers than the cost of paying investors to bear them.

We have suggested changes where we have found that the existing regime may allocate risks inappropriately in a way which may create a barrier to the rollout of OSW.

Each of the risks identified has been assigned a risk magnitude (considering likelihood and impact of risk) based on the following scale:

- *Red.* Significant financial risk to investors that is likely to stop investment happening, requiring mitigation from the Government.

- *Amber.* Moderate financial risk to investors that will have significant cost or contractual implications and may need mitigation from the Government.
- *Green.* Low-level financial risk is not likely to stop investment, the Government may consider mitigation.

18.3 RESULTS

The main financial risks for OSW in Romania are summarized in Table 18.1 and then discussed, alongside possible mitigations for the Government to consider. See also Chapters 3 and 4.5 of the *Key Factors* report.[9]

TABLE 18.1 GENERAL OFFSHORE WIND INVESTMENT RISKS

Risk	Description	Project phase	Risk magnitude RAG	Suggested Government mitigation / measures
1. Development risks prior to exploration license	Developers carry low risk in bidding for an exploration license	Project development	G	Government can increase appetite for bidding by: Establishing clear and investor-friendly legal frameworks; and Giving clarity about long-term vision for OSW volume in Romania and showing clear plan for delivery of first projects.
2. Development risks with exploration license	Developers carry the risk of finding that the site is not viable or the Government deciding not to auction it or losing it in the offtake auction. The proposed OSW law is not yet in place and has not been tested. A change of leadership may lead to a change in policy towards OSW.	Project development	A	Good spatial planning and strategic environmental assessment will reduce risk of finding that the site is not viable. A full alignment between all government stakeholders should be in place to ensure there are no unexpected hurdles or non-unitary interpretations of the legislation, especially relating to the permitting process. Clarity about OSW plans will increase confidence in Government auctioning sites. Government compensation in this case should be written into exploration license terms. The developer is reimbursed if it loses the auction, but this does not compensate for opportunity value of effort. This could be mitigated by a small scoring advantage in the auction, but at the risk of decreasing competition from those without exploration license. Good Government-industry engagement regarding draft law will increase confidence in its suitability.

Risk	Description	Project phase	Risk magnitude RAG	Suggested Government mitigation / measures
2. Development risks with exploration license (cont.)			A	Cross-party commitment within parliament to long-term development of OSW will increase industry confidence in long-term policy continuity, including through changes in government.
3. Environmental and social risks	Potential environmental and social risks leading to permitting challenges and construction delays.	Project development/ Construction	A	Need to take account of stakeholder views and follow Good International Industry Practice (GIIP) in selecting sites and providing permits.
4. Grid connection risks	A mismatch between the timing required by Transelectrica to reinforce the transmission network to the grid connection point and the OSW developer's project timetable could lead to delay in grid connection being available.	Construction	R	Need robust terms in grid connection agreement, with compensation for the developer if reinforcement is delayed, due to the high capital cost and long lead time to construct the OSW project. Likewise, a developer should be held to account on timely delivery of the wind farm.
5. Curtailment risks	Limitations in transmission network strength and grid management, or excess supply of electricity compared to demand could result in the curtailment of OSW and impact project revenues. As the proportion of variable renewable energy generation increases, this is likely to become more of a consideration, as seen in other markets.	Operation	A	Currently, there is no curtailment compensation, and to date, it does not seem to have been a significant consideration. Transelectrica manages curtailment decisions. As the proportion of variable renewable energy increases, it is suggested that curtailment compensation will need to be written into relevant contracts.
6. Counterparty risks	High volumes of OSW could challenge the creditworthiness of Transelectrica.	Operation	A	Government backstops offtaker obligations for multiple GW-scale projects, if needed.[xxviii] In case of strategic investments, the Romanian Government may decide to provide government guarantees or further support. For example, the Ministry of Finance is guaranteeing the financing scheme for Nuclearelectrica for Cernavodă Units 3 and 4, with approval from the European Commission.

xxviii. The risk that needs to be mitigated relates to certainty of income for electricity generated. It may be that risks are already sufficiently mitigated to satisfy international investors via electricity contracts and CfD, but this should be confirmed.

Risk	Description	Project phase	Risk magnitude RAG	Suggested Government mitigation / measures
7. Policy / regulatory risks	Changes in government could jeopardize long-term power contracts.	Operation	G	Contract for difference (CfD) contracts with OpCom will be covered by private law, so are not dependent on policy or regulation.
8. Exchange rate and inflation risks	Adverse movements in Leu relative to € could lead to reduced foreign investor appetite.	Operation	G	Romania is likely to have joined the Eurozone before main CAPEX committed on first project(s). Although CAPEX is the major contribution to levelized cost of energy, OPEX and energy prices will increase in nominal terms. it will be important to ensure suitable indexation of revenue: Between revenue setting at competition and CAPEX setting at financial investment decision[xxix] During operation.
9. Country risks	Local conditions stemming from the Romania political, economic and legal framework could impact focus on OSW and the stability of the industry and project earnings.	Project lifecycle	A	Enforceability of contracts, both with government and suppliers, is key, with access to international arbitration essential. The stability and predictability of the legal, regulatory and fiscal regime is paramount for developing long term projects such as OSW. Stability clauses in OSW concession agreements should be considered, to address such risk, over the project lifecycle, as well as minimizing unnecessary changes within agencies, regulation and national initiatives.[xxx]
10. Regional security risks	Risks due to the current Russia/Ukraine conflict.	Project lifecycle	R	Support actions to end conflict and address unexploded ordinance and other associated risks.

18.4 DISCUSSION

Many of the investment risks discussed do need to be addressed in order to make the market sufficiently attractive for investors, because the overall market size is not that large. This leads to a range of recommendations that are incorporated into Section 5.

Based on this analysis, it is recommended that:

- The MOE introduces a new, clear and investor-friendly OSW law and associated regulation relating to OSW frameworks, involving other public stakeholders, as required.

xxix. This has become a greater consideration in recent times due to increases in commodity prices (such as steel and transport) that have been far higher than general inflation – see Section 7 for more details. Ireland (for example), incorporated indexation in its recent ORESS1 auction – see https://assets.gov.ie/239377/556f7efc-b401-40d8-b1d8-bc8785527286.pdf.

xxx. Stability clauses are to protect the terms of long-term, capital-intensive investments against non-commercial changes to the investment environment – for example changes of government. OSW projects are an example of such investments, with operating contracts over 20 years or more.

- The MOE agrees with other relevant Government departments, to define inter-departmental cooperation and alignment on OSW, covering leasing, permitting, offtake, transmission and health and safety frameworks, and key areas of delivery including supply chain and finance, to ensure there are no unexpected hurdles or non-unitary interpretations of legislation or frameworks.
- The MOE establishes a long-term Government-industry forum[xxxi] involving local and international project developers and key suppliers, to work together to address the new OSW law, the recommendations throughout the roadmap and other considerations, as they arise.
- The MOE, working with the Government General Secretariat, drives stability and predictability of the legal and fiscal regime, including stability clauses in OSW concession agreements.
- The National Energy Regulatory Authority (ANRE) amends the template grid connection agreement (and any auxiliary regulations) to incorporate compensation terms in the grid connection agreement to apply if transmission network reinforcement is delayed and this impacts export of energy.
- The MOE ensures curtailment compensation and indexation is in relevant contracts.
- The Ministry of Finance considers whether to signal its commitment to backstop offtaker obligations for multiple GW-scale projects, if needed.
- The MOE works with others to ensure enforceability of contracts, both with Government and suppliers.

xxxi. For example, UK's Offshore Wind Industry Council (OWIC) – see www.owic.org.uk for details of membership and work.

19. FINANCE

19.1 PURPOSE

The cost of finance is among the key drivers of the economic assessment of offshore wind (OSW) projects and as such has a significant impact on prices agreeable to developers under power purchase agreements (PPAs) and ultimately the cost to consumers. This section presents a high-level assessment of the potential role of broader public policy (including concessionary and climate finance) in the OSW rollout in Romania. It presents examples where public financial support has been used to enable other types of large infrastructure industries. It also considers the availability of local and international bank finance.

19.2 METHOD

We identified relevant financial instruments that could play an enabling role in the development of the Romanian OSW industry. We have also identified several case studies that show a successful path to utilizing public and concessionary financing relevant to OSW.

19.3 RESULTS

We discuss six categories of financial support relevant to minimizing cost of OSW to consumers, beyond equity provided by project owners:

- Enabling local and international bank lending;
- Tax and policy incentives;
- Multilateral lending;
- Credit enhancement mechanisms;
- Climate finance;
- Green debt instruments; and
- Green equity instruments.

19.3.1 Enabling local and international bank lending

Much debt finance in OSW globally has been provided by international banks. Enabling a competitive market for bank finance is a key way to minimize levelized cost of energy (LCOE). Over the last years, Romania has lost ground in attractiveness for renewable investments, for example Iin EY's Renewable Energy Country Attractiveness Index (RECAI). Romania dropped out of the top 40 countries in the RECAI in 2015 and has not yet returned. On the positive side, the country currently is ranking 28th in terms of PPA attractiveness.[68]

Regulatory background

Climate mitigation is an urgent priority for Romania. The country remains behind its EU peers in terms of air quality, the intensity of energy use, and waste management. Romania had the fifth highest GHG emissions intensity (emissions per GDP unit) among all EU countries in 2019.[69] From a global climate change perspective, the country ranks 49th globally in fossil CO_2 emissions, with over 78 million metric tons of CO_2 equivalent emitted annually.[70]

As part of the European Green Deal, the European Commission has set a target of reducing CO_2 emissions in the EU by 55% by 2030. The related Sustainable Finance Action Plan aims to incorporate environmental, social, and governance criteria into the European financial system to promote more eco-friendly investments and business models.

According to Romania's Integrated National Energy and Climate Plan for 2021–30 (NECP),[5] €150 billion will be needed to meet its nationally determined contribution (NDC) to climate change mitigation, especially in the renewable energy and energy consumption sectors and including buildings of all types. The lack of depth and diversification in the Romanian financial sector constrains its ability to mobilize capital to reach this climate action target. According to the National Bank of Romania (NBR), banks' green portfolio represents on average only 3 percent of the total banking loan portfolio.

Although the Government has committed in its National Resilience and Recovery Plan[7] (NRRP) to phase out all production from coal fired power plants by 2032 at the latest, natural gas has a significant role in the energy transition of Romania as a transition fuel in the NECP.

Local banks

Romania has a strong local banking market, which is highly connected to the European banking sector, not only through EU banking regulations but also ownership relations. Overseas banks currently hold approximately 68% of total banking assets. Eight out of the ten largest local banks in Romania in terms of total financial assets are part of leading European banking groups from Austria (Erste Group, Raiffeisen), France (Société Générale), The Netherlands (ING), Italy (UniCredit), Greece (Alpha Bank), Hungary (OTP) and Türkiye (Garanti). As such, strategic and operational decisions can be expected to be driven by their headquarters, in particular related to larger exposures. There are 34 banks in the market and the sector is relatively concentrated, with the five largest banks holding approx. 63% of the market share. The largest bank in the country is Banca Transilvania with a 20% market share.

Emerging from the pandemic, the banking system has maintained its strong capital, liquidity, and profitability position. The sector's asset quality has improved substantially with the non-performing loan (NPL) ratio falling to 3% of total loans as of June 2022, down from over 21% in 2014. Romania has the highest NPL coverage ratio in Europe at 70%, far exceeding the EU average of 44%. NPLs are likely to increase due to exposures to non-financial corporations with a higher concentration of trade to affected countries and second-round effects on households that are likely to suffer from a drop in real disposable incomes.

The sector's total capital adequacy ratio (CAR) was 21% as of June 2022, comfortably above the NBR's 8% target. In June 2022, return on average assets (ROAA) and return on average equity (ROAE) stood at about 1.45% and 16%, respectively, among the highest in the EU. The increasing cost of funding and pressure on asset quality may however impact the profitability of the banking sector in the near future.

Romanian banks together with their European holdings had historically been active in financing renewable energy projects starting with the first wave of onshore renewables during 2011 to 2015. The surge in new capacity was based on a supportive regulatory regime that included the issuance of green certificates over a period of 15 years as an incentive mechanism to make those projects attractive for investors.

A number of Romanian banks have implemented sustainability strategies and defined guidelines for their investments. Romania's largest bank, Banca Transilvania, has already implemented an exit strategy from fossil fuels and has no exposure to such sources of power generation[71] though other banks are not yet as advanced.

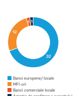
Two Multilateral Financing Institutions (MFIs), European Bank for Reconstruction and Development (EBRD) and World Bank Group's International Finance Corporation (IFC), kicked off the lending activity in the sector through jointly raising financing for the first utility scale renewable energy project in Romania through €188 million (excluding VAT financing) for the Cernavoda (138 MW) and Pestera (90 MW) onshore wind projects, sponsored by the Spanish investor EDPR. Three European commercial lenders – two of them with local banking units - joined this financing under a B-Loan umbrella.

Commercial lenders later continued financing with or without MFIs through either their European parents on larger projects, as shown in Table 19.1, or local units on smaller projects (many not published).

Long-term project finance on a non/limited recourse basis with tenors between 12 and 15 years represented almost all the financing transactions, in one instance a 12-year corporate loan with export credit coverage was put in place of €180 million to the utility client ENEL covered by the Danish Credit Export Agency, EKF.

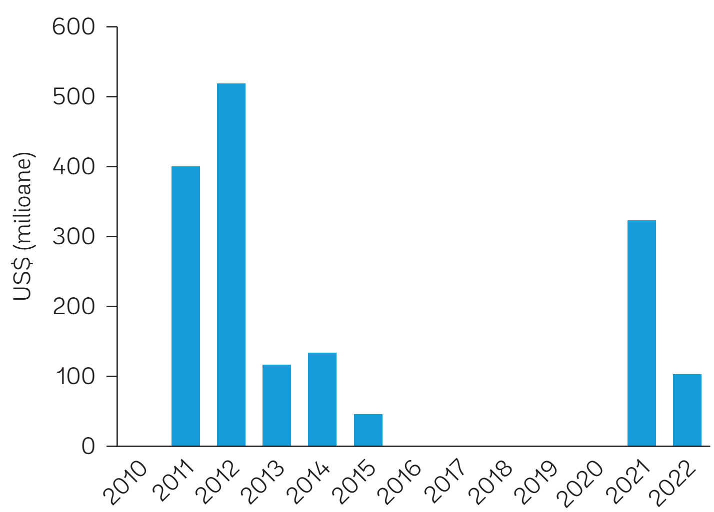
A series of adverse measures introduced by the government since 2013 with the aim at reducing the cost of electricity to the end-consumer brought the sector to a halt in 2015, as shown by financing activity shown in Figure 19.2.

FIGURE 19.1 ACCUMULATED NUMBER OF INVESTMENTS MADE BY EACH LENDER, 2010-2020



Source: Dealogic.

FIGURE 19.2 ONSHORE RENEWABLE FINANCING VOLUME ROMANIA, 2010-2022



Source: Dealogic.

Driven by increasing electricity prices, financing activity was revived in 2021, generated through M&A activities for brownfield renewable projects or portfolios. A second wave of financing greenfield renewable projects without support measures is expected to start in 2023. This is expected to be driven by high market prices for electricity and the increasing efforts of larger industrial offtakers to procure electricity over a longer term through commercial PPAs[xxxii].

All recorded financing transactions since 2011 are denominated in Euros given the integration of the Romanian energy market into the European markets as well as the price floor of the Green Certificates (as available for existing renewable generators) being indexed to Euros. This implicit currency hedge, together with low attractiveness of local currency financing due to higher levels of local interest rates led to limited demand for local currency funding for renewable projects.

On the supply side, (international) banks that do not have a funding base in local currency are facing constraints with raising Romanian Lei through hedges in the international derivative markets, which are related to liquidity (only small sizes of €20 to 30 million available for hedging without price impact) and tenors (up to three years usually possible without limitations). Going forward, it is expected for Romania to join the Eurozone in 2024.

Table 19.1 outlines a selection of bank financed onshore wind farm and PV solar projects in Romania where lender groups have been publicly disclosed (including MFIs in **bold**).

TABLE 19.1 FINANCING DETAILS OF RENEWABLE ENERGY PROJECTS

Project Name	Project developer	Debt providers	Approximate amount (€ million)	Financing year
Cernavoda Power SA	EDPR	La Caixa, Societe Generale, UniCredit, **EBRD, IFC**	140	2011
Pestera Wind Farm	EDPR	La Caixa, Societe Generale, UniCredit, **EBRD**	62	2011
Cernavoda Power	EDPR	**IFC**, La Caixa, Societe Generale, UniCredit Bank Austria AG	74	2011
Pestera Wind Farm	EDPR	La Caixa, SG (Societe Generale) Corporate & Investment Banking, UniCredit Tiriac Bank, **EBRD, IFC**	97	2011
Enel Green Power	Enel Green Power	Export Credit Agency (EKF)	221	2012
Chirnogeni wind	EP Global Energy	**EBRD**, UniCredit Bank Austria, ING Bank, Erste Bank	85	2012
EP Wind Project (Rom) Six	EP Global Energy	Erste Bank, ING Bank, UniCredit Bank Austria AG, **EBRD**	115	2012
VS Wind Farm	EDPR	**EBRD**, Erste Bank Group, UniCredit	60	2012
LJG Green Source Energy Alpha	Samsung C&T, LJG	Intesa Sanpaolo, UniCredit	109	2013
Cujmir Solar	EDPR	**Black Sea Trade & Development Bank, EBRD**	38	2014

xxxii. Legally possible since 31 December, 2021 through the Emergency Ordinance GEO no. 143/2021 and confirmed by the regulator ANRE in April 2022.

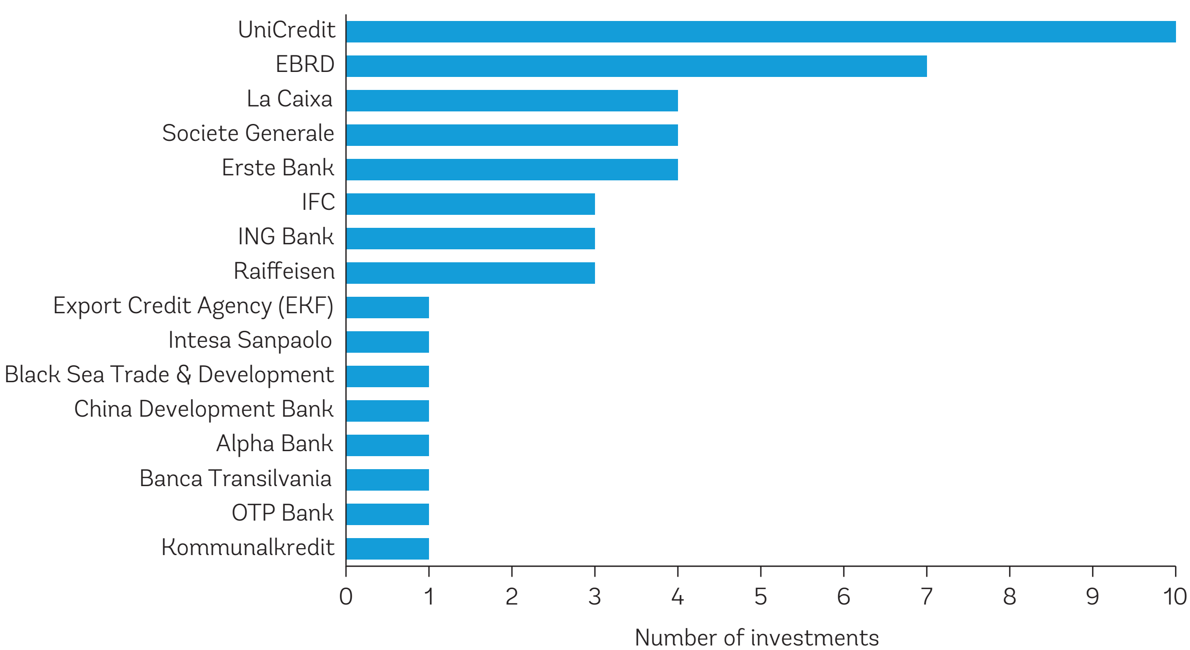
Project Name	Project developer	Debt providers	Approximate amount (€ million)	Financing year
Corni Eolian	ERG Renew	ING Bank, Raiffeisen Bank International	86	2014
Mireasa Energies	Monsson group	**China Development Bank Corp**	43	2015
Felix Renewable Holdings	Macquarie Infrastructure and Real Assets	Alpha Bank, Banca Transilvania, Erste Bank, OTP Bank, Raiffeisen Bank International, UniCredit	300	2021
LJG Green Source Energy Alpha	Greenvolt	Raiffeisen Bank Internationa, UniCredit	63	2022
Enery Power Ro Holding	Enery	Kommunalkredit Austria	33	2022

Source: Dealogic.

International banks

Other than purely domestic banks and local banks with European parents, there has been no active engagement of large international banking groups (e.g. any of the top 20 largest banks in the S&P ranking[72]) in financing the renewable sector in Romania. This is seen to be due to the relatively small size of the economy, the banking market itself and the comparably small deal size in the market. A limited number of international, mostly European, lenders without banking operations in Romania such as Kommunalkredit (Austria) or La Caixa (Spain) shown in Figure 19.3 are active lenders to the renewable sector and are now looking at Romania mostly on an opportunistic basis or driven by client relations.

FIGURE 19.3 NUMBER OF INVESTMENTS PER INDIVIDUAL BANKS, 2010-2022



Source: Dealogic.

It is worth mentioning that some banking groups that are active in Romania, in particular Société Générale, ING and UniCredit as well as European Investment Bank (EIB) among the MFIs are already experienced lenders to OSW projects in other regions including Europe, Asia and the US. The knowledge and experience gained through those investments are expected to mean that there will be strong interest in structuring and lending to OSW projects in Romania, should the regulatory environment contribute to the potential project's bankability. Table 19.2 outlines a selection of bank financed OSW projects worldwide where lender groups have been publicly disclosed (including banks active in Romania and MFIs in **bold**).

TABLE 19.2 FINANCING DETAILS OF OSW ENERGY PROJECTS WORLDWIDE

Company	Deal Note	Lenders	Approximate amount (€ million)	Financing Year
Deepwater Wind Block Island	Development of 30 MW Block Island OSW project (US)	KeyBank NA, OneWest Bank FSB, **Societe Generale**	276	2015
Deepwater Wind Block Island	Refinancing of operating 30 MW Block Island OSW project (US)	CoBank ACB, HSBC, KeyBank, **Societe Generale,** Sumitomo Mitsui Financial Group	259	2018
Dudgeon Offshore Wind	Refinance of operating 402 MW Dudgeon OSW project (UK)	BNP Paribas Fortis, DBS Bank (Hong Kong SAR, China), DNB Markets, MUFG Bank, Norinchukin Bank, SEB, **Societe Generale,** Sumitomo Mitsui Banking Corp	822	2018
Formosa 1 Wind Power	Development 120 MW Formosa 1 Phase 2 OSW project (Taiwan, China)	ANZ, BNP Paribas, Cathay United Bank Co, Credit Agricole CIB, DBS, EnTie Commercial Bank Co, **ING,** KGI Bank, MUFG Bank, **Societe Generale,** Taipei Fubon Commercial Bank	554	2018
Ocean Breeze Energy	Acquisition of Ocean Breeze Energy by Macquarie Group	Bank of China, Goldman Sachs, **ING,** KB Kookmin Bank, Norinchukin Bank, SEB, **UniCredit Bank**	853	2019
Rentel	Refinance of existing to development the 309 MW Rentel OSW project (Belgium)	Belfius Bank & Insurance, BNP Paribas Fortis, KBC, KfW IPEX Bank GmbH, Rabobank, **Societe Generale**	890	2019
Yunneng Wind Power	Development of the 640 MW Yunlin Yunneng OSW project (Taiwan, China)	BNP Paribas, Cathay United Bank Co, Credit Agricole CIB, CTBC Bank Co, DBS, Deutsche Bank, E.Sun Commercial Bank, EnTie Commercial Bank Co, **ING,** Mizuho Bank, MUFG Bank, Natixis, OCBC, **Societe Generale,** Standard Chartered Bank, Sumitomo Mitsui Banking Corp, Taipei Fubon Commercial Bank Co, Taiwan Cooperative Bank	1,661	2019

Company	Deal Note	Lenders	Approximate amount (€ million)	Financing Year
Akita Offshore Wind Farm	140 MW Akita and Noshiro OSW projects (Japan)	77 Bank, Akita Bank, Bank of Iwate, Dai-ichi Life Holdings Inc, Hokuto Bank, Meiji Yasuda Life Insurance, Mizuho Bank, MUFG Bank, Nippon Life Insurance Co, Shinsei Bank, **Societe Generale,** Sumitomo Mitsui Banking Corp, Sumitomo Mitsui Trust Bank,Yamagata Bank	820	2020
Eoliennes Offshore des Hautes Falaises	Construction and operation of 497 MW Fécamp OSW project farm (France)	Bank of China, BayernLB, BNP Paribas, Caisse d'Epargne de Haute Normandie, CaixaBank, CM-CIC, Commerzbank, Credit Agricole CIB, DekaBank, DZ BANK, **European Investment Bank – EIB,** Helaba, KfW, La Banque Postale SA, LBBW, Mizuho Bank, MUFG Bank, Rabobank, Santander, SG Corporate & Investment Banking, Siemens Bank Standard Chartered Bank, Sumitomo Mitsui Banking Corp, UniCredit	2,480	2020
Global Tech I Offshore Wind	Refinance of 416 MW Global Tech I OSW project (Germany)	ASN Bank Novib, BayernLB, **ING Bank,** KfW IPEX Bank, Kommunalkredit Austria Rabobank, **SG Corporate & Investment Banking,** Skandinaviska Enskilda Banken	652	2020
Eoliennes Offshore du Calvados	Construction and operation of a 448 MW Calvados OSW project (France)	BayernLB, BNP Paribas, CaixaBank, CIBC, CM-CIC, Credit Agricole CIB, **European Investment Bank – EIB,** Helaba, KfW IPEX Bank, La Banque Postale, Mizuho Bank, Rabobank, **SG Corporate & Investment Banking,** Siemens Bank GmbH, Standard Chartered Bank, Sumitomo Mitsui Banking Corp, UniCredit	2,380	2021
Green Power Ishikari	Development of 112 MW Ishikari Bay OSW project (Japan)	DBJ, Mizuho Bank, MUFG Bank, Shinsei Bank, **Societe Generale,** Sumitomo Mitsui Banking Corp, Sumitomo Mitsui Trust Bank	337	2022

Source: Dealogic.

19.3.2 Tax incentives

The following current incentives are relevant to OSW:

- **Excise Duties.** Electricity produced from renewable sources is exempt from excise duties.
- **Accelerated depreciation of fixed assets.** For technical equipment, an accelerated depreciation method can be used for tax purposes. This allows up to 50% of the fixed asset value as depreciation in the first year of use. In the following years, the depreciation is calculated based on the remaining value of the fixed asset divided by the remaining useful life.
- **Exemption from corporation tax for reinvested profit.** Profits invested in certain technical equipment are exempt from corporation tax under certain conditions. The corporation tax rate in Romania currently is 16%.
- **The assets for which this tax incentive is applied must be retained for at least half of their useful economic life, but no longer than five years.** The company cannot apply the accelerated depreciation on equipment subject to this tax incentive.

- **Simplification of VAT payment methods.** In some circumstances, sales of electricity to traders or other entities that have a consumption versus purchase of energy ratio of less than 1% (assessed annually, based on quantities) can follow simplification measures.
- **Losses carried forward.** Limited losses incurred can be carried forward for a period to reduce taxable profits.

The Government has the opportunity to explore any potential fiscal instruments relating to the support of OSW subject to the country's context and its position as an EU Member State. This may be at developer level, considering the attractiveness of projects, or at the supply chain level, considering in-country investment to serve OSW projects.

19.3.3 Multilateral lending

Besides EBRD and IFC, other MFIs active in the market so far are Black Sea Trade & Development Bank and China Development Bank, which financed a project using Chinese wind turbines.

The ability of private sector developers to secure finance from MFIs can create several benefits in terms of the overall availability of finance and its cost. For sectors they prioritize, they will typically offer a source of lower cost finance. Participation is also likely to increase appetite from other lenders because:

- They are often willing to take on a larger tranche of financing for early, higher risk projects;
- Their presence often increases interest among private institutions;
- Their B-Loan umbrella (sub-participation by commercial banks not located in the country) offers some protection regarding expatriation of funds in case of transfer restrictions imposed by the central bank or withholding tax (WHT) benefits (not as subject to WHT) for lenders and consequently to sponsors;
- Their environmental and social impact assessment standards such as IFC PS ensure that best practice in environmental and social impact assessment (ESIA) is applied, making it easier for other investors to participate – this is very much aided by regulatory requirements ensuring that ESIAs and permits meet such standards and other Good International Industry Practice (GIIP);
- Their due diligence processes are often relied on by others, reducing the cost of participation by private financing parties; and
- Their participation often comes with other support, either advisory or in terms of credit enhancement (read more about IFC Upstream).[73]

While in less developed markets MFIs may be able to offer concessional loans (loans on more favorable terms than market loans, either lower than standard market interest rates, longer tenures, or a combination of these terms), Romania as an EU country is not eligible for such funds to be utilized in projects. The European Investment Bank (EIB), as the investment bank of the European Union, may however be able to provide more beneficial terms than commercial lenders or other MFIs resulting in lower credit margin and/or longer tenors. In September 2023, EIB supported one of the world's largest wind farms with €610 million in financing,[74] As mentioned in the press release, over the past decade, the EIB has channeled more than €100 billion into the EU energy sector. More recently, in December 2023, EIB approved a €5 billion tailored initiative to support wind energy component manufacturers as part of the EIB's contribution to the European Wind Power Package.[75]

Where there are areas of priority, MFIs may also participate at the equity level in projects (or provide convertible debt). This can act as means to ensure there is available finance, in particular for upfront development costs prior to debt-financing being available.

MFIs played a key role in lending to the sector during the first wave of renewables financing in Romania in the period 2011 to 2015, pioneering first transactions and involving commercial banks as participants. In recent financings of brownfield assets since 2021, MFIs have not been involved, which can be explained by commercial banks getting comfortable to invest in de-risked projects in the sector and a low additionality, which MFIs usually seek to provide.

19.3.4 Credit enhancement mechanisms

Where private investors are involved in a public private partnership (PPP) scheme for an infrastructure investment, typically involving a set of contractual obligations of a public counterparty, project bankability and availability of financing can be significantly improved through the use of investment guarantees and credit enhancement mechanisms. The latter can be secured from public or private insurance companies, as well as export credit agencies and development finance institutions (DFIs).

A relevant de-risking solution for OSW financing could be provided by the Multilateral Investment Guarantee Agency (MIGA), which is a member of the World Bank Group, in the form of investment guarantees extended to foreign private sector financiers including equity sponsors and lenders. A key coverage in the context of PPPs is breach of contract, whereby the MIGA backstops contractual obligations of a sovereign, eligible sub-sovereign or state-owned entity under a project agreement (e.g. concession agreement, implementation agreement, PPA, etc.) and guarantees the payment of termination amounts due by the relevant public authority upon completion of a dispute resolution process. Importantly, as a member of the World Bank Group, MIGA's added value stems from its ability to resolve investment disputes between host governments and private investors to the satisfaction of all parties, preventing potential claim situations from escalating and leading to project termination. MIGA's breach of contract coverage can support renewable energy projects (including OSW) under a typical project finance structure, as well capital market transactions and project bond issuance.

A recent example entails the Scatec Green Bond Project in Egypt[76] (May 2022), where MIGA has supported the refinancing of the existing debt of six operational solar PV power plants developed as part of Egypt's landmark solar Feed-in-Tariff Program (FiT Program), aimed at mobilizing private investments to build one of the world's largest solar PV projects.

The projects have been refinanced through the issuance of a bond totaling up to €310 million, with joint support from MIGA (through investment guarantees) and EBRD (through a liquidity support facility). The complementarity of the two products has driven strong appetite from institutional investors and the bond issuance secured a rating of BBB+ by Scope, six notches above the sovereign.

Beyond PPPs, MIGA can also support the Romanian government, as well as eligible sub-sovereign entities and state-owned enterprises (SOEs) to access commercial financing at improved terms for the development of public sector projects. MIGA's credit enhancement guarantees are typically extended to commercial lenders, covering the risk of non-payment by an eligible public authority under an unconditional and irrevocable financial obligation (e.g. as stipulated under a loan agreement). The product, which covers up to 95% of the loan principal, interest as well as hedging instruments, is Basel compliant, providing capital relief to lenders, which in return allows public borrowers to secure financing at better terms. MIGA-backed commercial financing can represent a complementary solution to EU or DFI funding in case of existing financing gaps. Such structure can also entail MIGA coverage for commercial loans secured in order to fund public sector participation into PPP projects, e.g. into the OSW PPP projects if/where relevant.

19.3.5 Climate finance

Climate finance refers to sources of public finance aimed at supporting developing economies to make investments that mitigate climate change and adapt to its impacts. The impetus for global climate finance funds comes from the United Nations Framework Convention on Climate Change (UNFCCC). The main climate finance mechanisms are the Green Climate Fund (GCF), the Global Environment Facility (GEF) and the Climate Investment Funds (CIF).

The UNFCCC calls for financial assistance from countries with greater financial resources (Annex 1 countries) to those that require assistance to address climate change (non-Annex 1 countries). Romania is an Annex 1 country due its advanced economic development catalyzed through its accession to the EU in 2008. As such, the country is no longer eligible to receive any funds from the GCF, GEF or CIF.

19.3.6 European Funds

The funds available from the EU for renewable energy are:

1. **The Modernisation Fund.** [77] This is a dedicated funding program to support 10 lower-income EU Member States (including Romania) in their transition to climate neutrality by helping to modernize their energy systems and improve energy efficiency. So far in Romania, there is certainty only on initial allocations that were already granted to Transelectrica and CE Oltenia. Several calls are under preparation, including for gas-fired plant, combined heat and power plant, district heating projects and renewable energy. €110 million is likely to be allocated for grid-connected technology and €105 million for industrial generators consuming at least 70% of their own supply.
    - Eventually, the Modernisation Fund will have a much higher budget across the 10 member states than initially assumed (now estimated at €48 billion).
    - Funds are a proportion of revenue from the EU Energy trading Scheme (EU-ETS) based on CO_2 prices. Funds can be spent by the end of 2030, which means projects need to be operational in 2029.
    - Spending is strictly linked to achieving the indicators on installed renewable energy sources (RES) in a country's National energy and climate plan (NECP).
    - There is a particularly hard (likely non-negotiable) constraint for large projects (like OSW) where allocations will be conditional on injecting a defined amount of renewable energy into the grid by a defined date. If the target is not achieved the grant would need will to be repaid.
    - The expected targets for RES are unlikely to be reached without OSW. It is ;likely, therefore, that there would still be several € billion available in the Modernisation Fund that EC could allocate to OSW in Romania
    - This would require the Ministry of Energy to prepare a scheme or a list of well-justified projects and negotiate financing directly with the EC, also considering the other constraints (permitting and other delivery risk), a well-substantiated justification for the need for state aid and assurance that the energy will be injected in the system by the end of 2030.

We understand that according to discussions with the State Aid Schemes Implementation Directorate, the Modernisation Fund can be used to support OSW project delivery but cannot currently be used for technical assistance. We further understand that updates to eligibility are under discussion, including regarding technical assistance.

2. **National Recovery and Resilience Plan (NRRP).** There is a total allocation of €460 million for wind and solar, for capacities which currently need to be put in operation by end-June 2024. There are negotiations to extend the deadline at least by 6 months, but this is too soon for OSW in Romania.
3. **The Operational Program (OP) Sustainable Development 2021-2027.** This focuses on sources of renewable energy not developed under other EU funds, e.g. solar and geothermal for heating. The OP is meant to be complementary / not overlap with the NRRP and Modernisation Fund. Due to the scope and timing, it is less relevant than the Modernisation Fund.

19.3.7 Green debt instruments

Green debt instruments are bonds or securities issued to fund projects or assets that have a positive environmental or climate impact. These bonds can be issued either by public or private actors, and may bring the following benefits:

- Enhancements to the issuer's reputation, as green bonds serve to enhance their commitment to environmental goals or targets;
- They require good standards of ESIA to be applied;
- Investor diversification, as there is a growing pool of capital earmarked for green projects. Thus, the issuer can access investors who may not have been interested in purchasing a regular bond; and
- Potential pricing advantages if the wider investor base allows the issuer to get better pricing terms on a green bond than on a regular bond, though evidence to support the existence of a pricing advantage is mixed.

The IFC and Amundi Asset Management launched the Green Cornerstone Bond Fund in 2018, the world's largest green bond fund targeting emerging markets. The IFC will provide first-loss coverage through a junior tranche to lower risk and attract private sector investments.[78]

Green bonds have not (yet) been issued to finance renewable energy projects in Romania but green bond issuance is expected to grow in line with global trends and may eventually reach the power generation sector, though there is limited precedent of 'project bonds' with no recourse to a corporate issuer/sponsor in the country yet.

Romanian companies and financial institutions work increasingly with green bonds, although there is a large space for growth. Romania has issued €1.75 billion green bonds in the period 2012-21[79]. The Ministry of Finance intends to launch sovereign green bonds starting in 2024, following the of the Sovereign Green Bond Framework in December 2023.[80] In Romania, green project spend amounts to €60 billion, both at the government and corporate level. If implemented, the additional impact on the economic growth could reach up to 5.7 percentage points in the next six years[81].

The focus of banks and companies in the sustainable finance area lies in green bonds issuance. For example, in May 2021, MAS Real Estate issued a green bond to finance projects in Romania. It priced a €300 million unsecured green 5-year Eurobond maturing on May 16, 2026, carrying a 4.25% fixed coupon, with an issue price of 98.9%.

For the most part, green bonds in Romania are issued by larger international investors, the most active of which are international banks. BCR and Raiffeisen Bank, two of the biggest banks in Romania raised more than RON 3,6 billion (€812 million) with 4 green bond and 2 sustainability bond issuances carried out in 2021 and 2022:

- In April 2021, Raiffeisen Bank issued the first green bond worth over RON 400 million (€80 million) on the Bucharest Stock Exchange[82].
- In July 2021, Raiffeisen Bank listed the second green bond issuance on the Bucharest Stock Exchange, worth over RON 1.2 billion (€242 million)[83].
- In June 2022, Raiffeisen Bank placed its third green bond, a 5-year green bond issuance and raised RON 525 million (€106 million) from investors[84].
- In June 2022, BCR raised RON 702 million (€142 million), double the planned amount[85].
- In August 2022, Raiffeisen Bank issued its first sustainable bonds and raised RON 500 million (€100 million). Bank planned to invest in climate-smart initiatives including renewable energy [86].
- In November 2022, Raiffeisen Bank is listed its second issue of sustainable bonds on the Bucharest Stock Exchange to a value of RON 325.5 million (€142 million)[87].

MFIs like IFC actively invests in green and sustainability bonds in Romania and thereby help promoting both climate and social financing, strengthening the financial market.

Romania is developing rapidly in terms of climate financing; however, it can invest more effort to advance innovative financial instruments (such as sovereign green bonds) at the national level. This would demonstrate the state's interest in advancing climate finance and would drive more private entities to engage in climate finance.

The Romanian green bond market will continue to grow as green bonds are a useful instrument for issuers and investors, but also climate change and the Paris Agreement commitments require a continuous effort to support renewable energy and other climate-related projects.

19.3.8 Green equity instruments

Green equity instruments relate to equity issuances by a company where the capital raised is to be used specifically for projects that have a positive environmental impact.

There are currently two main green equity instruments being used in Romania that are relevant to the financing of OSW:

- Private equity/venture capital/unlisted equity funds that are either active through their own renewable energy platforms or aid project developers to secure a funding stream for their projects. For example:
  - Actis Energy Fund 5, a private equity fund raised and managed by Actis focusing on Energy Transition opportunities through vestments in power generation and distribution businesses. Actis has a pipeline of over 2 GW of solar PV and onshore wind projects in Romania.
  - Three Seas Initiative Investment Fund, managed by Amber Infrastructure and funded by development banks of eleven Eastern European states bordering the Baltic Sea, Black Sea and the Mediterranean Sea. It invested a significant equity stake in the renewable energy platform Enery, which owns a portfolio of 85 MW of operating solar PV generation assets in Bulgaria,

Czechia and Slovakia and has a significant development portfolio of over 2 GW in a number of countries, including Romania.

- Joint venture partnerships that pool capital, skills and resources for a specific project or platforms. As an example in the electricity sector, asset manager Allianz Capital Partners (ACP), has partnered with the German utility E.ON in Romania and acquired a 30% stake in its electricity and gas distribution network.

19.4 DISCUSSION

There are a number of viable sources of finance for OSW developments, and a track record of renewable transactions across loan, bond, green bond and equity markets. We anticipate that the greatest volume of finance will come from MFIs and European lenders, but with local lenders and potentially some opportunistic international lenders that are attracted by size playing an important role. A well-informed, competitive debt market supporting experienced project developers that are able to show their commitment through equity investment is key to minimizing weighted average cost of capital (WACC) for OSW projects.

- European lenders are active in the Romanian market mostly through their Romanian subsidiaries or on an opportunistic basis. Some of these banks have experience with OSW through other established European OSW markets. While through their subsidiaries they would have access to Lei-denominated balance sheets, large scale financing is likely to seek loan proceeds to be in Euros, as currently the case for most renewable energy financing.
- Romania has an established and active banking market. Local lenders even without belonging to a European banking group have a growing appetite for renewables, and growing familiarity with project finance structures. Local banks are well capitalized and ready to lend but lack experience with OSW.
- MFIs are active and familiar with the Romanian context. They have a role to play in 'de-risking' OSW development in the coming years until there is a greater local track record of successfully operational OSW projects. Direct lending and credit enhancement appear to be suitable tools to unlock private sources of debt that are otherwise available in the country.
- The EU Modernisation Fund provides an opportunity for substantial support, dependent on projects being installed by the end of 2029.
- The Romanian green bond market is small but growing and currently focused on financial institutions as issuers. Given the small pool of investors and need for a minimum credit rating, raising project bonds without credit enhancement is likely to be challenging in the short term. Larger corporate developers may be able to secure bond issuance (and green bonds) as part of corporate bond programs, which in turn could be used to fund OSW.
- Government has established a series of tax measures that support renewable energy more generally.

19.5 RECOMMENDATIONS

Based on this analysis, it is recommended that:

- The Ministry of Energy (MOE) establishes the feasibility and attractiveness of using the Modernisation Fund to support OSW, including any flexibility regarding timescales due to the time it takes to develop OSW projects in a new market.
  - There may be opportunities to use the fund to support early-stage Government work, site exploration and eventual construction.
- The Ministry of Environment, supported by the Ministry of Finance, addresses any shortfalls in Romanian ESIA requirements compared to EU Regulations, GIIP, and other lender standards.
- The MOE, with the Ministry of Finance considers financial mechanisms to reduce cost of capital for OSW projects, including access to climate and other concessional finance and ensures international market standards for contractual risk allocation and arbitration. Early engagement with MDBs is encouraged, in order to shape any guaranty scheme, credit enhancement, first loss support or other arrangement.
- The MOE explores together with the Ministry of Finance any potential fiscal instruments relating to the support of OSW subject to the country's context and its position as an EU Member State.

20. PUBLIC INSTITUTIONS

20.1 PURPOSE

The purpose of this work package is to define the potential roles and responsibilities of public institutions in delivering offshore wind (OSW) projects in Romania. It describes the roles typically required to administer regulatory frameworks, presents examples of public institutions that are responsible for these roles in other markets and proposes potential public institutions that could have these roles in Romania.

20.2 METHOD

We listed the roles and responsibilities typically required to administer regulatory frameworks, recognizing that the roles and responsibilities of public institutions varies between markets depending on the structure of their OSW frameworks.

We then identified the public institutions in the UK and Poland that are currently responsible for administrative roles in an established market and an emerging market that is ahead of Romania.

Based upon the administrative roles required in Romania and the responsible public organizations in other European markets, we proposed potential public organizations that could have these roles in Romania.

We then provided recommendations around capacity building for each of the proposed public organizations that will enable them to effectively manage and administer the regulatory frameworks required to deliver OSW projects in Romania.

20.3 RESULTS

20.3.1 Roles and responsibilities

The key roles typically required to manage and administer regulatory frameworks in OSW markets are:

- Multi-sector marine spatial planning;
- OSW marine spatial planning;
- Lease competition administration (exploration license in Romania);
- Lease contract award (exploration license in Romania);
- Permitting assessment;
- Permitting award;
- Revenue support competition administration(also lease in Romania);
- Revenue support contract award (also lease in Romania);

- Grid connection contract award;
- Health and safety oversight; and
- Technical certification.

Key needs for organizations

As discussed in the *Key Factors* report, organizations playing these roles each need to:

- Be well resourced, so that they can provide a timely service;
- Deliver secure, robust, and fair processes, supported by relevant legislation and legal advice;
- Provide relevant information, including principles as well as practical guidance;
- Engage early with stakeholders about possible changes and listen to their views; and
- Have the trust of the project development and finance communities.9

Multi-sector marine spatial planning

It is important to consider environmental, social and technical constraints with territorial waters and the Exclusive Economic Zone (EEZ) to identify broad potential areas for OSW deployment. This requires an organization to:

- Define the plan area (typically the national EEZ).
- Engage with stakeholders in relevant sectors to ensure all marine users are accounted for in the planning process.
- Build an evidence base through existing spatial data, future plans and stakeholder consultation to understand current and future environmental, social and technical constraints.
- Carry out a spatial modelling exercise to define where marine users operate.
- Conduct a consultation process to ensure the proposed plan is likely to be adopted by marine users.
- Monitor, review and adapt the plan at regular intervals to ensure the plan remains relevant.

OSW marine spatial planning

It is important to identify the least constrained, most technically attractive areas for OSW deployment within the broad potential areas defined within the multi-sector marine spatial plan. This requires an organization to follow similar steps to above to designate broad areas or specific sites for each licensing round.

As well as the factors considered above, levelized cost of energy (LCOE) analysis and technical parameters such as water depth and ground conditions will be relevant.

Lease competition administration (exploration license in Romania)

The organization responsible for administering the lease competition (exploration license competition in Romania)) does not need to be the same organization responsible for awarding the contract. The competition administration organization needs to:

- Provide relevant information, including clarity regarding objectives, processes, rules, selection criteria and timings;
- Engage early with key stakeholders to brief them and listen to their views;
- Administer any prequalification process to ensure the project developer has the capability to deliver the project;
- Ensure that bidders have had a chance to ask questions about the process and understand the answers;
- Ensure that bidders have had time to understand risks and opportunities sufficiently to put in positive bids;
- Manage a secure, robust, and fair assessment process;
- Administer the results process and follow-up activities with successful companies;
- Administer any appeals process; and
- Provide long-term visibility of future competitions and ensure they are aligned with government targets.

Lease contract award (exploration license in Romania)

The organization responsible for awarding the lease, or the exploration license needs to:

- Have the authority to award (sign) such contracts;
- Define the lease or license terms to encourage developers to progress with development by defining clear milestones that must be achieved;
- Define the period over which the lease or license will be active; and
- Work with developers and the administrative organization following the award of the lease or license to ensure the terms and conditions are being met (in the case of Romania, this will involve ensuring the data collection requirements are being met).

Permitting assessment

A single organization responsible for managing a one-stop shop for assessing permits needs to:

- Provide relevant information, including clarity regarding objectives, processes, assessment criteria and timings;
- Engage early with developers considering applying for permits to ensure they are aware of key considerations;
- Keep wider organizations and stakeholders informed of the upcoming workload*;
- Assess documentation from a developer and make early requests for clarifications;
- Manage assessment and responses from stakeholders, ensuring that they are provided with the latest information*;
- Manage additional information requests to the developer;
- Keep the ultimate permitting award body informed about the status of permitting;

- Make a final recommendation to the permitting award body, including any conditions required to protect the environment and affected communities; and
- Administer any appeals process.

If there is no such one-stop shop arrangement, then each organization responsible for a permit (or providing assessment contributing to a permit) will need to provide a subset of the above (excluding activities marked*).

Permitting award

The organization responsible for awarding permits need to:

- Hold legal authority to award the permit;
- Define the permit assessment requirements including the need for site surveys, stakeholder engagement and an environmental and social impact assessment;
- Define the period over which the permit will be active; and
- Work with developers and the administrative organization following the award of the permit to ensure the terms are met.

Revenue support competition administration (also lease in Romania)

The organization responsible for administering the revenue support competition needs to undertake the same activities as defined for the organization responsible for administering the lease competition. It will also need to:

- Ensure any requirements that are aimed at benefitting the wider industry are well understood by project developers and there is a robust process in place to monitor commitments following award; and
- Define any bid price limits that bidders will need to bid within.

Revenue contract award (also lease award in Romania)

The organization responsible for awarding the revenue support contract needs to:

- Design an offtake mechanism that is bankable and provides investors with the certainty they need;
- Hold legal authority to award such contracts; and
- Have financial resources to honor the contract over its full term.

Grid connection contract award

The transmission network operator (TNO) responsible for awarding grid connection contracts needs to:

- Define and administer the process developers must follow to apply for a grid connection;
- Review applications and make decisions about the priority and timing of grid connections; and
- Finalize contract terms with developer, including liabilities for late delivery, then build and operate transmission network up to location of grid connection.

Health and safety oversight

The OSW industry needs effective health and safety practices and a culture that protects people and the environment. This requires project developers to adhere to Environmental, Health and Safety (EHS) guidelines and standards set out by international organizations, such as the WBG, and national regulators. The national EHS regulator needs to:

- Ensure existence of a national EHS regulatory framework that is fit for purpose in OSW;
- Keep the national EHS regulatory framework aligned with accepted good practices set out by international OSW EHS guidelines;
- Provide relevant permits; and
- Implement inspection and monitoring program that ensure projects are meeting EHS standards, building a strong EHS culture throughout the industry.

Technical certification

OSW component design, manufacture, installation and operations follow technical standards to reduce project risk. Sufficient international standards are in place to provide assurance of good practice, should inspections be carried out to ensure compliance. If additional national standards apply, then a national standards body needs to:

- Harmonize between relevant international and national standards, where possible; and
- Enforce compliance with remaining national standards.

20.3.2 Responsible organizations

Table 20.1 summarizes the organizations that are currently responsible for the roles outline above in England and Poland. It also provides suggestions of potential organizations that could be responsible for administering the processes and awarding contracts for each regulatory framework in Romania. The two example markets are chosen to reflect an established and an emerging European market that has shown good practice.

TABLE 20.1 RESPONSIBLE ORGANIZATIONS IN ENGLAND AND POLAND AND PROPOSED RESPONSIBLE ORGANIZATIONS IN ROMANIA

Role	England	Poland	Romania
Multisector marine spatial plan	Marine Management Organization	Ministry of Infrastructure	Ministry of Economy
OSW spatial planning	The Crown Estate	Director of Maritime Office and the Minister of Infrastructure	Ministry of Economy
Lease competition administration (exploration license in Romania)	The Crown Estate	Energy Regulatory Office (ERO)	Ministry of Energy (MOE)
Lease contract award (exploration license in Romania)	The Crown Estate	ERO	Romanian Energy Regulatory Authority (ANRE)

Role	England	Poland	Romania
Permitting assessment	Planning Inspectorate	Ministry of Marine Economy and Inland Navigation (sea bed and sea-bed cable location permit); Regional Directorate for Environmental Protection (EIA); ERO (project construction, energy generation and energy use permit)	Existing bodies responsible for awarding different permits for related sectors. New one-stop shop authority only needed in high growth scenario
Permitting award	Department for Energy Security and Net Zero	Ministry of Marine Economy and Inland Navigation (sea bed and sea-bed cable location permit); Regional Directorate for Environmental Protection (EIA); ERO (project construction, energy generation and energy use permit)	Existing bodies responsible for awarding different permits for related sectors.
Revenue support competition administration (also lease in Romania)	Department for Energy Security and Net Zero and National Grid ESO	ERO	MOE
Revenue support contract award (also lease in Romania)	The Low Carbon Contracts Company	ERO	OpCom
Grid connection contract award	National Grid ESO	Państwowe Sieci Elektroenergetyczne (PSE)	Transelectrica
Health and safety oversight	Health and Safety Executive	Central Institute for Labor Protection	ACROPO
Technical certification	British Standards Institute	Polish Committee for Standardization	ACROPO

20.4 DISCUSSION

In any OSW market, there needs to be clarity on responsible organizations and their roles. Many of these organizations will exist already to fulfill other roles. Each market is different in this respect, and it needs leadership to establish which organization should play which role.

20.5 RECOMMENDATIONS

Based on this analysis, it is recommended that:

- The MOE leads in establishing which organization should play which role regarding the different frameworks needed for OSW.

21. STAKEHOLDERS

One of the goals of the project is to establish a strong network of industry stakeholders whose views and collaboration will aid development and socialization of the offshore wind (OSW) roadmap for Romania. The engagement carried out in the inception mission and consultation mission of this roadmap aimed to start the process of establishing such a network, and key stakeholders identified during the missions are listed below.

Early and constructive stakeholder engagement is essential for a number of reasons including:

- Working together with industry to address recommendations in this roadmap and other considerations
- Input into policy and frameworks
- Identifying priority biodiversity receptors, verifying data and ensuring they are considered appropriately and proportionately in planning for OSW development.

Stakeholder engagement should be an integral and important part of future processes, including marine spatial planning and project-specific environmental and social impact assessment.

A list of key stakeholders has been identified and is provided in Table 21.1 under seven headings:

- *Government.* Government departments, regulators, and institutions at national and regional level. This list includes Government Owned or Controlled Corporations (GOCCs) and private corporations with congressional franchises performing relevant governmental functions.
- *Offtakers and power companies.* Electricity companies that may be involved distributing energy from OSW.
- *Project developers.* OSW project developers known to have expressed interest in OSW in Romania.
- *OSW supply chain.* Supply chain businesses known to be active in OSW in Romania.
- *Non-governmental organizations (NGOs).* National and international non-governmental organizations with relevance or declared interest in OSW in Romania.
- *Academic organizations.* Romania Academic organizations with relevance or declared interest in OSW in Romania.

By nature, this list is dynamic and as interest in the market continues to increase, it will be outdated soon after publication.

TABLE 21.1 KEY STAKEHOLDERS

Name	Role
Government	
Autoritatea Competentă de Reglementare a Operațiunilor Petroliere Offshore la Marea Neagră (ACROPO), Authority for the Regulation of Offshore Oil Operations in the Black Sea (https://acropo.gov.ro/)	Authority responsible for ensuring the safety of offshore oil and gas operation in the Black Sea. Operates under the Romanian Government and in Coordination of the Chancery of the Prime Minister.
Autoritatea Nationala de Reglementare in Domeniul Energie (ANRE), Romanian Energy Regulatory Authority (https://www.anre.ro/)	Authority responsible for the regulation of the heating, electricity and gas markets in Romania. Operates under the Romanian Government and in Coordination of the Chancery of the Prime Minister.
Agenția Națională pentru Protecția Mediului (ANPM) National Agency for Environmental Protection (http://apmdj.anpm.ro/ro/responsabil-pentru-relatia-cu-mass-media)	Agency responsible for enforcing environmental regulations in Romania, including monitoring and assessing environmental quality, implementing and enforcing environmental laws and regulations, and promoting sustainable development. Operates under the Ministry of Environment, Water and Forests.
Consiliul Concurenței, Romanian Competition Authority (https://www.consiliulconcurentei.ro/en/)	Organization responsible for promoting competition, encouraging market development, ensuring customer choice, and penalizing abuse of market power in the electricity industry. Operates under the Romanian Parliament
Administratia Porturilor Maritime, Constanța Maritime Port Administration (https://www.portofconstantza.com/pn/ro/home)	Organization responsible for port planning, development, operations, and regulation. Part of Ministry of Transport and Infrastructure.
Ministerul Anterprenoriatului SI Turismului, Foreign Investment General Directorate (http://www.imm.gov.ro/ro/mmaca/investitii-straine/)	Responsible for the development of large investment projects because it is the point of contact for foreign investments in Romania. Its main objective is to attract foreign investment.
Directia Hidrografica Maritima, Maritime Hydrographic Directorate (https://www.dhmfn.ro/index.shtml)	Responsible for creating, managing and keeping up to date the national maritime hydrographic data system, developing, managing, and updating the information on cartography, marine geodesy and maritime navigation and performing bathymetric surveying.
MARSPLAN, Maritime Space Planning Committee (https://marsplan.ro/en/)	Consists of competent authorities which represent the organizations responsible for the development and monitoring of the implementation of the maritime space development plan.
Ministerului Agriculturii și Dezvoltării Rurale, Ministry of Agriculture and Rural Development (https://www.madr.ro/en/)	Government department responsible for the promotion of agricultural development and growth. It develops and applies strategies to do with agriculture and food production, rural development, sustainable management of soils, plant, animal and genetic resources.
Ministerul Culturii, Ministry of Culture (http://www.cultura.ro/)	Government department responsible for managing archeological resources and historical properties and sites. Elaborates and ensures the application of the strategy and policies in the field of culture, national cultural heritage, as well as intangible heritage.

Name	Role
Ministerul Dezvoltării, Lucrărilor Publice și Administrației, Ministry of Development, Public Works and Administration (https://www.mdlpa.ro/)	Government department responsible for assisting in general supervision over local governments. Provides the secretariat of the Maritime Space Planning Committee. It is the authority for maritime space planning. It carries out government policies in spatial planning.
Ministerul Economiei, Ministry of Economy (http://www.economie.gov.ro/)	Government department responsible for the regulation, management, and growth of industry and trade.
Ministerul Educației, Ministry of Education (https://edu.ro/)	Government department responsible for managing and supervising Romania's technical education and skills development.
Ministerul Energiei, Ministry of Energy (http://energie.gov.ro/)	Government department that prepares, integrates, coordinates, supervises, and controls all energy-related plans, programs, projects, and activities, covering both traditional and renewable sources.
Ministerul Antreprenoriatului și Turismului , Ministry of Entrepreneurship and Tourism (http://imm.gov.ro/)	Government department is responsible for overseeing and promoting the tourism industry in Romania, as well as implementing the Government Program in fields such as entrepreneurship, small and medium-sized enterprises, foreign investments, business environment, and foreign trade, in addition to tourism.
Ministerul Mediului, Apelor și Pădurilor, Ministry of Environment, Water and Forests (http://www.mmediu.gov.ro/)	Government department responsible for the conservation, management, development, and appropriate use of the environment and natural resources within the country.
Ministerul Finanțelor, Ministry of Finance (https://mfinante.gov.ro/ro/web/site/)	Government department responsible for the formulation, institutionalization, and administration of fiscal policies.
Ministerul Afacerilor Externe Ministry of Foreign Affairs (http://www.mae.ro/)	Government department responsible for implementing the foreign policy of Romania, in accordance with the legislation in force and with the Government's Program.
Ministerul Afacerilor Interne, Ministry of Internal Affairs (https://www.mai.gov.ro/)	Government department responsible for implementing Romania's internal policy in accordance with current legislation and the Government's Program.
Ministerul Apărării Naționale, Ministry of National Defence (https://www.mapn.ro/)	Government department responsible for guarding against external and internal threats to peace and security. It establishes limits of the safety zones of military ships and the perimeters and regimes of military ports.
Ministerul Cercetării, Inovării și Digitalizării Ministry of Research, Innovation and Digitalization (https://www.research.gov.ro/)	Government department responsible for establishing and updating Romania's strategic objectives in the field of scientific research, technological development and innovation.
Ministerul Muncii Si Solidaritatii Sociale Ministry of Labour and Social Solidarity (http://mmuncii.ro/j33/index.php/ro/)	Government department responsible for managing policies related to labor, social protection, and social inclusion in Romania. Also responsible for promoting employment and job creation, ensuring safe working conditions, managing social assistance programs, and overseeing pension and health insurance systems.
Ministerul Transporturilor și Infrastructurii, Ministry of Transport and Infrastructure (https://www.mt.ro/web14/)	Government department responsible for the promotion, development, and regulation of transportation systems and transportation services. Also responsible for the development of the maritime industry of Romania and development and regulation of shipping enterprises.

Name	Role
Agenția Națională pentru Resurse Minerale, The National Agency for Mineral Resources (NAMR) (https://www.namr.ro/home-page/)	Agency responsible for issuing licenses for mineral exploration and mining, regulating and overseeing mining activities, conducting geological surveys, managing the country's mineral resources database, and promoting investment in the mining sector. Operates under the Ministry of Economy.
Administrația Națională Apele Române, (NARW) National Administration of Romanian Waters (https://rowater.ro/)	Agency managing surface and ground water resources in Romania, allocating use rights, ensuring flood protection, and administering the Water Management National System. Operates under the Ministry of Environment, Water and Forests.
Agenția Națională, pentru Pescuit ș,i Acvacultură, National Agency for Fishing and Aquaculture (http://anpa.ro)	Agency responsible for the promotion of fisheries development and growth. Operates under the Ministry of Agriculture and Rural Development in the development of the maritime space.
Agenția Națională pentru Arii Naturale Protejate, (ANANP) National Agency for Protected Natural Areas (http://ananp.gov.ro/)	Government department responsible for the development, improvement, management, and conservation of the country's fisheries and aquatic resources. Operates under the Ministry of Environment, Water and Forests.
Politia de frontiera, Romanian Border Police (https://www.politiadefrontiera.ro/en/main/home.html)	A law enforcement agency responsible for protecting and guarding the Romanian border.
CERONAV, Romanian Center for the Training and Improvement of Naval Transport Personnel (https://www.ceronav.ro/index.html)	A self-financed public national institution providing marine training. Linked to the Ministry of Transport and Infrastructure.
Autoritatea Națională de Reglementare în domeniul Energiei, Romanian Energy Regulatory Authority (https://www.anre.ro/en/)	Authority responsible for the regulation of the heating, electricity and gas markets in Romania. Role is to issue, approve and monitor the implementation of regulatory framework for the electricity, heat and natural gas sectors and markets in terms of efficiency, competition, transparency and consumer protection.
Autoritatea Navală Română, Romanian Naval Authority (https://portal.rna.ro/english)	Authority responsible for enforcing maritime laws, conducting maritime security operations, safeguarding life and property at sea, and protecting marine environment and resources, Operates under the Ministry of Transport and Infrastructure.
Offtakers and power companies	
Electrica E.ON ČEZ Group Public Power Corporation (PPC), of Greece	Power distribution companies
Transelectrica	Publicly traded (mainly state owned) company responsible for operating, maintaining, and developing the country's state-owned transmission network.
Offshore wind project developers known to have expressed interest in offshore wind in Romania	
Copenhagen Offshore Partners	Developer with expressed interest in Romania
European Energy	Developer with expressed interest in Romania

Name	Role
Hidroelectrica	Developer with expressed interest in Romania
Skyborn renewables (wpd)	Developer with expressed interest in Romania
TotalEnergies	Developer with expressed interest in Romania
Supply chain businesses known to be active in OSW in Romania.	
Damen	Operates Mangalia Shipyard
Jan De Nul	Globally active installation / EPC contractor with office in Romania.
Port of Constanța	Constanța port has the role of port authority for the Romanian Ports – Constanța, Midia and Mangalia (and Tomis Marina).
Prysmian	Manufacturer of transmission cable
STX Europe	Has two shipyards in Romania
Vard	Has ship building facilities on the Danube.
Non-government organizations with relevance or declared interest in offshore wind	
Arcadia Romanian Association for International Cooperation and Development (https://arcadianetwork.org/)	Focuses on international cooperation and development by providing a neutral space for analysis of development issues and engaging with international partners.
HENRO (https://henro.ro/)	Energy sector association comprising Hidroelectrica, Electrocentrale București, Nuclearelectrica, Romgaz and Complexul Energetic Oltenia to provide a common voice to authorities.
Mai Bine (https://www.traieste.maibine.org/)	Aims to create an inclusive local community that promotes environmental protection, social entrepreneurship, fair trade, civic involvement, and the circular economy through various activities, events, initiatives, and projects.
Mare Nostrum (https://www.marenostrum.ro/)	Focuses on education for sustainable development, marine and coastal biodiversity conservation and natural resources management.
REPER 21 (https://reper21.ro/)	Promotes societal responsibility and sustainable development by creating a space for dialogue, creation, and action.
Romania Wind Energy Association (https://rwea.ro/en/)	National wind energy association (covering onshore and OSW).
WWF Romania (https://wwf.ro/)	WWF Romania is the local chapter of WWF that aims to conserve nature and reduce threats to the diversity of life on Earth through partnerships.
Academic organizations with relevance or declared interest in offshore wind	
Dunărea de Jos University of Galați	Currently conducting Project DREAM (Dynamics of the REsources and technological Advance in harvesting Marine renewable energy) which involves evaluating the wind parameters of different European coastal environments and assessing the expected performances of recent technologies for harvesting marine renewable energy, as well as analyzing the synergy of wind with wave and solar energy and assessing the impact of marine energy farms on the shoreline dynamics.

Name	Role
Danube Delta National Research and Development Institute – INCDDD	Conducts research on wetland ecosystems, biodiversity monitoring, and sustainable use of natural resources. Also provides feasibility studies and technical input for fisheries and environmental reconstruction works.
National Research and Development Institute for Marine Research "Grigore Antipa" Constanța	Focuses on basic research and applied technology related to coastal and marine environment management. Responsible for proposing environmental regulations and representing Romania in marine science with international organizations. Conducts oceanographic surveys and research on marine aquaculture, marine radioactivity, and the protection and conservation of marine resources.
National Research-Development Institute for Marine Geology and Geoecology - GeoEcoMar Bucharest	Experience in research in marine geophysical mapping, ecosystem understanding and natural hazard monitoring. Provides services such as impact studies and environmental assessments.
Politehnica Bucharest University	Managed the Aqua-RET2 project to identify the labor market needs of the marine renewable sector and develop innovative training programs to meet those needs. Plan to help transfer skills to the marine renewables sector and ensure that training is responsive to labor market needs.

APPENDIX A: GLOSSARY

Abbreviation	Definition
AEP	Annual energy production
ATR	Grid connection permit
BP	Building permit
CAPEX	Capital expenditure
CCS	Carbon capture and storage
CfD	Contract for difference
CTV	Crew transfer vessel
DFI	Development finance institution
DSO	Distribution system operators
EEZ	Exclusive economic zone
ESF	Environmental and Social Framework
ESIA	Environmental and social impact assessment
ESS	Environmental and social standards
FEED	Front end engineering and design
FID	Final investment decision
FTE	Full-time equivalent
GCA	Grid Connection Agreement
GEBCO	General Bathymetric Chart of the Oceans
GIIP	Good international industry practice
GIS	Geographical information system
GVA	Gross value added
GWA	Global wind atlas
GW and GWh	Gigawatt and Gigawatt hour
HVDC	High voltage direct current
H&S	Health and safety
KBA	Key Biodiversity Areas
LCOE	Levelized cost of energy
LCOH	Levelized cost of hydrogen
MDB	Multilateral development bank
MFI	Multilateral Financing Institution
MSP	Marine spatial plan
MW and MWh	Megawatt and Megawatt hour
NDC	Nationally Determined Contribution
NECP	National Energy and Climate Plan
NGO	Non-governmental organization
NRRP	National Resilience and Recovery Plan

OMS	Operations, maintenance and service
OPEX	Operational expenditure
OSS	Offshore substations
OSW	Offshore wind
PEM	Proton Exchange Membrane
PPAs	Power purchase agreements
PPPs	Public private partnership
RD&D	Research, design and development
RE	Renewable Energy
SDG	Sustainable Development Goal
SEA	Strategic environmental assessment
SOE	State-owned enterprise
SOLAS	Safety of life at sea regulations
SOV	Service operation vessel
SPMT	Self-propelled modular transport
SVC	Static var compensator
TDP	Transmission Development Plan
UC	Urbanism certificate
WACC	Weighted average cost of capital
WCD	Works completion date
WDPA	World database on protected areas

APPENDIX B: ORGANIZATION ABBREVIATIONS

Abbreviation	Definition
ACROPO	Authority for the Regulation of Offshore Oil Operations in the Black Sea
ANRE	The National Energy Regulatory Authority
BVGA	BVG Associates
CIF	Climate Investment Funds
DTU	Danish Technical University
EBRD	European Bank for Reconstruction and Development
EIB	European Investment Bank
ESMAP	Energy Sector Management Assistance Program
EU	European Union
GCF	the Green Climate Fund
GEF	the Global Environment Facility
GWEC	Global Wind Energy Council
GWNET	Global Women's Network for the Energy Transition
GWO	Global Wind Organization
IFC	International Finance Corporation
IRENA	International Renewable Energy Agency
ISPE	Institute for Power and Engineering
MIGA	Multilateral Investment Guarantee Agency
MOE	Ministry of Energy
NAMR	National Agency for Mineral Resources
NATO	North Atlantic Treaty Organization
NBR	National Bank of Romania
UNFCCC	the United Nations Framework Convention on Climate Change
WBG	World Bank Group

APPENDIX C: CONCEPT STUDY FOR AN EARLY OFFSHORE WIND PROJECT IN ROMANIA

1. PURPOSE

This study is intended to complement the content within the Offshore Wind Roadmap for Romania (referred to throughout as the 'Roadmap'). The Roadmap provides a high-level strategic assessment of the potential for offshore wind (OSW) in Romania. This study, however, focuses on a hypothetical OSW project which is intended to be representative of one of Romania's early OSW projects. The intention of this study is to provide the Ministry of Energy (MOE) and other stakeholders with context on the delivery of an early OSW project in Romania and how these private sector development activities relate to the public sector recommendations made in the Roadmap.

For the hypothetical OSW project considered in this study, we have assumed a project size of about 300 megawatts (MW), balancing the higher levelized cost of energy (LCOE) cost of a smaller project with the lower risk. Many projects in other markets are larger to reduce LCOE through economies of scale and make efficient use of the limits of current electrical equipment. We have chosen an indicative location, as shown by the star in Roadmap Figure 6.2. The assumptions made in this appendix are broadly representative of likely sites in Romania.

2. METHOD

To develop the project concept and delivery strategy we carried out:

- Project plan definition, including description of activities in the development stage.
- Site initial design based on assumptions and considerations for an early project
- Balance of plant initial design
- Installation initial design
- Operational strategy initial design
- Levelized cost of energy initial estimation.

This appendix is structured following these six topics, starting with a list of key recommendations that need to be progressed to enable timely development of early projects.

Further information on OSW project components is available in *Guide to an Offshore Wind Farm*[88].

3. PREREQUISITES FOR COMMERCIAL DEVELOPMENT OF AN EARLY PROJECT

When developing OSW projects for the first time in any new market, investors will need sufficient certainty in the market to encourage them to invest. Early OSW projects, such as described here, will only progress if various prerequisites to support OSW completed in time. The key prerequisites for Romania are provided in the following list (these items are the priority recommendations provided in Roadmap Section 5).

1. The Ministry of Energy (MOE) establishes how OSW fits within Romania's broader energy strategy, including through a least cost generation analysis, considering temporal patterns for generation by onshore wind, solar and OSW.
2. The MOE progresses a proportionate OSW spatial plan, incorporating Strategic Environmental Assessment in line with Good International Industry Practice (GIIP), involving:
    - Sensitivity mapping of environmental and social attributes
    - Consideration of avian migration routes to/from the wetlands of the Danube Delta
    - Better understanding of the distribution and abundance of cetaceans, and
    - The cumulative impact of multiple projects.

    This should include focus on engagement with key stakeholders and will result in early designation of offshore wind energy areas.
3. The MOE and Ministry of Economy include OSW in the next revision of the National Maritime Plan, formalizing the proportionate OSW spatial plan described above.
4. The MOE introduces a new, clear and investor-friendly OSW law and associated regulation relating to OSW frameworks, involving other public stakeholders, as required.
5. The Government General Secretariat establishes a one-stop-shop permitting entity in order to simplify the decision-making process and interface for project developers and enables the use of digital services for submitting applications and similar.
6. The new permitting entity develops an OSW specific process based on the current permitting process, also ensuring that it meets GIIP to help de-risk projects and facilitate access to international finance.
7. Transelectrica develops a 2050 vision for a nationwide electricity transmission network for a decarbonized energy system, with milestone plans for 2030 and 2040 and consideration of finance. This is a topic much wider than OSW, considering all electricity, transport and heat, and should include viability of subsea interconnection between Ukraine, Romania, Bulgaria and Türkiye and also with Azerbaijan, providing balancing between the relevant states. Transelectrica incorporates MOE's OSW development vision into its next ten-year plan, published in 2024, and considers offshore hubs and the potential impact of international interconnects.
8. Transelectrica undertakes power systems studies to understand the potential impacts of large volumes OSW on the future transmission network and Environmental and social impact assessments (ESIAs) in line with GIIP and lender requirements to understand the environmental and social implications of transmission network upgrades, feeding these into MSP activities.

9. Transelectrica, MOE, distribution system operators (DSOs) and other relevant balancing parties agree a softening of the network management rules to better reflect the probabilistic nature of variable output renewables, including OSW, whilst remaining with EU regulations.
10. The National Energy Regulatory Authority (ANRE) amends the template grid connection agreement (and any auxiliary regulations) to incorporate compensation terms in the grid connection agreement to apply if transmission network reinforcement is delayed and this impacts export of energy.

The presence of these prerequisites will enable early projects to progress, but further actions, as described in Roadmap Section 5 are needed to establish a longer-term pipeline of projects.

4. PROJECT PLAN DEFINITION

4.1 Overview of project development and delivery

The development and construction of an OSW project is typically a long and expensive process, especially when compared with other renewable energy projects like onshore wind and solar PV. In established OSW markets, it usually takes five to ten years to develop a commercial-scale project from initial concept to financial close, and a further two to three years to construct it. During the development phase for this scale of project, a developer is likely to incur between €40 and 70 million of development expenditure (DevEx).

We have assumed that the example, early OSW project in Romania, described in the following sections, could be delivered within nine years from the start of the early development activities. If the Government starts the early development activities in 2023, the project could be operational before 2032. This assumes the Government follows the recommendations in Roadmap Section 5 and that project development and construction activities follow good industry practices and proceed at a pace typically witnessed in other markets.

There are expected to be three phases in the development of an OSW project in Romania:

- Early-stage development (under exploration license)
- Power purchase competition, and
- Late-stage development (including construction).

Figure C4.1 shows the major development activities required to deliver this example, early OSW project, and the timeline for these activities, along with the phases of development. Four milestones are shown; site exploration license award; award of revenue competition; financial investment decision; and commercial operations date (COD). For development to progress efficiently, numerous activities need to be undertaken in parallel – delays in any activity will usually have a subsequent impact on the progress of another. The typical duration for each of the activities shown in Figure C4.1 is based on industry norms and good practice. These activities and their purpose are discussed in Appendix C Sections 4.3 to 4.5.

FIGURE C4.1 TIMELINE FOR EXAMPLE EARLY OFFSHORE WIND PROJECT [xxxiii]

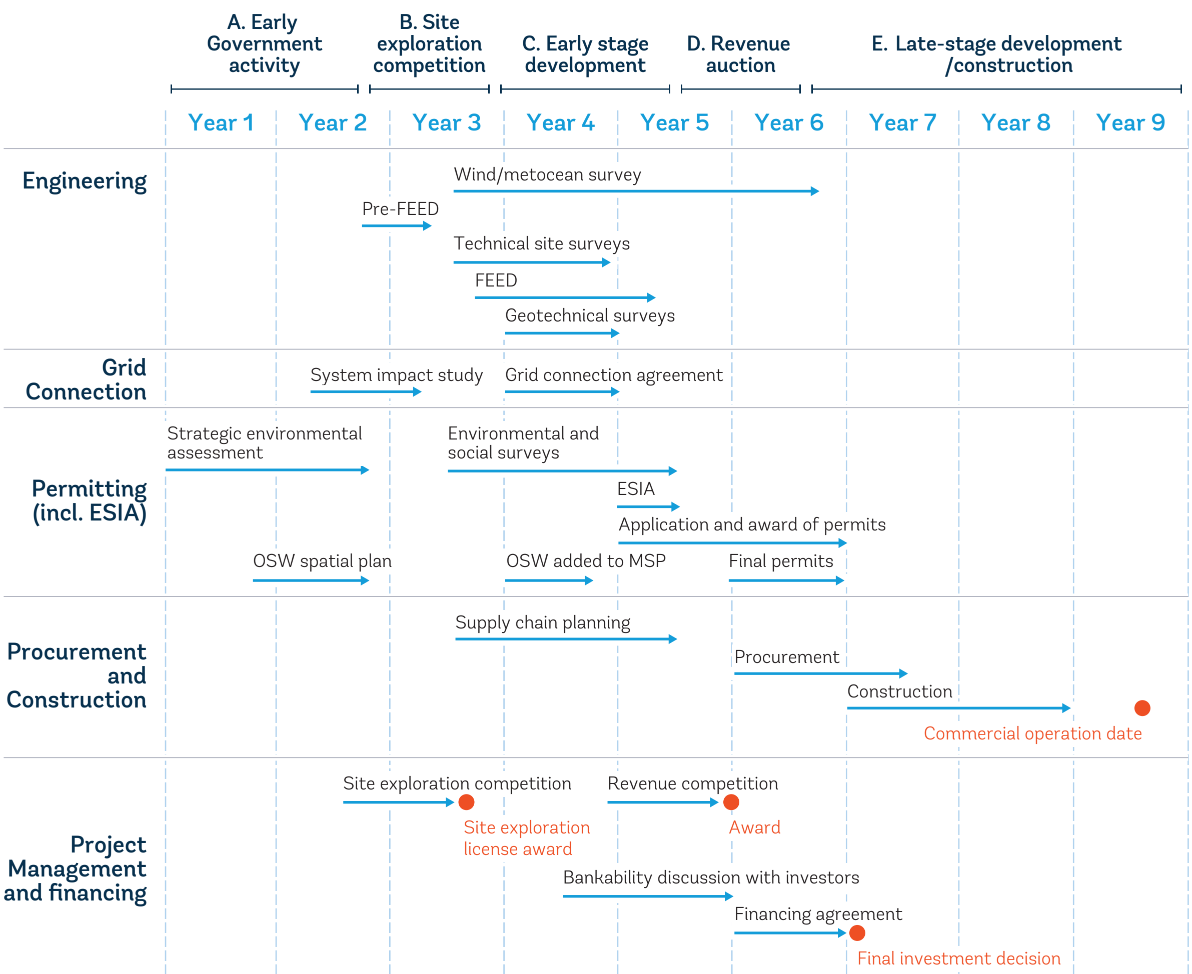


Table C4.1 provides a breakdown of the estimated development and capital costs associated with the delivery of this example, early OSW project. These estimates are based on typical costs from other emerging OSW markets and can be highly variable depending on site conditions, environmental survey requirements, and delays. In this example, around €15million is likely to be spent in the exploration phase before offtake competition, and about €45 million is likely to be spent in total on all development activities prior to reaching financial close and commencing construction. There are many risks related to this expenditure and investors need to reduce and manage those risks through the development process to provide sufficient certainty to invest more.

The total capital expenditure (CAPEX) for this example 300 MW OSW farm is around €1billion. This is equivalent to around €3.5 million per MW and is the industry's typical forecast cost for the latter part of this decade. The project CAPEX could vary significantly however, due to numerous factors over the eight year period, but particularly site conditions, program delays, and equipment price fluctuations.

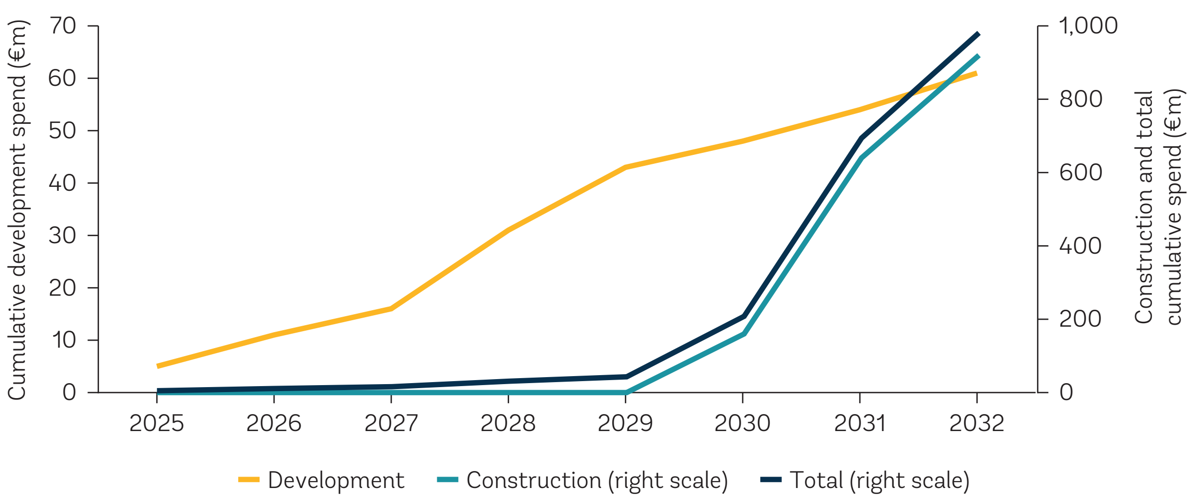
The estimated spend profile for the project throughout its development and construction is summarized in Figure C4.2.

xxxiii. Note: ESIA = Environmental and social impact assessment; FEED = front-end engineering and design

TABLE C4.1 ESTIMATED COSTS TO DEVELOP AND CONSTRUCT AN EXAMPLE 300 MW OFFSHORE WIND PROJECT

Project spend, rounded (€m)	2025	2026	2027	2028	2029	2030	2031	2032
Stage	Early-stage development			Power purchase competition	Late-stage development			
Design	0.5	0.5	0.5	3	0.5			
Wind / metocean survey	0.7	0.7	0.7					
Technical site surveys	1	2	1	8	8			
Environmental and social surveys	1.5	1.5						
Project management / development team / other subcontract	1	2	2	4	4	5	6	7
Construction						160	480	280
"Annual development, exc. construction"	5	7	4	15	13	5	6	7
"Cumulative development, exc. construction"	5	11	16	31	43	48	54	61
Cumulative, construction only	0	0	0	0	0	160	640	920
Cumulative, total	5	11	16	31	43	208	694	981

FIGURE C4.2 ESTIMATED SPEND PROFILE FOR THE DEVELOPMENT AND DELIVERY OF AN EXAMPLE EARLY OFFSHORE WIND PROJECT



4.2 Project development team

The size of the core development team is likely to grow from less than 10 at the start of the development, to around 15 people at the revenue competition stage, and finally 20-30 by the time the project gets to the construction stage. During the construction stage the size of the team will depend on the contracting structure chosen but could be as high as 40 people. These numbers only refer to the dedicated project team and do not include the thousands of third-party staff required at different times for development, fabrication, and installation activities.

During the project's operations phase, the core team would typically comprise about 8 office-based staff plus 8-10 15 professional service staff plus 20 practical technicians, working double shifts on a 24/7 basis.

4.3 Early-stage development

Early Government activity

In this stage the Government undertakes the necessary early activities to enable a site exploration competition, including a strategic environmental assessment (SEA) and establishing visions and targets for OSW and how it fits in with the broader energy strategy.

Activities in this stage includes:

- Retaining an Independent Engineer and Transaction Advisor to support activities.
- Establishing potential OSW energy areas based on:
  - A SEA using available environmental and social data, and
  - An economic analysis based on a basic technical review confirming wind speeds and geotechnical conditions.
- Designating either OSW sites or wind energy areas for the site exploration competition.
- Progressing the OSW law, setting installed capacity targets for OSW in 2030 and 2035, and an OSW capacity vision to 2035 and beyond.
- Establishing how OSW fits within the broader energy strategy, including a least cost generation analysis considering temporal patterns for generation by onshore wind, solar and OSW.
- Running a site exploration license competition as outlined in Roadmap Section 13.

Early stage development

In this stage the developer(s) awarded the site exploration license carries out a number of early stage development activities, including carrying out a range of technical, environmental and social surveys, obtaining a grid connection agreement, applying for and obtaining permits, as well as project design work.

Activities in this stage (see Figure C4.1) include:

- A preliminary front-end engineering and design (pre-FEED) study.
  - Pre-FEED studies are used to develop an outline concept of the project for the purposes of defining the consent envelope and to inform environmental and social impact assessment.[xxxiv]
  - A pre-FEED study includes development of the project concept including outline definition of the wind farm design, turbine dimension envelope, foundation options, electrical export system design, export cable routing, OSS design, grid connection and onshore substation, construction ports and operational facilities. It goes into greater detail than the conceptual assumptions and options considered within this high-level report.

xxxiv. The use of a consent envelope, (the principle named the Rochdale Envelope in the UK), provides the ability to permit a project without fixing every detail. This is important as offshore wind technology continues to progress rapidly compared to project development timelines. The envelope encompasses ranges of technical characteristics, such as the number of turbines, variations of rotor diameters and blade tip heights, and different foundation types. This means that developers have the flexibility to make those decisions later on in the project development, but still get the permits needed early on.

- As the project's development progresses and more data is gathered through technical surveys, the depth and detail of the design progresses. The pre-FEED study is developed into a full FEED study which contains far more analysis than the outline, conceptual design in the pre-FEED work. This FEED study will be continually refined through the development process and then will be deepened even further in the post-PPA award development phase, as the final design is completed.
- Technical surveys including wind resource, metocean, geological and hydrographical data collection campaigns.
  - Wind resource and metocean assessment is carried out to provide atmospheric and oceanographic datasets to inform the engineering design of a wind farm, potential future energy production, and to fully define the operating conditions at the proposed wind farm location.
    - OSW resource data collection campaigns will typically utilize vertical profiling wind lidars (Light Detection and Ranging). Lidars are remote sensing devices that use lasers to measure wind speed and direction up to 250m above sea level. Lidars can be installed on floating buoys or on fixed platforms. Good International Industry Practice (GIIP) is to collect at least two years of wind resource data for the purposes of establishing a robust understanding of the site wind resource to inform subsequent project finance evaluation and engineering design activities.
    - Typically, a measure-correlate-predict (MCP) process is used to predict long-term wind resource. This combines on-site measurement over a small number of years with long-term datasets from nearby. Some developers may choose to continue data collection until on-site construction starts. Actual developer choices will depend on confidence of investors in the certainty of wind resource. For each site, there becomes a point where the cost of further investment in resource measurement outweighs the benefits due to reduction in uncertainty. For early projects in Romania, this point may be later than in established OSW markets which often have long-term datasets to correlate with.
    - Metocean surveys are used to measure the wave and tidal conditions at the project location. The data is used to inform foundation design and operational vessel selection. Metocean sensors include wave, sea level and current sensors (for example acoustic Doppler current profiler). These can sometimes be sea bed-positioned or located on floating buoys, including integration with floating Lidars. These will record the full wave data spectrum including velocity, direction and period. Multiple sensors are used to provide spatial coverage and redundancy.
  - Geological seabed surveys analyze the seabed of the proposed wind farm site and export cable route to assess its geological condition and engineering characteristics. The data collected is utilized in a wide range of engineering and environmental studies. They consist of geophysical and geotechnical surveys.
    - Geophysical surveys establish sea floor bathymetry, seabed features, water depth and soil stratigraphy, as well as identifying hazardous areas on the seafloor and risks such as unexploded ordnance (UXO). Geophysical surveys are non-intrusive and include remote sensing techniques such as seismic methods, echo sounding and magnetometry. The techniques used consist of bathymetry (water depth) mapping with conventional single or multibeam echo soundings or swathe bathymetry, sea floor mapping with side scan sonar, magnetometer for UXO, acoustic seismic profiling methods and high-resolution digital surveys. Surveys run along transects across zones within the proposed wind farm site and cable routes.
  - Hydrographic surveys examine the impact of the wind farm development on local sedimentation and coastal processes, such as erosion. They are often part of geophysical surveys. Such

surveys are also repeated by the project developer as part of the post construction monitoring during the operations phase.

- Financing strategy development, including discussions with lenders to ensure bankability and on high-level, indicative terms (needed to inform the bid price for the revenue auction). It is possible to reduce the cost of finance though reducing risk at all stages of activity.
  - Environmental, social, and technical studies (both onshore and offshore) including; baseline bird, habitat and marine mammal surveys; social studies including, socioeconomics, fishing, archaeology, cultural heritage, and visual impact assessment; and technical studies including marine navigation.
  - Environmental studies are undertaken by specialists with expertise in local habitats and species. Survey vessels and aircraft are used to collect the data. Surveys look at the distribution, density, diversity and number of different species.
  - GIIP is to collect two years of data covering consecutive species breeding and migration seasons. This data will be required for input into the pre-FEED and environmental and social impact assessment (ESIA).
  - Social studies assess the impact that a proposed wind farm may have on the community living in and around the coastal area near the wind farm. These studies should particularly investigate the potential for adverse impacts on livelihoods, cultural heritage, tourism, recreation, and vulnerable communities.
  - Marine navigation studies are undertaken by specialist contractors. Baseline data on existing marine traffic in and around the proposed wind farm are compiled from existing records, usually obtained from automatic identification systems installed on most medium and large sea going vessels. The potential impact of the wind farm on marine traffic is assessed and restricted areas identified.
  - Socio-economic studies assess the impacts of a wind farm or coastal infrastructure, for example a port, such as changes in employment, transportation or recreation, or changes in the aesthetic value of a landscape. It estimates the impacts on the local society, not only of these socio-economic changes, but also of the composite of biological, geological, and physical effects caused by the proposed change on the local area. Socio-economic studies include a mix of objective and subjective data. Objective data can include statistics on age, income distribution, ethnicity, mortality, housing type and occupancy, and education. Subjective data can be derived from surveys and observations. These are used to provide systematic estimates of the ways in which various groups perceive their socio-economic environment and thus the impact of the proposed change. Studies also consider the onshore cable route and substation.
  - Fishing studies consider the impact of the proposed wind farm on artisanal and commercial fishing areas. They involve consultation with local fishing stakeholders and identify areas of restriction and mitigation measures.
  - Archaeology studies are carried out by specialist contractors who identify areas of archaeological sensitivity that might be impacted by the onshore and OSW farm infrastructure. Areas of restriction and mitigation measures are identified.
  - Visual assessments comprise of photomontages from specific viewpoints of what the proposed wind farm and associated infrastructure will look like. These are used to inform consultation exercises with relevant stakeholders including covering defense, environmental, fisheries, local communities, tourism and transport considerations.

- An ESIA, which will be used to secure the permits prior to the revenue auction.
  - The preliminary ESIA will assess the potential impact of the proposed development on the physical, biological and human environment during the construction, operation and decommissioning of the example early OSW project.
  - After assessing the potential impacts, mitigation measures are defined and applied to determine the residual effects associated with the development. A core part of the ESIA is the cumulative impact assessment (CIA) where the impacts of the example early OSW project are combined with those impacts from other OSW projects are assessed.
  - Consultation with statutory consultees, special interest groups and the local community is performed throughout the ESIA process and allows the consenting authority as well as other stakeholders and the public to voice their opinion.

4.4 Power purchase competition

In this stage the Government makes the data collected in the previous stage available and runs a revenue auction. Activities in this stage includes:

- Opening a data room of all the data from the early stage development work.
- Running an auction among pre-qualified companies and selects winners for each site.
- This requires bidders to carry out project planning and costing, based on a sourcing strategy, which includes consideration of:
  - How products and services are purchased, with the most common broad strategies being via:
    - Wide engineer, procure, construct and install (EPCI) contracts, where a few, large contracts are placed, each for an end-to-end scope of supply, or
    - Multi-contracting, where the project developer takes a more involved role managing different contracts for supply and installation of different items[xxxv].
  - What forms of relationship are established, typically then linking to what forms of contract are used, with a range of combinations available, covering:
    - Long-term relationships, with incentives to reduce cost / add value, and potentially share benefits of successful delivery, through to
    - Single-project relationships driven by short-term least cost / best value, with only penalties for late/poor delivery.
  - Health and safety (H&S) requirements for the project, as Romania does not currently have any H&S regulation in place specifically for the OSW industry. There requirements should be in line with international regulations, standards, and guidelines, as well as national standards and regulations where applicable.
- The winner(s) compensates the site exploration consortia where applicable.
- If any of the sites do not proceed beyond this point, then the Government compensates site exploration consortium.

xxxv. For more information about contracting strategies, see https://guidetoanoffshorewindfarm.com/procurement-structures#.

4.5 Late-stage development

Development and commercial stage

The aim of this stage of activity is for the developer to finalize the detailed design of the example early OSW project, to secure all remaining permits, reach a final investment decision (FID), finalize procurement, and construct the project.

Activities in this phase of work include:

- Completion of the environmental and technical surveys, including detailed site specific geotechnical surveys, to inform detailed design activities
  - Geotechnical site investigations are conducted to determine soil/rock strata boundaries and engineering properties or specific sea floor features. Geotechnical studies are predominantly intrusive and include such methods as boreholes with soil/rock sampling, and cone penetration testing (CPT).
  - Geotechnical surveys require specialized equipment and skilled personnel. The scope of the investigation depends on the type of foundation being considered and the variability in the seabed characteristics. Boreholes and CPTs to depths of up to 70m are carried out to investigate the physical characteristics of the seabed. Surface push CPTs are also used as a rapid method to gather sea bed soil stratigraphy.
- Finalization of design activities
- Securing final permits and grid connection agreement
- Completion of turbine and balance of plant procurement
- Securing financing agreement and reaching FID, and
- Project construction.

5. SITE INITIAL DESIGN

5.1 Preliminary project concept

To establish key parameters for this early example project, we considered likely typical conditions in Romania, as discussed in Roadmap Section 6, technology likely to be available in the market at the time of procurement, and international good practice. In practice, a developer would establish these parameters in the site exploration phase.

The key parameters of the early example project are listed in Table C5.1. A large-scale project is chosen in order to provide economies of scale and reduce levelized cost of energy (LCOE) to levels competitive with other forms of generation.

TABLE C5.1 KEY PARAMETERS OF THE EARLY PROJECT BASED ON SITE ASSUMPTIONS

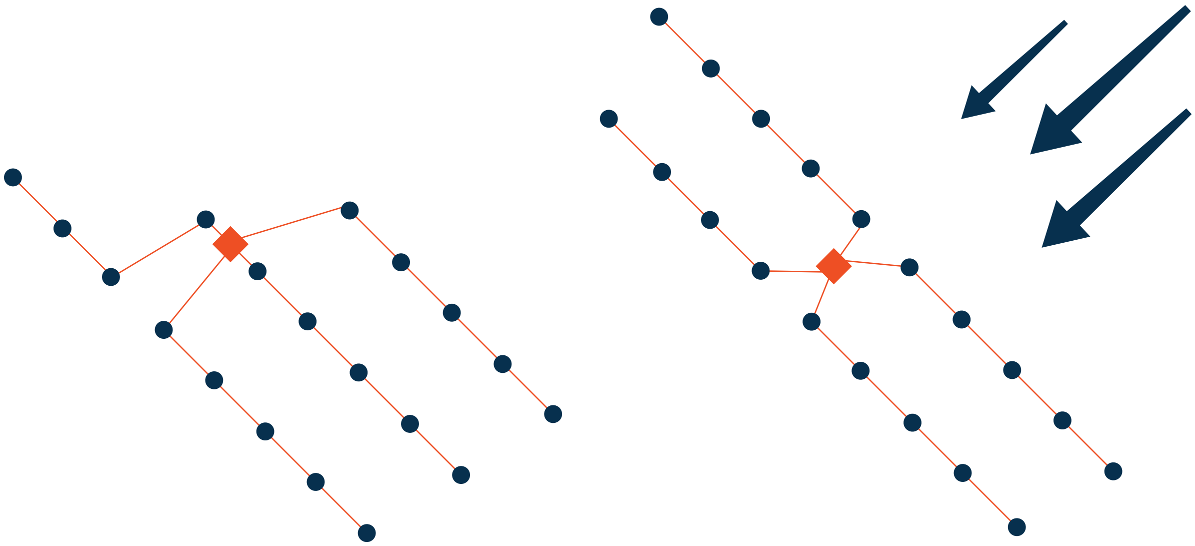
Parameter	Units	Value	Notes
Project capacity	MW	About 300	This capacity likely covers an area of approximately 70 km^2 and incorporates 19 turbines with a capacity of 16 MW each. Electrical connections are based on the use of a standard HV transformer on a single offshore substation.
Commercial operation date (COD)		2032	Fastest anticipated timing.
Final investment decision (FID)		2029	
Turbine rating	MW	16	Expected largest turbine available in the market when turbine needs to be selected, as discussed in Roadmap Section 7. Typically, the largest turbines available offer the lowest LCOE.
Rotor diameter	m	256	Anticipated rotor size for 16 MW turbine, as used in the modelling in Roadmap Section 7 and typical of products anticipated being available in the market, without matching any particular product announced to date.
Mean wind speed (100m height)	m/s	7.6	Typical for anticipated Romanian sites and consistent with starred location in Roadmap Figure 6.2.
Mean water depth	m	50	Typical for anticipated Romanian sites and consistent with starred location in Roadmap Figure 6.2.
Geology/seabed characteristic			Sand/mud assumed suitable for use of monopiles.
Offshore export distance	km	80	Typical for anticipated Romanian sites and consistent with starred location in Roadmap Figure 6.2.
Onshore cable distance	km	20	Arbitrary choice, as no specific connection point assessed.
Transmission technology		HVAC	Single small OSS is required.
Distance from construction port	km	80	Typical for anticipated Romanian sites and consistent with starred location in Roadmap Figure 6.2.
Distance from operations port	km	80	Typical for anticipated Romanian sites and consistent with starred location in Roadmap Figure 6.2.

5.2 Layout

With the prevailing wind direction for Romania being from the north east, the turbines are assumed to generally face in a north easterly direction. Based on typical industry 'rules of thumb', two preliminary layouts are shown in Figure C5.1.[xxxvi] The turbine locations are shown in black, array cables and offshore substation (OSS) in red and prevailing wind direction in blue. A multi-row, radial string topology for array cables is the most appropriate and is similar to that adopted for many operational wind farms worldwide. There are numerous alternative array topologies that could be investigated and selected at the FEED stage, based on the site constraints for which algorithms can be applied to optimize LCOE.

xxxvi. The spacing will depend on detailed modelling of aerodynamic wake effects and techno-economic optimisation of lifetime cost and energy production. From assessment of operating projects, typical turbine spacing is nine rotor diameters (downwind of the prevailing wind direction, assuming that there is one) and six rotor diameters (across-wind), as stated in Roadmap Section 10.

FIGURE C5.1 PRELIMINARY LAYOUT OF EXAMPLES FOR EARLY PROJECT AT A GENERIC LOCATION



5.3 Turbine selection

The selection of the turbine size and technology is a critical decision for any proposed OSW project and will not only be based on LCOE, but also a variety of other factors including:[xxxvii]

- The availability and track record of specific wind turbine models available to Romania
- The wind turbine supplier capability
- The suitability of the turbine for the prevailing conditions
- The track record of the supplier
- The general reliability of the machines
- The SCADA system capabilities for the wind turbine
- The progress with certification for new models, and
- The operational phase support arrangements potentially offered by the suppliers.

Generally, the larger the capacity of the wind turbine, the lower the LCOE due to lower per MW costs for many elements and higher energy production due to higher turbine hub height.

Site mean wind speed

The site mean wind speed is lower than for typical sites in established OSW markets, meaning the energy production (and hence capacity factor) is lower, as shown in Roadmap Table 7.3.

Typically, projects at lower-wind sites will use a turbine with a lower specific rating (ratio of rated power to rotor swept area, W/m2). In other words, for a turbine of given rating, with a larger rotor diameter to capture more energy during the time when the turbine is operating at below its rated power.

xxxvii. For more information about turbines, see https://guidetoanoffshorewindfarm.com/guide#T.

In onshore wind, turbine suppliers offer a range of turbines of similar scale with a range of specific ratings to suit a wide range of sites. These are described according to international standard IEC-61400. IEC wind Class I turbines are designed for the highest wind sites and Class IV for the lowest.

In OSW, as the global market size currently is smaller, and the range of mean wind speeds on viable sites is smaller, turbine suppliers have yet to offer such a range. Currently, almost all OSW turbine suppliers offer products to IEC wind Class I. Towards the end of the 2020s or into the 2030s, more wind turbine suppliers are likely to offer offshore turbines more suited to lower wind sites such as those in Romania. If this does not happen, then it may be that smaller turbines (of scale 5 to 7 MW) designed for onshore lower-wind sites may offer a lower LCOE solution than the use of larger turbines optimized for higher wind sites.

6. BALANCE OF PLANT INITIAL DESIGN

6.1 Turbine foundations

The mean water depth for the example early project site is 50 m. project developers expect to use monopiles for such depths with the chosen scale of turbines, with jacket foundations sometimes being preferred.

The choice of foundations depends on a number of factors other than water depth, such as the geological conditions, environmental considerations, the local manufacturing and installation supply chain, equipment and experience in the region. An early task undertaken in the site exploration phase, therefore, would be a foundation option assessment.

Assuming the loading characteristics for a typical 16 MW wind turbine, a 90 to 100 m long monopile with a diameter of 11-12 m is estimated for the example early project. With an average steel thickness of 110 to 120 mm, this equates to a mass of about 2,700 tonnes of steel per foundation, including the transition piece connection to the wind turbine. The actual embedment length, diameter and thickness of the monopile will depend upon the hydrodynamic loading and soil conditions at each turbine location and will be calculated at a later stage of project design once more site data is gathered.

6.2 Array cables

The example OSW farm comprises 19 turbines, each of 16 MW capacity. It is normal practice to connect several turbines into cable 'strings', with up to five turbines in each 'string' when considering turbines of this size and the standard array system rating of 66kV alternating current (AC).

For the example early project, an 800 mm^2 copper cable[xxxviii] is assumed as it is commonly available and widely used under most environmental and installation conditions. At a depth of 2 m below seabed, this cable has a current rating of 815 A and comfortably accommodates about 80 MW capacity at 66 kV, when considering a worst-case scenario of 0.95 pu voltage and 0.95 power factor. For this higher voltage, less array cable is needed to transmit the power to the offshore substation. Based on an 800 mm^2 copper array cable, five 16 MW wind turbines will be included in each string and there will be 4 strings required to achieve 300 MW. Cable sizing will vary along the strings, reducing in steps from 800 mm^2.

xxxviii. Note, cables contain three conductor cores. The total cross section area of these three cores is 800mm^2.

The cable construction for the wind farm is assumed to be a wet-type design, though other designs exist.[xxxix] The three conductor cores can be made from either copper or aluminum. Cable suppliers provide designs based on specifications.

It should be noted that further optimization would be required based on power systems studies into the voltage drop and considering distance to connection, amperage, and capacity to determine the most suitable array cable arrangement.

6.3 Offshore substation and export cable

The OSS collects power from the wind farm via the array cables from the wind turbines and transforms it to a higher voltage for transmission to the onshore substation via subsea export cables. The export at higher voltage reduces losses in the export system and is therefore more important the further offshore the wind farm is located. For most OSW farms, an AC connection offers the most reliable and cost-effective option for transmission and this is therefore assumed for the early example site. Only at distances to the point of grid connection of 60 km and above might direct current (DC) solutions be more cost effective.

The choice of OSS transformer is a question of a trade-off between cost and redundancy and as such benefits from a cost benefit analysis at a later stage in the project development process. Generally, power transformers are naturally cooled, ester oil filled units, which removes fire suppression equipment requirements. For a 300 MW project, a single 450 MVA transformers may be used.

An OSS typically is purpose-designed for each project. Typical OSS platforms are multi-deck structures which provide redundancy in electrical systems and also offer control rooms and facilities for the wider wind farm, although simple facilities are possible to reduce initial costs.

Both monopiles and jackets can be used for OSS foundations, depending on the seabed conditions. For the early example project it is assumed a locally manufactured jacket foundation would be used.

Subsea export cables

Export subsea cable is generally three-core copper cable and analysis is typically based on one thermally isolated cable circuit with a seabed/ground temperature of 20oC and laying at a depth of 2 m into a soil with a thermal resistivity of 0.8 km/W. For a 300 MW project, the maximum current at 230 kV AC equates to circa 835 A considering a scenario of 0.95 Vpu and 0.95 pu power factor. At this rating, a 1600mm^2 (per core) cable will be sufficient. Designs are finalized at a later stage of project design.

Onshore export cables and onshore substation

The onshore export cable is typically single core and will need to be incorporated between the landfall and the onshore substation. The maximum currents for the onshore cables are the same as the offshore cables.

It is expected to operate the export system within the range of ±0.95 power factor, possibly through actively contributing to voltage control within this range. There are many reactive compensation methods, but generally fixed compensation reactors will be provided to compensate for the cable

xxxix. For more information about cables, see https://guidetoanoffshorewindfarm.com/guide#B_1.

capacitance and a static synchronous compensator (statcom) or similar device will be utilized to provide the full reactive range at the onshore substation. This reactive compensator can also be located offshore if there is a benefit to do so. A detailed study needs to be undertaken, but for a wind farm of 300 MW capacity a reactive compensator circa 150-200 MVAr can be anticipated.

The harmonic performance requirement will also need to be studied. If required, the harmonic mitigation measure is usually in the form of an AC harmonic filter, which can be located within either the offshore or onshore substation.

Onshore grid connection

The factors that need to be considered with onshore grid connections, and their potential impact on the project are shown in Table C6.1.

TABLE C6.1 ONSHORE SUBSTATION CONSIDERATIONS

Issue	Consideration	Impact
Fault levels	Fault level at substation may not allow for connection.	Busbar and equipment uprating may be required leading to additional costs.
Available bays	Number of required spare bays may not be available within the building or there may not be sufficient space for busbar extension for transformers. Harmonic filters and reactive compensation may also be required which might require further bays and space considerations	May require additional land purchase if available for substation extension to accommodate the infeed bays and additional equipment.
Network constraints	Aside from local constraints (such as site fault levels), power systems studies may reveal wider network constraints such as voltage or thermal issues which could require further network upgrades	Reactive compensation such mechanically switched capacitors (MSCs) and shunt reactors may be required on site; static var compensators (SVCs) or synchronous compensation may be required for voltage issues. Additional circuits or quadrature boosters may be required to address thermal issues.
Cable Landfall	Cable routing consideration at the landfall site will need to be assessed with respect to the geotechnical, environmental and social constraints.	Cable routes determined by geotechnical considerations – such as the requirement for horizontal drilling – will have to balance cost (drilling vs longer routes) and potential environmental and social impacts.

7. INSTALLATION INITIAL DESIGN

Transportation and installation plans are required for the wind turbine, foundations, OSS, and cables.[xl] The following initial design solutions are for monopile turbine foundations and jacket OSS foundation. It is anticipated that the installation sequence will be all foundations and substations, then cabling and finally turbines, using ports as follows:

- Use of a single construction port, where all components are pre-assembled ready for installation.

xl. For more information on installation, see https://guidetoanoffshorewindfarm.com/guide#I.

- Tower manufacture in another port, with towers transported to the construction port for loading with other imported turbine components such as blades and nacelles.
- OSS topside fabricated and assembled in another port and transported to site from there.

7.1 Turbine monopile installation

Monopiles are assumed to be installed using a dynamically positioned floating vessel (that is kept in position and stabilized by water thrusters during the lift), but a jack-up vessel (with legs placed on the seabed to stabilize the vessel) can also be used. Once the vessel is in position, the monopile will be moved into position using the main crane and upending tool and held in position by a gripper tool. It will then be driven into the seabed using a hammer and anvil system, potentially using a relevant noise suppression system to reduce environmental impact, before mounting a transition piece onto the top of each monopile.

Transition pieces are assumed to be carried and installed by the same vessel, although a two-vessel strategy in which transition pieces are installed by a separate vessel can be used. This focuses the utilization of the monopile installation vessel, which is likely to have higher day rate costs than a vessel used to install the transition pieces. A disadvantage of this approach is the additional cost of mobilizing and demobilizing two vessels, rather than using a single vessel for both activities.

Feeder strategies have also been used for monopiles, particularly when main crane vessels have little deck space for transporting components. In this case, the monopiles are floated to site using tugs or transported using platform supply vessels.

The approximate timetable for the installation of each monopile foundation once at the wind farm site is:

- Transport and positioning of installation vessel: 2 hours
- Preparations: 1 hour
- Lifting and pile positioning: 1 hour
- Pile driving: 6 hours, and
- Transition piece fitting: 2 hours.

The full cycle time is likely to be about 2 days per monopile; a figure that considers mobilization and demobilization, loading and waiting on weather. The wave and wind conditions at the site will dictate the construction activities that can be undertaken. If wave heights or wind speeds are too high, construction work cannot proceed, and the installation teams need to wait for the conditions to improve before they can continue.

Under some ground conditions with a rocky seabed, monopiles are grouted into a pre-drilled rock socket. Where a seabed features sand and boulders, a combination of drilling and pile driving is often required. An example of a jack-up monopile installation vessel is shown in Figure C7.1.

FIGURE C7.1 EXAMPLE MONOPILE FOUNDATION INSTALLATION VESSEL

Source: Courtesy of Jan de Nul.

7.2 Offshore substation installation

The OSS foundation is installed prior to the topside structure.

OSS installation is a heavy lift operation (about 1,500 tonnes). Vessels with the necessary lift capacity typically do not have the deck space to accommodate a substation platform. The substation is therefore floated out of the substation fabrication port on a barge, usually directly to the wind farm site. Figure C7.2 shows a single vessel solution.

Alternatively, a "float over" technique can be used. The topside is fully constructed at port, transferred to a barge, floated out to site where the jacket foundation has been pre-installed, then lowered into place.

FIGURE C7.2 EXAMPLE SUBSTATION INSTALLATION VESSEL

Source: Courtesy of ScottishPower Renewables.

7.3 Cable installation

In most offshore markets, cables are installed using specialist cable lay vessels (CLVs), as shown in Figure C7.3.

FIGURE C7.3 EXAMPLE CABLE-LAYING VESSEL

Source: Courtesy of DeepOcean.

Array cable installation is completed in the following stages:

- Deployment of pull-in, termination and testing equipment on the turbines and OSS
- Pre-lay inspection for each cable run
- Between each pair of end points (turbine to turbine, turbine to OSS, or OSS to shore), 1st end pull-in, cable lay and 2nd end pull-in, followed by termination and testing
- As-built survey, and
- Recovery of pull-in, termination and testing equipment.

The process for cable lay will depend on geotechnical survey results and will involve:

- Trenching, via:
- Pre-lay trenching, then cable lay into the trench, with post-lay backfill
- Simultaneous lay and burial, or
- Post-lay trenching, where cable is placed on the seabed before trenching and burial.
- Or surface lay with post-lay artificial covering, via a combination of rock/rubble dump, concrete mattresses, metal framing, or a cable protection system.

Based on initial work, we expect that the seabed conditions at the early example site will allow for simultaneous lay and burial. An example cable plough, used to simultaneously lay and bury a cable, is shown in Figure C7.4.

Export cables are laid by the export cable lay contractor, moving away from the landing point, leaving sufficient cable on the landing point for another contractor (or a sub-contractor to the export cable lay contractor) to bury it in an open cut trench up to the joint chamber onshore. In cases where the landing point has rocky terrain or cliff, or to avoid specific environmental or social sensitivities, the horizontal direction drilling (HDD) method may be adopted.

FIGURE C7.4 EXAMPLE CABLE PLOUGH

Source: Courtesy of Royal IHC.

7.4 Wind turbine installation

Offshore turbine installation is undertaken by purpose-built OSW jack-up vessels due to the need for a stable platform to perform offshore lifting operations and mating of components at height. Installation methods vary depending on the turbine supplier and the relative size of turbine and vessel. Installation methodologies aim to reduce, as far as practical, offshore operations. An example turbine installation vessel is shown in Figure C7.5.

The installation of a turbine from positioning the vessel at a given foundation to departure takes about 24 hours, depending on location and weather conditions. The cycle time is between 1.5 and 4 days, depending on the project (factoring in mobilization, demobilization, loading and waiting on weather).

A constraint during transportation and installation is the acceleration limit defined by the turbine supplier to avoid damaging the turbines and invalidating warranties. This is typically about 0.5 g (approximately 4.9 m/s2).

Blade installation is constrained not only by the operating range of the vessel but also the wind speeds, and the limit has been gradually increased with innovations in blade lifting equipment. The current maximum is normally 13m/s at hub height and any increases beyond this may be limited by health and safety risks.

It is expected that tower sections are preassembled onshore with any internal components and the completed structure is transported vertically to site for installation, where it is lifted and secured in position.

The most common remaining process is to lift and place the nacelle plus hub on the tower then lift individual blades to mate with the hub, turning the rotor each time to repeat the same lift three times.

See Roadmap Section 17 for discussion of access to the Black Sea for OSW jack-up vessels.

FIGURE C7.5 EXAMPLE TURBINE INSTALLATION VESSEL

Source: Courtesy of Seajacks.

8. OPERATIONAL STRATEGY INITIAL DESIGN

8.1 Operations, maintenance and service contracting strategy

For an early project in a new market, we assume an approach to lower developer risk through a medium-term warranty and service agreement with the wind turbine supplier for the turbines, and a similar approach to the operations, maintenance and service (OMS) for the balance of plant (BoP), including the foundations, array cables and export cables.[xli]

xli. For more information on OMS, see https://guidetoanoffshorewindfarm.com/guide#O.

Crucial to the long-term strategy for OSW in Romania will be the transference of skills and increase in local industry-specific expertise in these areas.

8.2 Operations base and logistics

It is most likely that the operational base will be in the same area as the construction base. The requirements for an operations base are much less than those required for manufacturing and installation. Aspects to consider for the operations base include:

- Land lease costs
- Indoor facilities (200-400 m2 required)
- Indoor warehouse facilities (300-800 m2 required)
- Outdoor storage space (800-1500 m2 required)
- Parking space (500-1000 m2 required)
- Vessel birthing space

Vessel strategy is strongly influenced by the choice of port. The final decision on this will require detailed modelling of weather risk and port upgrade costs to find the optimal solution. Initial analysis suggests the use of a service operation vessel (SOV), though these are normally used on larger projects. An SOV only needs to visit port every two weeks, so distance of the port to the project is less important than if crew transfer vessels (CTVs) were being used, as these return to port each day.

SOVs are typically 10 to 20 times the cost (€/vessel/day) of CTVs , but they support larger numbers of technicians and can facilitate 24-hour working using shift patterns. An example SOV is shown in Figure C8.1.

FIGURE C8.1 EXAMPLE SERVICE OPERATION VESSEL

Source: Courtesy of Esvagt.

9. LEVELIZED COST OF ENERGY INITIAL ESTIMATE

Based on the information presented in Roadmap Section 7, adjusted for smaller project size, the estimated breakdown of costs for the early example project are as shown in Table C9.1. These figures are based on expectations of typical future industry prices and engineering judgement rather than site-specific designs and industry quotations. These estimates, therefore, should be considered as having a high degree of uncertainty and will only become more accurate once site-specific information is available and engineering analysis is undertaken.

Assuming a 30 year life and contingency, insurance and decommissioning impact as discussed in Roadmap Table 7.4[xlii], the estimated LCOE is €97 /MWh, in 2023 terms. See Roadmap Section 7 for a discussion of the sensitivity to key parameters and the potential impact on LCOE.

TABLE C9.1 SUMMARY OF EXAMPLE EARLY OFFSHORE WIND PROJECT COST ESTIMATES

Type	Element	Value	Unit
Development (DEVEX)	Development	61	€ million
Capital expenditure (CAPEX)	Turbines	484	€ million
	Foundations	168	€ million
	Array cables	16	€ million
	Installation of generating assets	70	€ million
	Offshore substation	94	€ million
	Export cables	118	€ million
	Installation of transmission assets	33	€ million
	Total CAPEX	8	€ million
Operational expenditure (OPEX)	Operation and planned maintenance	9	€ million/year
	Unplanned service	61	€ million/year
Financing Cost	Weighted average cost of capital (WACC)	6.0[xliii]	%
Net annual energy production[xliv]		1,051	GWh/year
Capacity factor	Net capacity factor[xlv]	40	%

xlii. The construction contingency budget will depend on the site characteristics, the installation methods chosen, supplier experience, contractual terms with key suppliers, insurance terms and approach to risk. We have assumed that only part of that contingency budget is actually spent. We have assumed that €70 million is spent on construction insurance and from the contingency budget (about 7% of CAPEX). Decommissioning is assumed to cost about 60% of installation cost, but this is highly dependent on how the market progresses up to, and beyond 2050. It excludes any residual value from materials removed from the wind farm, due to uncertainty in future recycling / reuse value.

xliii. See under Roadmap Table 7.3 for derivation of this WACC. It is considered as an optimistic scenario, assuming substantial risk reduction measures are implemented by different government departments, lower-cost international finance is used and blended with concessional finance sources to further reduce the cost of capital. The typical WACC for an early project in an emerging offshore wind market could be 8% or higher without these measures to reduce the WACC. A higher WACC would result in a higher LCOE.

xliv. Net annual energy production includes losses due to:

- Aerodynamic array losses
- Wind farm blockage effect
- Electrical array losses
- Losses due to unavailability of the wind turbines, foundations and array cables
- Losses from cut-in/cut-out hysteresis, power curve degradation, and power performance loss.

xlv. Note that this capacity factor is lower than typically seen in established OSW markets, due to lower wind resource, but higher than in Roadmap Table 7.3 due to reduced wake effects for a smaller project.

REFERENCES

1 *An EU Strategy to harness the potential of offshore renewable energy for a climate neutral future,* EUROPEAN COMMISSION, November 2020, available online at https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52020DC0741&from=EN, last accessed March 2023

2 *A European Green Deal.* January 2020. European Commission. Available online at https://commission.europa.eu/strategy-and-policy/priorities-2019-2024/european-green-deal_en. Last accessed March 2023.

3 *Commission proposes transformation of EU economy and society to meet climate ambitions.* July 2021. European Commission. Available online at https://ec.europa.eu/commission/presscorner/detail/en/IP_21_3541. Last accessed March 2023.

4 *REPowerEU Plan.* May 2022. European Commission. Available online at https://eur-lex.europa.eu/resource.html?uri=cellar:fc930f14-d7ae-11ec-a95f-01aa75ed71a1.0001.02/DOC_1&format=PDF. Last accessed March 2023.

5 *The 2021-2030 Integrated National Energy and Climate Plan,* April 2020, European Union, Available online at https://energy.ec.europa.eu/system/files/2020-06/ro_final_necp_main_en_0.pdf, Last accessed March 2023.

6 *Romania's National Recovery and Resilience Plan: Latest state of play,* February 2023, European Parliament, Available online at https://www.europarl.europa.eu/thinktank/en/document/EPRS_BRI(2022)733641, Last accessed March 2023.

7 *Recommendations for Romania's Long-Term Strategy: Pathways to climate neutrality.* December 2022. Energy Policy Group. Available online at https://www.enpg.ro/wp-content/uploads/2022/12/Romanian_LTS_EPG_Report.pdf. Last accessed March 2023.

8 *Key Factors for Successful Development of Offshore Wind in Emerging Markets,* Arup in association with BVG Associates on behalf on the World Bank Group, September 2021, available online at https://documents1.worldbank.org/curated/en/343861632842395836/pdf/Key-Factors-for-Successful-Development-of-Offshore-Wind-in-Emerging-Markets.pdf, last accessed September 2021.

9 *Planul de Dezvoltare a RET perioada 2022 – 2031,* November 2020, Transelectrica, Available online at https://www.transelectrica.ro/documents/10179/14441468/Planul+de+Dezvoltare+a+RET+perioada+2022-2031+aprobat.pdf/dd6c9e5c-067c-4d97-ab15-596c9ff8dd70, Last accessed March 2023.

10 *Carbon footprint of electricity generation, Houses of Parliament,* June 2011, available online at https://www.parliament.uk/documents/post/postpn_383-carbon-footprint-electricity-generation.pdf, last accessed March 2023. Used a value of 500 metric tons of CO2 per GWh, approximate average of median values listed for coal, coal CCS, gas and gas CCS.

11 Stacey Dolan and Garvin Heath, Life cycle greenhouse gas emissions of utility scale wind power: Systematic review and harmonization, *Journal of Industrial Ecology,* 16, (2012), 136-S154. Offshore wind lifetime emissions of 12 metric tons of CO2 per GWh are insignificant compared to the 500 metric tons from fossil fuels.

12 *A clean energy solution – from cradle to grave,* Siemens Gamesa Renewable Energy, 2019, available online at: https://www.siemensgamesa.com/-/media/siemensgamesa/downloads/en/sustainability/environment/siemens-gamesa-environmental-product-declaration-epd-sg-8-0-167.pdf, last accessed March 2023.

13 US Energy Information Agency, https://www.eia.gov/, last accessed March 2023.

14 American Wind Energy Association, https://www.awea.org/wind-101/benefits-of-wind/environmental-benefits, last accessed March 2023.

15 US Energy Information Agency, https://www.eia.gov/, last accessed March 2023.

16 *Offshore Technical potential in Romania,* March 2020, World Bank Group, Available online at https://documents1.worldbank.org/curated/en/141221587050442759/pdf/Technical-Potential-for-Offshore-Wind-in-Romania-Map.pdf, last accessed March 2023.

17 *Offshore Wind Technical Proposal,* December 2019, Energy Sector Management Assistance Program, Available online at https://esmap.org/esmap_offshorewind_techpotential_analysis_maps, last accessed March 2023.

18 'Net-Zero Industry Act: act now or Europe's wind turbines will be made in China' press release https://windeurope.org/newsroom/press-releases/nzia-act-now-or-europes-wind-turbines-will-be-made-in-china/, last accessed November 2023.

19 'Gender diversity in energy: what we know and what we don't know', *Press release,* International Energy Agency, 6 March 2020, available at: https://www.iea.org/commentaries/gender-diversity-in-energy-what-we-know-and-what-we-dont-know, last accessed November 2021.

20 ' Taiwan 'leads' on female offshore wind representation', *Renews,* 20 October 2021, available at: https://renews.biz/73025/taiwan-leads-on-female-offshore-wind-representation/, last accessed November 2021

21 'The Business Benefits of Gender Diversity', Press release, Gallup, 20 January 2014, available at: https://www.gallup.com/workplace/236543/business-benefits-gender-diversity.aspx, last accessed October 2021.

22 UN Women, CEDAW,1979, available at: https://www.un.org/womenwatch/daw/cedaw/

23 Directive of the European Parliament and of the Council of 5 July 2006 on the implementation of the principle of equal opportunities and equal treatment of men and women in matters of employment and occupation (2006/54/EC). Available at: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex%3A32006L0054.

24 Council Directive of 19 October 1992 on the introduction of measures to encourage improvements in the safety and health at work of pregnant workers and workers who have recently given birth or are breastfeeding (92/85/EEC). Available at: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex%3A31992L0085

25 Directive European Parliament and of the Council on the work-life balance for parents and carers (20191158). Available at: https://osha.europa.eu/en/legislation/directive/directive-20191158-work-life-balance-parents-and-carers

26 News on gender equality treatment in Romania, Dentons, May 2019. Available at: https://www.dentons.com/en/insights/alerts/2019/may/29/news-on-gender-equality-treatment-in-romania

27 The World Bank, Women Business and the Law, 2022. Available at https://wbl.worldbank.org/en/data/exploreeconomies/romania/2023

28 *Global Gender Gap Report 2022,* July 2022, World Economic Forum, Available online at https://www.weforum.org/reports/global-gender-gap-report-2022/, Last accessed March 2023.

29 Wind Energy: A Gender Perspective, January 2020, available at: https://www.irena.org/publications/2020/Jan/Wind-energy-A-gender-perspective, last accessed October 2021.

30 UK Government, March 4 2020, available at: https://www.gov.uk/government/publications/offshore-wind-sector-deal/offshore-wind-sector-deal, last accessed October 2021.

31 The World Bank Environmental and Social Framework, The World Bank, September 2020, available online at https://www.worldbank.org/en/projects-operations/environmental-and-social-framework, last accessed in September 2021.

32 *The Law on Safety and Health at Work and the Methodological Norms,* September 2006, The Romanian Parliament, Available online at https://osha.europa.eu/fop/romania/ro/legislation/hotarare_1218_06_septembrie_2006.shtml, Last accessed March 2023.

33 *Law No. 165/2016 on the safety of offshore oil operations,* July 2016, Ministry of Energy, Available online at https://iclg.com/practice-areas/oil-and-gas-laws-and-regulations/romania, Last accessed March 2023.

34 *DNV-ST-0145 Offshore substations,* September 2021, DNV, Available online at https://www.dnv.com/energy/standards-guidelines/dnv-st-0145-offshore-substations.html, Last accessed March 2023.

35 *DNV-ST-0119 Floating wind turbine structures,* June 2021, DNV, Available online at https://www.dnv.com/energy/standards-guidelines/dnv-st-0119-floating-wind-turbine-structures.html, Last accessed March 2023.

36 *DNV-ST-0126 Support structures for wind turbines,* December 2021, DNV, Available online at https://www.dnv.com/energy/standards-guidelines/dnvgl-st-0126-support-structures-for-wind-turbines-2744, Last accessed March 2023.

37 *DNV-ST-0437 Loads and site conditions for wind turbines,* November 2021, DNV, Available online at https://www.dnv.com/energy/standards-guidelines/dnv-st-0437-loads-and-site-conditions-for-wind-turbines.html, Last accessed March 2023.

38 *Wind Turbine Generator Systems,* October 2008, International Electrotechnical Commission, Available online at https://webstore.iec.ch/preview/info_iec61400-1%7Bed3.0%7Den.pdf, Last accessed March 2023.

39 *BS EN 50308:2004, Wind turbines - Protective measures - Requirements for design, operation and maintenance,* May 2004, European Standards, Available online at https://www.en-standard.eu/bs-en-50308-2004-wind-turbines-protective-measures-requirements-for-design-operation-and-maintenance/, Last accessed March 2023.

40 *Good Practice Guidelines and Safe by Design Workshop Reports,* November 2022, G+, Available online at https://www.gplusoffshorewind.com/work-programme/workstreams/workshops, Last accessed March 2023.

41 *RenewableUK Health & Safety Publications,* May 2016, RenewableUK, Available online at https://www.renewableuk.com/page/HealthSafety, Last accessed March 2023.

42 *International Convention for the Safety of Life at Sea (SOLAS), 1974,* November 1974, IMO, Available online at https://www.imo.org/en/About/Conventions/Pages/International-Convention-for-the-Safety-of-Life-at-Sea-(SOLAS),-1974.aspx, Last accessed March 2023.

43 *ICAO Heliport Manual*, May 2021, International Civil Aviation Organization, Available online at https://store.icao.int/en/heliport-manual-doc-9261, Last accessed March 2023.

44 *Law on Electrical Energy and Natural Gases no. 123/2012 and amending Laws no. 155 and no 290*, National Energy Regulatory authority (ANRE), July 2012, Available online at https://www.climate-laws.org/geographies/romania/laws/law-on-electrical-energy-and-natural-gases-no-123-2012-and-amending-laws-no-155-and-no-290, Last accessed March 2023.

45 *Law No. 165/2016 on the safety of offshore oil operations*, July 2016, Ministry of Energy, Available online at https://iclg.com/practice-areas/oil-and-gas-laws-and-regulations/romania, Last accessed March 2023.

46 *Law No. 256/2018 on certain measures necessary for the implementation of petroleum operations by holders of petroleum agreements relating to offshore and onshore oil blocks*, May 2018, The Romanian Parliament, Available online at: https://www.cdep.ro/pls/proiecte/upl_pck2015.proiect?cam=2&idp=20042, Last accessed March 2023.

47 *Law no. 292 of December 3*, 2018, December 2018, THE ROMANIAN PARLIAMENT, Available online at https://legislatie.just.ro/Public/DetaliiDocumentAfis/208590, Last accessed March 2023.

48 *Law no. 265 of 29 June 2006 on the approval of the Government Emergency Ordinance no. 195/2005 on environmental protection*, June 2006, The Romanian Parliament, Available online at https://www.ecolex.org/details/legislation/law-no-265-of-29-june-2006-on-the-approval-of-the-government-emergency-ordinance-no-1952005-on-environmental-protection-lex-faoc197062/, Last accessed March 2023.

49 *Law No. 50 Of 29 July 1991 (Republished)*, July 1991, The Romanian Parliament, Available online at https://www.global-regulation.com/translation/romania/3743977/law-no.-50-of-29-july-1991-%2528republished%2529-authorizing-execution-of-construction-works.html, Last accessed March 2023.

50 *Law No. 17 of August 7, 1990 (Republished) Concerning the Legal Regime of the Inland Maritime Waters, Territorial Sea, Contiguous Zone and the Exclusive Economic Zones of Romania*, August 1990, The Romanian Parliament, Available online at https://www.global-regulation.com/translation/romania/3073456/law-no.-17-of-august-7%252c-1990-%2528republished%2529-concerning-the-legal-regime-of-the-inland-maritime-waters%252c-territorial-sea%252c-contiguous-zone-and-t.html, Last accessed March 2023.

51 *15th meeting of Black and Azov Seas Working Group*, Maritime Hydrographic Directorate, Available online at https://iho.int/uploads/user/Inter-Regional%20Coordination/RHC/MBSHC/BASWG/BASWG15/NationalReport_Romania.pdf, Last accessed March 2023.

52 Water Law (No. 107 of 1996) https://leap.unep.org/countries/ro/national-legislation/water-law-no-107-1996, Last accessed June 2023.

53 *Law no. 230 of 1 June 2004 on the approval of the Government Ordinance. 38/2004 modification of the Government Ordinance. 57/2002 relating to scientific research and technological development*, June 2004, The Romanian Parliament, Available online at https://www.global-regulation.com/translation/romania/3784641/law-no.-230-of-1-june-2004-on-the-approval-of-the-government-ordinance.-38-2004-modification-of-the-government-ordinance.-57-2002-relating-to-scientif.html, Last accessed March 2023.

54 *Electricity Information*, July 2022, IEA, Available online at https://www.iea.org/data-and-statistics/data-product/electricity-information, Last accessed March 2023.

55 *Total energy generation capacity installed in the production units of Romania,* December 2021, u/Adrian_Judu, Available online at https://www.reddit.com/r/dataisbeautiful/comments/nd2ttq/oc_total_energy_generation_capacity_installed_in/, Last accessed March 2023.

56 *Planul de Dezvoltare 2022-2031,* January 2022, Transelectrica, Available online at https://www.transelectrica.ro/web/tel/planul-de-dezvoltare-ret-2022-2031, Last accessed March 2023.

57 *The Power Transmission Grid,* January 2022, Transelectrica, Available online at https://www.transelectrica.ro/en/web/tel/transport-detalii, Last accessed March 2023.

58 *RET Development Plan,* Transelectrica, Available online at https://www.transelectrica.ro/documents/10179/11093725/1_1_RET+Development+Plan+in+2020+%E2%80%93%20 2029+%E2%80%93%20main+coordinates.pdf/553c49c9-785e-4b69-842a-aeb3a6373844, Last accessed March 2024

59 *Black Sea Subsea Link to Connect Azerbaijan's Offshore Wind Farms with Romania,* December 2022, Offshorewind.biz, Available online at https://www.offshorewind.biz/2022/12/19/black-sea-subsea-link-to-connect-azerbaijans-offshore-wind-farms-with-romania-hungary/, Last accessed March 2023.

60 *Offshore wind farms in the German Bight,* January 2023, Wikimedia, Available online at https://upload.wikimedia.org/wikipedia/commons/a/a1/Map_of_the_offshore_wind_power_farms_in_the_German_Bight.png, Last accessed March 2023.

61 *Industry position on how offshore grids should develop,* June 2019, Wind Europe. Available online at https://windeurope.org/wp-content/uploads/files/policy/position-papers/WindEurope-Industry-position-on-how-offshore-grids-should-develop.pdf. Last accessed October 2023.

62 *Connection to Electricity Network,* May 2013, The Romanian Energy Regulatory Authority, Available online at https://www.anre.ro/en/1385652740/1385654037/connection-to-electricity-network, Last accessed March 2023.

63 *Recommendations for Romania's Long-Term Strategy: Pathways to climate neutrality,* June 2022, EPG, Available online at https://www.enpg.ro/https-www-enpg-lts-epg-report/, Last accessed March 2023.

64 *A hydrogen strategy for a climate-neutral Europe,* July 2020, EUROPEAN COMMISSION, Available online at https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52020DC0301, Last accessed March 2023.

65 *European Commission approves €149 million Romanian scheme under Recovery and Resilience Facility to support renewable hydrogen production,* August 2022, European Commission, Available online at https://ec.europa.eu/commission/presscorner/detail/en/ip_22_4865, Last accessed March 2023.

66 *Dobrogea – developing the first clean hydrogen valley in Central and Eastern Europe,* June 2021, EPG, Available online at https://www.enpg.ro/dobrogea-developing-the-first-clean-hydrogen-valley-in-central-and-eastern-europe/, Last accessed March 2023.

67 *Regulation (EU) 2019/943 of the European Parliament and of the Council,* June 2019, European Parliament and of the Council, Available online at https://www.legislation.gov.uk/eur/2019/943#:~:text=(34)%20The%20management%20of%20congestion,be%20based%20on%20market%20mechanisms., Last accessed March 2023.

68 *Can decentralized energy get good enough, fast enough?,* November 2022, Renewable Energy Country Attractiveness Index, Available online at https://assets.ey.com/content/dam/ey-sites/ey-com/en_gl/topics/power-and-utilities/ey-recai-60-v2.pdf, Last accessed March 2023.

69 *Climate action in Romania, Latest state of play,* August 2021, European Parliamentary Research Service, Available online at https://www.europarl.europa.eu/RegData/etudes/BRIE/2021/696185/EPRS_BRI(2021)696185_EN.pdf, Last accessed March 2023.

70 *CO2 emissions of all world countries,* September 2022, Emissions Database for Global Atmospheric Research, Available online at https://edgar.jrc.ec.europa.eu/report_2022, Last accessed March 2023.

71 *Financing our future,* April 2021, Banca Transilvania Financial Group, Available online at https://www.bancatransilvania.ro/files/app/media/relatii-investitori/financial-results/2021/Financial-results-2021/Sustainability-Report-2021.pdf, Last accessed March 2023.

72 *The world's 100 largest banks,* April 2022, S&P Global Market Intelligence, Available online at https://www.spglobal.com/marketintelligence/en/news-insights/latest-news-headlines/the-world-s-100-largest-banks-2022-69651785, Last accessed March 2023.

73 *Biodiversity Conservation and Sustainable Management of Living Natural Resources,* International Finance Corporation, available online at https://www.ifc.org/wps/wcm/connect/topics_ext_content/ifc_external_corporate_site/sustainability-at-ifc/policies-standards/performance-standards/ps6, last accessed September 2021.

74 *Poland: InvestEU – EIB supports one of the world's largest wind farms with €610 million in financing,* September 2023, European Investment Bank, Available online at https://www.eib.org/en/press/all/2023-341-poland-investeu-eib-supports-one-of-the-world-s-largest-wind-farms-with-eur610-million-in-financing, Last accessed March 2024.

75 *EIB commits €5 billion to support Europe's wind manufacturers and approves over €20 billion in financing for new projects,* December 2023, European Investment Bank, Available online at https://www.eib.org/en/press/all/2023-510-eib-commits-eur5-billion-to-support-europe-s-wind-manufacturers-and-approves-over-eur20-billion-in-financing-for-new-projects, Last accessed March 2024.

76 *Scatec Green Bond Egypt,* May 2022, Scatec ASA, Available online at https://www.ebrd.com/work-with-us/projects/psd/52879.html, Last accessed March 2023.

77 *Modernisation Fund,* May 2022, European Commission, Available online at https://climate.ec.europa.eu/eu-action/funding-climate-action/modernisation-fund_en, Last accessed March 2023.

78 *Converting Emerging Markets to Green Finance: Amundi and the IFC,* Imperial College Business School, March 2020, available online at https://www.ifc.org/wps/wcm/connect/f34bfbf8-dabb-4357-8051-858b8dcfdd84/IFC+Amundi+Case+Study+-+Imperial+CCFI_March+2020.pdf?MOD=AJPERES&CVID=nl7w3oF, last accessed September 2021.

79 *Emerging Market Green Bonds Report 2021,* June 2021, International Finance Corporation, Available online at https://www.ifc.org/wps/wcm/connect/f68a35be-6b49-4a86-9d65-c02e411de48b/2022.06+-+Emerging+Market+Green+Bonds+Report+2021_VF+%282%29.pdf?MOD=AJPERES&CVID=o5EzvO0, Last accessed March 2023.

80 *The framework related to the financing of projects that are intended to protect the environment and combat climate change,* Ministry of Finance, Available online at https://mfinante.gov.ro/static/10/Mfp/trezorerie/GreenBondFrameworkofRomania_14022024.pdf. Last accessed March 2024.

81 *Investors are more and more interested in green financing at the global level*, June 2021, Bucharest Stock Exchange, Available online at https://bvb.ro/AboutUs/MediaCenter/PressItem/Investors-are-more-and-more-interested-in-green-financing-at-the-global-level/5359, Last accessed March 2023.

82 *Raiffeisen Bank first green bonds worth over RON 400mn started trading on Bucharest Stock Exchange*, May 2021, Bucharest Stock Exchange, Available online at https://bvb.ro/AboutUs/MediaCenter/PressItem/Raiffeisen-Bank-first-green-bonds-worth-over-RON-400mn-started-trading-on-Bucharest-Stock-Exchange/5336, Last accessed March 2023.

83 *Raiffeisen Bank largest issue of green bonds worth over RON 1.2bn starts trading today at the Bucharest Stock Exchange*, February 2021, Bucharest Stock Exchange, Available online at https://www.bvb.ro/AboutUs/MediaCenter/PressItem/Raiffeisen-Bank-largest-issue-of-green-bonds-worth-over-RON-1.2bn-starts-trading-today-at-the-Bucharest-Stock-Exchange/5372, Last accessed March 2023.

84 *Romanian lender BCR and Raiffeisen Bank raise EUR 248 mln with green bond issues*, June 2022, Romania-insider, Available online at https://www.romania-insider.com/bcr-raiffeisen-green-bonds-jun-2022, Last accessed March 2023.

85 *BCR prints a new Green Senior Non-Preferred RON bond issuance with a total value of RON 702 million*, June 2022, Banca Comercială Română (BCR), Available online at https://www.bcr.ro/en/press/press-release/2022/06/15/bcr-noua-emisiune-obligatiuni-verzi-senior-nepreferentiale-lei#, Last accessed March 2023.

86 *Raiffeisen Romania issues RON 500 mln of 5-yr sustainability bonds*, August 2022, Romania-insider, Available online at https://www.romania-insider.com/raiffeisen-ro-sustainability-bond-aug-2022, Last accessed March 2023.

87 *Raffeisen Bank lists its second issue of sustainable bonds on the Bucharest Stock Exchange*, November 2022, Bucharest Stock Exchange, Available online at https://bvb.ro/AboutUs/MediaCenter/PressItem/Raffeisen-Bank-lists-its-second-issue-of-sustainable-bonds-on-the-Bucharest-Stock-Exchange/5758, Last accessed March 2023.

88 *Guide to an offshore wind farm*, The Crown Estate and Offshore Renewable Energy Catapult, January 2019, available online at https://guidetoanoffshorewindfarm.com, last accessed May 2022.

THE WORLD BANK
IBRD • IDA | WORLD BANK GROUP

IFC | International Finance Corporation
WORLD BANK GROUP

Funded by the European Union