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Offshore Wind Development Program

OFFSHORE WIND ROADMAP FOR AZERBAIJAN

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EXECUTIVE SUMMARY

This report provides a strategic vision for development of offshore wind (OSW) in Azerbaijan, looking at both opportunities and challenges under different growth scenarios. It is intended to provide evidence to support the Government of Azerbaijan in making decisions about strategies, policies, frameworks, and delivery mechanisms relating to this new industry at a time when interest in OSW globally is increasing. Inevitably, there will be much further work to do by stakeholders to finalize a path forward; as such, areas of further recommended work are identified throughout this report. It should be noted that the analysis is focused on OSW aspects only, and does not include in-depth, whole system modelling of current or future energy scenarios.

This roadmap was prepared in collaboration with the Azerbaijan Ministry of Energy and initiated by the World Bank and the International Finance Corporation (IFC) under the umbrella of the World Bank Group's Offshore Wind Development Program — which aims to accelerate offshore wind development in emerging markets — and was funded by the Energy Sector Management Assistance Program (ESMAP) and PROBLUE.

RATIONALE FOR OFFSHORE WIND IN AZERBAIJAN

Today, Azerbaijan has an electricity system dominated by thermal generation, fueled by natural gas extracted from local reserves. Fortunately, the country also possesses strong renewable energy resources including a world-class offshore wind potential located next to major demand centers. Exploitation of this OSW potential offers an opportunity for Azerbaijan on several fronts:

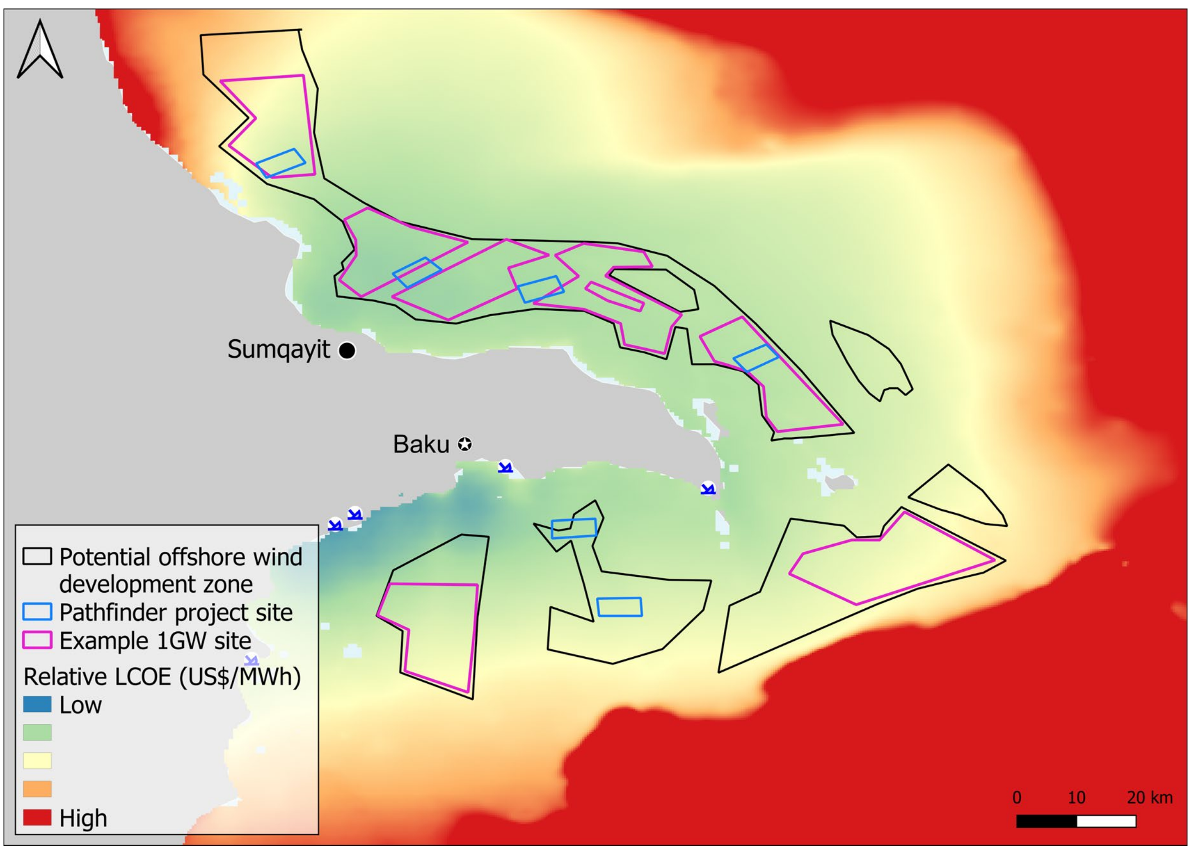
- **Decarbonization.** Azerbaijan's electricity system will need to evolve over the long-term to a decarbonized energy system covering electricity, transport, industry, and heating. Such a system will need to be founded on large-scale electricity from renewables such as OSW and, decreasingly over time, natural gas. Hydrogen may also play a role as an energy vector and storage for some aspects of transport and industrial heat.
- **Export potential.** If developed at scale, offshore wind offers an opportunity for Azerbaijan to increase its exports of both electricity and natural gas (as more gas is made available for export due to reduced national consumption of gas for domestic electricity production). It may also offer a long-term opportunity for hydrogen export, assuming Azerbaijan can generate green hydrogen at costs that are competitive in a global market.
- **Industrial transition.** Offshore wind development is an opportunity for Azerbaijan to transition a significant part of its existing oil and gas workforce over to clean energy. This transition would not only involve direct construction of the wind farms themselves but also development of associated infrastructure (e.g., ports and vessels) and manufacturing (e.g., towers and foundations). Diversifying this workforce will help ensure that skilled, long-term jobs are retained.

- **Large scale competitively priced power.** While the first OSW projects in Azerbaijan will likely have a higher levelized cost of energy (LCOE) than current generation, this cost gap may be driven down over time through ambitious targets. Based on experience in other countries, it is estimated that Azerbaijan will be able to narrow this gap to a point where OSW achieves cost parity, provided the right strategy and market competition.

AZERBAIJAN'S OFFSHORE WIND POTENTIAL

The World Bank has previously assessed Azerbaijan's OSW technical resource at 35 GW in shallow waters (for fixed foundations) and 122 GW in deep waters (for floating foundations),[i] excluding environmental and social considerations. Analysis for this roadmap has built on the previous resource assessment and uses high-level assessments of biodiversity, social, and technical constraints to eliminate less desirable areas and focus on the most favorable offshore wind zones (see Figure ES.1). This has reduced the amount of resource potential from the original estimate; however, the potential development zones still provide a resource potential that is many times larger than the country's energy demand. For example, Figure ES.1 shows that Azerbaijan could develop all of the OSW capacity proposed in this roadmap (in seven blocks of 1 GW each) using fixed foundation projects in shallow waters between 10 and 40 meters relatively close to shore. The analysis in this roadmap suggests that the lowest LCOEs will be in areas north of the Absheron peninsula.

FIGURE ES.1: MAP OF AZERBAIJAN'S OFFSHORE WIND POTENTIAL AND IDENTIFICATION OF FAVORABLE DEVELOPMENT ZONES



i Technical resource only assesses potential based on wind speed and water depth. The realizable, or practical, resource potential is therefore lower than the technical potential due to areas being unsuitable based on environmental, social, or technical constraints.

SCENARIOS FOR OFFSHORE WIND DEVELOPMENT

The analysis underpinning this roadmap is based on two possible scenarios for Azerbaijan's OSW industry. The headline impacts of the two scenarios, considering the key metrics of electricity generation, economics, and emissions, are summarized in Figure ES.2; the cumulative installation capacity to 2040 is shown for both scenarios in Figure ES.3.

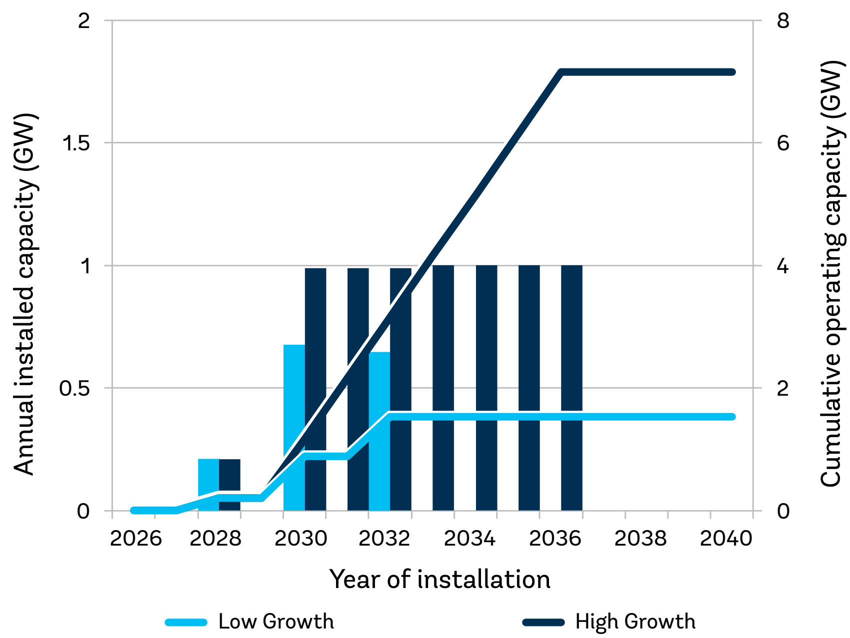
- **Low growth.** This scenario envisions a moderate expansion of OSW, resulting in 1.5GW of fixed foundation capacity and OSW supplying 7% of Azerbaijan's electricity needs by 2040 under a decarbonization pathway.[ii] The build-out of OSW capacity could begin with a pathfinder project of about 200 MW north of the Absheron peninsula which will help overcome Azerbaijan's unique logistical challenges and also help initiate early development of the local supply chain. Subsequent buildout will take place through two fixed foundation projects around the peninsula. In this scenario, required modifications to the electricity transmission network will be minor. Minor upgrades would also be needed for Bos Shelf and Baku Shipyards for component manufacture and construction support. The low growth scenario allows Azerbaijan to initiate an OSW market with minimal disruption to its wider energy sector and to meet its 2030 renewable energy installation targets, setting it on course to meet higher future targets. However, due to the low growth scenario's smaller scale, it offers less of an opportunity than the high growth scenario to create jobs, create economic value, drive down costs, and contribute to large-scale decarbonization.
- **High growth.** This scenario envisions a significant expansion of OSW, resulting in 7.2GW of fixed foundation capacity and OSW wind supplying 37% of Azerbaijan's electricity needs by 2040 under a decarbonization pathway. The high growth scenario is only realistic if Azerbaijan follows a future pathway where a significant amount of its heat and transport demand is decarbonized; hydrogen is incorporated as an energy vector; an upgraded transmission network allows for improved dispatch and demand side management capability; and interconnection with neighboring electricity markets (such as EU and Turkey) are strengthened to allow substantial export of zero-carbon electricity. Under this scenario, the larger local market enables strong local supply chain investment and optimization, with the potential for +50% local content (including towers, foundations, and substations). At the same time, higher growth means higher risk of adverse environmental and social impacts. This places an even greater importance on the need to develop a proportionate marine spatial plan and a framework for environmental and social legislation, along with a permitting process aligned with good international industry practice (GIIP). Note that this demand growth has been modelled in outline in this report but requires further detailed study to fully determine feasibility and pathways to deliver.

In the context of established and emerging global offshore wind markets both scenarios represent relatively modest market opportunities. Both scenarios require similar enabling actions but, under the high growth scenario, a more ambitious vision is established with a requirement for earlier action.

ii Under this roadmap, the electricity demand in 2040 in a decarbonization pathway was estimated to be 82 TWh per year. This was derived from a high-level set of assumptions and was intended to estimate the magnitude of potential change in demand over the coming decades. Recent net-zero modelling (separate to this study) however, suggests that electricity demand by 2040 might only reach 46 TWh. If a lower electricity demand is likely by 2040 then it is assumed that excess electricity generated by offshore wind could be exported to neighbouring countries and/or used for green hydrogen production. See Section 8 for details.

FIGURE ES.2 IMPACT OF OFFSHORE WIND IN AZERBAIJAN UNDER LOW AND HIGH GROWTH SCENARIOS, PERIOD 2020 TO 2040[III]

FIGURE ES.3 ANNUAL INSTALLED AND CUMULATIVE OPERATING CAPACITY IN THE TWO SCENARIOS



Source: BVG Associates.

iii All figures are cumulative over the period 2020 to 2040, unless stated. The fraction of electricity supply is discussed in 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 3.3, 4.3, and 10. CO_2 avoided is discussed in Section 7.1.

POTENTIAL ROLE OF GREEN HYDROGEN

Globally, there is strong interest in the potential role of offshore wind for the production of green hydrogen for both domestic and export markets. This roadmap assessed this potential at a high level in the Azerbaijan context:

- From a domestic perspective, production of green hydrogen can play an important role in the high growth scenario, particularly where excess generation can be used to produce hydrogen for energy storage, transport, industry, or the production of other green fuels. In this case, the viability of green hydrogen will be determined by domestic economics (for example, the competitiveness of green hydrogen versus imported fuel for road vehicles).
- For hydrogen export through shipping, early analysis suggests that the business case is not strong. The cost of green hydrogen is dependent on both the LCOE of the electricity used to produce it and the cost to transport to market. For Azerbaijan the landed cost of green hydrogen in export markets will likely be higher than that of green hydrogen from other markets as many of these competing markets (e.g., those around North Sea) have stronger offshore winds (averaging over 10 m/s) and fewer logistical constraints in bringing their product to market.
- For hydrogen export through pipelines there may be a long-term case for green hydrogen, although this would need to account for an estimated 10% transport cost increase to the delivered price, thus impacting its competitiveness in export markets. Further barriers to high volume hydrogen export exists as current pipelines would require technical adaptation to carry pure or blended hydrogen, and because the existing pipeline capacity currently is fully contractually committed to natural gas export through to 2040. This option, and the required cost of hydrogen, can be explored further with potential offtakers and consumers in the EU and neighboring markets.

CHALLENGES FOR DEVELOPING OFFSHORE WIND

This roadmap demonstrates that offshore wind can play an important role in Azerbaijan's energy mix. However, there are a number of distinct challenges that impact how and when this should occur:

- **Scale** – Azerbaijan's OSW build-out will not likely match the scale (in GW terms) of other established and growing OSW markets. In addition, it is unlikely that a strong regional OSW market will grow in the Caspian Sea in the next decade. As such, it will be a challenge for the country to achieve the large economies of scale that have benefitted other national and regional markets.
- **Logistics** – Access to Azerbaijan is limited by the constraints of the Volga-Don canal system which dictate the size of equipment and vessels which can be brought to the Caspian Sea. Although the transport of large turbines (15 MW) via this route is considered feasible, there are significant challenges for logistics, particularly the suitability of locally available vessels in the Caspian Sea to carry out installation activities.
- **Grid integration** – Offshore wind is a variable resource which can present grid integration challenges at certain penetration levels. The energy transition will require investments in smart grid technology, flexible sources of generation, storage and management solutions, including the

use of hydrogen, electric vehicles (EVs), and interconnectors to other electricity markets, each helping to manage the challenge of variability of generation from wind and solar.

- **Cost of energy** – The cost of energy for the first offshore wind projects in Azerbaijan will be higher than that of existing thermal generation and new-build onshore wind and solar. This cost can be driven down through a long-term energy strategy, scale, and a focus on cost reduction. Costs could also be reduced via lower cost concessional financing and government actions to increase certainty for investors.
- **Environmental and social impacts** – With increased scale, the risks of adverse environmental and social impacts rise, especially when cumulative impacts from multiple projects are considered.

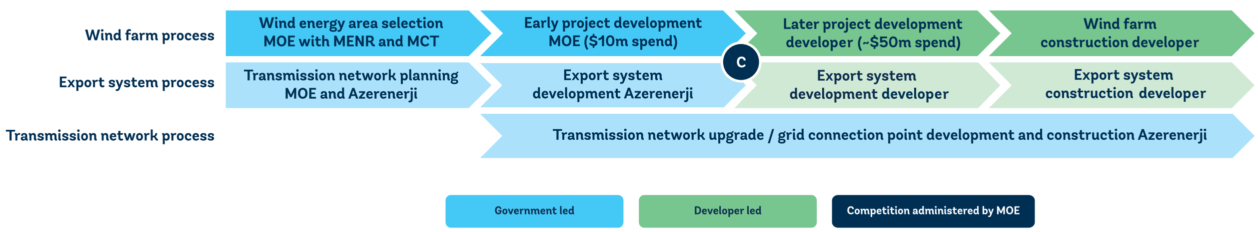
RECOMMENDED APPROACH

As described in the World Bank Group's *Key Factors* report,[2] the most critical first step in any nascent OSW market is to establish a clear energy strategy that signals the long-term role of OSW in the country's energy future. For Azerbaijan, it is suggested that the strategy and approach to implementation consider the following:

- **Offshore wind as part of long-term decarbonization.** Under a decarbonization strategy, it is likely that demand for electricity will rise through increased electrification of the transportation, industrial, and heating demands. As it does, offshore wind can bridge the gap by providing cost-competitive, large-scale, "variable baseload" power. The high growth scenario of 7.2 GW of OSW will help meet the increased demand for electricity under a decarbonization strategy. At the same time, all OSW production offsets in-country natural gas usage for electricity generation, enabling increased export of gas. At times when supply of electricity is greater than domestic demand, excess electricity can be absorbed by energy storage, green hydrogen production for in-country use, and electricity exports.
- **Need to attract competition between limited number of players.** With higher offshore wind targets, Azerbaijan will be able to attract stronger competition resulting in lower costs and a more robust supply chain build-out. The OSW opportunity in Azerbaijan will require the involvement of experienced international OSW developers to build out the potential, as the design, manufacturing, and logistics challenges are at a much greater scale than onshore renewables. As the OSW market in Azerbaijan presents scale and logistics challenges, it is likely that the Government will need to offer sufficient GW capacity to a small number of companies to attract attention and enable supply chain investment and learning. These companies (or consortia) will require experience in both OSW project development (from other markets) and in Caspian Sea project execution (through hydrocarbon activities). For example, in the high growth scenario, a first auction could be for up to 5GW capacity, split between two companies or consortia, with a further auction for the remaining 2GW to go to one winner.
- **Use of concessional finance to drive down initial costs.** To drive down the cost of capital and the resultant cost of energy to levels competitive with conventional generation and onshore wind and solar, Government will need to facilitate the deployment of multilateral, concessional, and climate finance for both OSW projects and infrastructure investments. This will include upgrades of the transmission network both to transfer energy from OSW projects (export cable) and to support increased electrification and decarbonization of the transport, heating, and electricity sectors looking to 2050.

- **Need for Government-led development.** It is suggested that the Government invest in upfront project de-risking and preparatory activities and invite developers to participate in a procurement process for defined projects. In this case, the Government would plan and de-risk OSW projects through upfront feasibility work, then auction specific project seabed rights, in-principle permits, and Power Purchase Agreements together in a single-stage auction process, similar to markets such as Denmark and the Netherlands. Suitably qualified bidders then tender a bid price per megawatt hour (MWh) of electricity sold. This approach will also help to encourage development of the local supply chain and create local economic benefits. Government will be compensated for its upfront investment by successful developers. Figure ES.4 illustrates the recommended government and developer responsibilities through the project lifecycle.

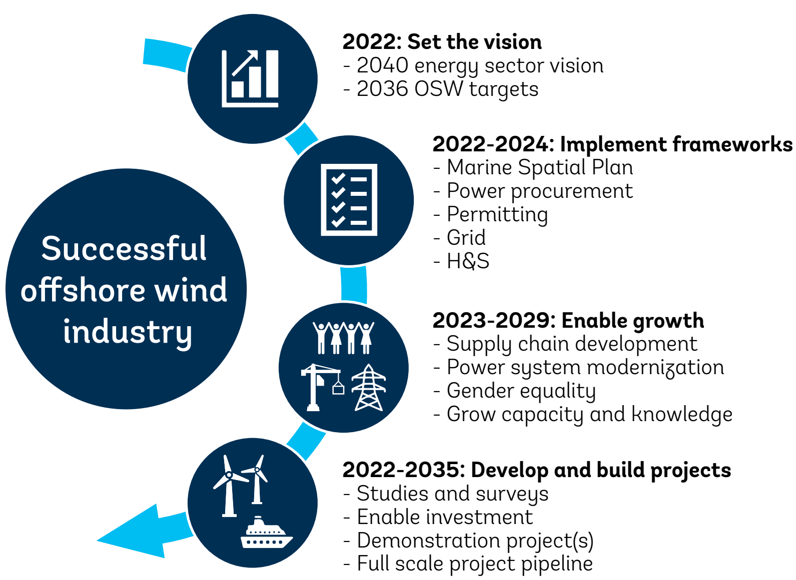
FIGURE ES.4 SUMMARY OF RECOMMENDED GOVERNMENT AND PROJECT DEVELOPER RESPONSIBILITIES FOR OFFSHORE WIND ACTIVITIES THROUGH THE PROJECT LIFECYCLE IN AZERBAIJAN. INDICATIVE SPEND IS SHOWN FOR A 1GW PROJECT



PRIORITY THEMES

Action will need to be taken by the Government of Azerbaijan to develop a successful industry. To help focus efforts, the roadmap identifies priority themes, as shown in Figure ES.5 and immediate, near-term, and longer-term recommended actions for the Government of Azerbaijan to consider. This begins with setting a vision and subsequently developing the processes and infrastructure that will enable the vision to be realized.

FIGURE ES.5 PRIORITY THEMES TO CREATE A SUCCESSFUL OFFSHORE WIND INDUSTRY



RECOMMENDED ACTIONS

The Government of Azerbaijan has an opportunity to develop a successful OSW market by establishing a robust and comprehensive strategy followed by appropriate policies, frameworks, and delivery. A key element will be to provide early visibility of a sufficient market to attract and sustain the interest of OSW developers and investors. International experience shows this to be an effective way to generate local economic benefit without having to resort to restrictive local content requirements. It is also the best way to reduce the long-term cost of OSW to consumers. It is important that policies and frameworks address the specific needs of the offshore wind industry, as highlighted throughout this report, and are coordinated across Government and stakeholders to ensure a consistent and efficient approach.

From the analysis and findings of this roadmap study, we recommend 28 actions. Each of these recommendations is described in more detail in Section 5 and evidence is provided in the Supporting Information found within Sections 6 through 23.

This roadmap's recommended actions are as follows:

Vision and volume targets

1. The Government publishes and communicates a vision for OSW in Azerbaijan and its role as part of a wider energy transition strategy and ensures that all subsequent policies and regulations consider this vision.
2. The Government sets installation targets for OSW for 2030 and 2036 and ensures that all subsequent policies and regulations consider these targets. After this, we recommend that the Government tracks cost reductions as project build-out progresses and adjusts installation targets dependent on cost reductions being achieved.

Leasing, permitting, and power purchase

3. Ministry of Energy (MOE), in consultation with Ministry of Ecology and Natural Resources (MENR), Ministry of Defense (MOD), and Ministry of Culture (MOC), undertakes site screening and investigations on the potential OSW development zones to determine possible environmental, social, and military constraints and hence level of suitability for further development of OSW as part of wider marine spatial planning activity, especially considering cumulative impact assessment.
4. MOE accelerates the identification and designation of OSW projects, taking advice on good practice and lessons learned from other governments that have implemented Government-led OSW procurement processes.
5. MOE initiates measurement and data gathering campaigns on key technical aspects of the potential OSW development zones including wind resource, metocean, geological, ecological, and social surveys to address any identified gaps in current knowledge.
6. MOE undertakes up front surveys and pre-front end engineering and design (FEED) work required to establish a project pipeline that will be subject to competitive bids.
7. MOE streamlines the permitting process, improving coordination between different Ministries and other bodies from whom permissions are required, whilst at the same time ensuring that permitting requirements including ESIA meet GIIP to help de-risk projects and facilitate access to international finance.

8. MOE extends the period of designation for a renewable energy location from a maximum of three years to eight years to allow necessary OSW survey, design, and development processes to be completed.
9. MOE establishes a single development rights competition solution solely for OSW, combining leasing, grid connection, and PPA.
10. MOE sets out a clear timetable for work to deliver this solution, including dates of competitions, and keeps all stakeholders well informed of timing and locations of activities, coordinating across Government to deliver.

Finance

11. MOE and Azerenerji structure OSW PPA terms to be attractive to commercial lending, including direct foreign investments, and consider mechanisms that reduce investor risk and the cost of finance and ensure an acceptable sharing of risk between the developer and Azerenerji.
12. MOE, Ministry of Economy, and Ministry of Ecology and Natural Resources adopts international standards for environmental and social governance such that projects can attract international finance and Government considers the deployment of concessional, multilateral, and climate finance towards offshore wind and decarbonization in Azerbaijan.

Transmission and port infrastructure

13. MOE publishes 2050 vision for a nationwide electricity transmission network for a decarbonized energy system, including consideration of the impact of market reform and analysis of the offshore development zones, with milestone plans for 2030 and 2040.
14. MOE undertakes country-wide power systems studies to understand the potential impacts of OSW and other renewables on the future electricity system, including those directly related to decarbonization of transport and heat, such as hydrogen production close to OSW grid connection points and the opportunity for increased electricity export, considering potential environmental and social impacts of grid upgrades.
15. Azerenerji prioritizes the modernization of systems required to perform system-wide generation supply and demand balancing and plant dispatch, needed for an efficient future energy system.
16. MOE and Azerenerji ensure clarity regarding grid code compliance, and consider compensation arrangements for delays to grid connection or project delivery timelines.
17. MOE works with ports of Baku Shipyard, Bos Shelf, and Zira to determine their interest and availability to deliver manufacturing and construction services to the OSW industry and explores routes to necessary upgrades, considering potential environmental and social impacts of upgrades.

Supply chain development, innovation, and diversity

18. MOE presents a balanced vision for local supply chain development, encouraging international engagement in key areas identified for local supply to ensure latest international good practice is accessed to keep costs down.
19. MOE and relevant Government agencies enable education and investment in local supply chain businesses, including in training of onshore and offshore workers.
20. MOE enables investment in a local wind turbine installation vessel in the high growth scenario.

21. MOE produces a roadmap of research priorities for advancing OSW in Azerbaijan, with focus on LCOE reduction and establishes an industry-academic board or national research and development (R&D) consortium/center to drive activities.
22. Academic institutions start developing second-cycle courses and doctoral training programs specific to OSW.
23. Industry and Government work together to encourage women to enter the offshore wind sector, including in engineering, design, management, and operations. Opportunities should be well promoted and gender decoders and gender-balanced language used to make recruitment practices unbiased.
24. MOE requires that developers successful in auctions involve their supply chain in gender equality working groups, supported by women's rights organizations in Azerbaijan, and the Global Wind Energy Council and Global Women's Network for Energy Transition.

Standards and regulations

25. MENR addresses any shortfalls in Azerbaijan environmental and social impact assessment (ESIA) requirements compared to those of International Finance Corporation (IFC), GIIP, and other lender standards.
26. Ministry for Emergency Situations (MES) adapts existing framework of technical codes and regulation, adopting international industry codes where appropriate.
27. MES develops H&S regulations specifically designed for application to the OSW industry, including reference to the international design and operational standards that should be followed.

Capacity building

28. MOE leads in helping government departments including MENR and other key stakeholders to grow capacity and knowledge needed to process the pipeline of OSW projects.

1 INTRODUCTION

This report is the output of a study commissioned by the World Bank Group (WBG) and delivered by renewable energy strategy consultancy BVG Associates (BVGA), in association with Kent, and Encotec, and with the input of The Biodiversity Consultancy.

It is one of a series of roadmap studies supported by the WBG as part of its offshore wind (OSW) development program that aims to fast-track the expansion of OSW power in emerging markets and provide technical assistance to these countries, so they can assess their OSW potential and develop a pipeline of bankable projects.[1]

It follows an invitation from the Government of Azerbaijan to the World Bank Group for assistance. The study was carried out over the period January 2021 to February 2022 with engagement and input from the Government of Azerbaijan and relevant agencies, the Azerbaijani supply chain, and the global OSW supply chain. See Section 20 for a list of stakeholders.

The study is intended to outline options for a successful OSW industry in Azerbaijan and support collaboration between the Government of Azerbaijan and the wind industry. The study proposes that Azerbaijan pursues a strategy to decarbonize its energy system, and that offshore wind can play a significant role in this decarbonization.

Further study beyond the scope of this work will be required to address important issues including:

- Long term energy system planning and the definition of robust decarbonization pathways, including least-cost generation planning studies, decarbonization of the heat and transportation sectors, and access to long-term finance
- Transmission network strengthening and changes to how the grid system is managed to allow for the efficient penetration of a high volume of variable renewables
- The potential for green hydrogen production and the role it can play in both domestic energy supply and energy export
- The potential for the integration of renewable energy strategies within the wider Caucasus region
- The role of interconnectors and the potential for substantially increased electricity exports to neighboring countries.

The study does not represent the views of the Government of Azerbaijan.

1.1 REPORT STRUCTURE

The report is structured as follows:

Roadmap

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

Supporting information

- Sections 6 to 8: Key ingredients for a successful wind industry, benefits and challenges of OSW, and market volume context in Azerbaijan.
- Sections 9 to 23: Analysis covering all key aspects of the future of OSW in Azerbaijan.

A glossary is provided in Appendix A and a list of organization abbreviations in Appendix B. A summary of canal route constraints is provided in Appendix C. A report from The Biodiversity Consultancy, *Azerbaijan — Priority Biodiversity Values* is provided in Appendix D. Jobs and economic benefit methodology is presented in Appendix E.

Throughout the report, we refer to WBG's report *Key Factors for Successful Development of Offshore Wind in Emerging Markets* (*Key Factors* report).[2] It describes experiences in OSW markets to date, covering:

- OSW as part of energy strategy
- Policy; and
- Frameworks and delivery

2 TWO SCENARIOS FOR OFFSHORE WIND IN AZERBAIJAN

Azerbaijan has a significant offshore wind (OSW) resource, located close to shore and its main population center, in relatively shallow water.

It has an opportunity to use this resource to generate over 35% of its electricity demand by 2040,[iv] as discussed in Section 8, with the industry continuing to develop beyond this.

This report explores the impact of two different, possible OSW growth scenarios, chosen to fit with realistic pathways for Azerbaijan in the context of its future electricity needs, as discussed in Section 8, covering a reasonable breadth of the possible routes forward for Azerbaijan 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 consumer benefit, environmental and social considerations, economic benefit, and other aspects in a quantifiable way. The scenarios were not established (and have not been tested) through deep energy system modelling. They were agreed with Government through consultation but have not been chosen to align with specific existing Government statements or targets.

Further work is required to develop a long-term renewable energy strategy for Azerbaijan that considers all renewable energy technologies. This study is focused on offshore wind and does not consider in-depth the potential role for other renewable technologies.

All other conditions between the two scenarios are unchanged, except that generation from OSW replaces more generation from natural gas in the high growth scenario.

- Low growth — that foresees 1.5GW of OSW with limited local industrialization, starting with a demo project of 210MW, contributing towards Azerbaijan's renewable energy targets.
- High growth — that foresees 7.2GW of OSW, sufficient to drive realistic levels of competition, local supply chain investment, and market-specific innovation and deliver an important contribution to the decarbonization of Azerbaijan's electricity, transport, and heat systems. The high growth scenario assumes a significant growth in Azerbaijan's electricity demand due to decarbonization of its energy system in line with global agreements. This demand growth has been modelled in outline in this report but requires further detailed study to fully determine feasibility and pathways to deliver.

OSW in northern Europe has benefited from the emergence of a regional market, where cumulative Government ambition and sustained development activity across many countries has led to the emergence of a wide supply chain capability, resulting in a competitive market that has driven much cost reduction, to the benefit of all countries in that market.

iv The detailed analysis in this roadmap covers the period up to 2040, not looking further due to the increased uncertainty regarding cost reduction and technology scale beyond a 20-year horizon. In a number of cases, however a vision to 2050 is discussed. This is because within this timescale, the energy systems of many countries will have been decarbonised, so it is important to keep a further horizon in mind.

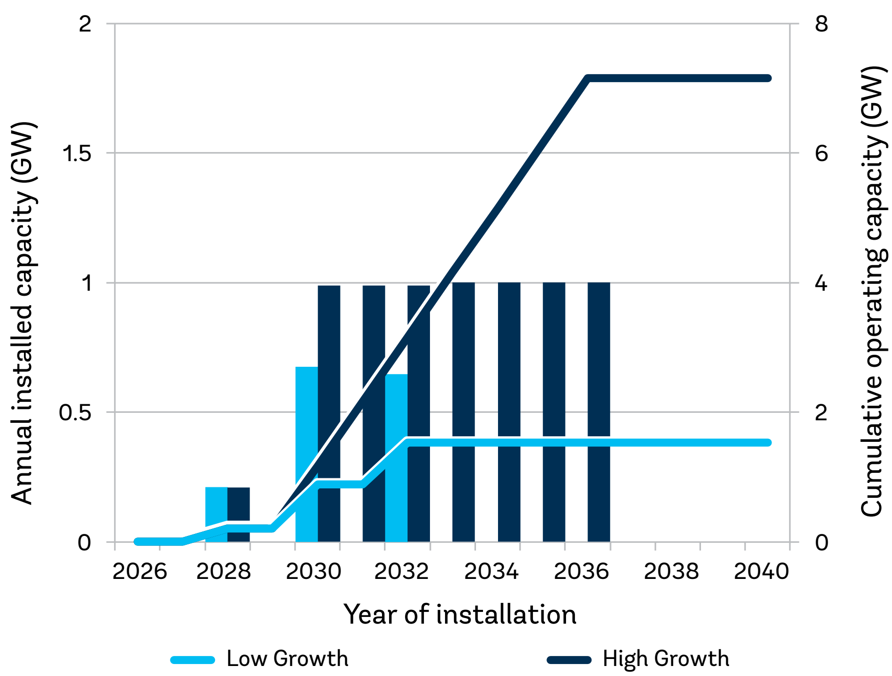
A Caspian Sea OSW market, where Azerbaijan could similarly benefit from OSW activity in other countries on the Caspian Sea, is not likely to emerge. Other countries with Caspian Sea coastline are considered unlikely to pursue OSW at scale because they have:

- Low OSW resources (Iran)
- OSW resources that are located far from centers of population and demand (Kazakhstan, Turkmenistan)
- Strong onshore wind and solar energy resources that are close to population (Kazakhstan, Turkmenistan)
- Good offshore wind potential on other coastlines that do not have the access limitations of the Caspian Sea (Russia).

2.1 VOLUMES AND TIMING

Figure 2.1 shows the annual and cumulative installations for the two scenarios. Note that although the scenarios appear to show smooth trends, actual annual installation rates can be expected to vary due to specific project sizes and timings. Large projects are suggested because of the cost reduction benefits available at scale.

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



Source: BVG Associates.

In both scenarios, the maximum annual installation rate is reached by 2030. In the high growth scenario, the maximum is 50% higher. 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 low growth scenario can be accommodated in any future energy mix. The high growth scenario is only realistic in a future energy mix where Azerbaijan follows a pathway where a significant amount of its heat and transport demand is decarbonized, where hydrogen is incorporated as an energy vector, and with an upgraded transmission network that includes improved dispatch, load, and demand side management capability

The scenarios are indicative of how the OSW market could be built out. In reality, following our recommendation:

- OSW development zones will be defined and projects will be developed and auctioned by Ministry of Energy (MOE), as discussed in Section 13
- Permits will be granted by the various authorities, as discussed in Section 12.

The pace of deployment will depend mainly on Government progress, but also industry's appetite to deliver. We show first project installed in 2028. Section 21 sets out the anticipated timescales in developing a first 210 MW scale pathfinder project, fitting with this date. There is an option for two pathfinder projects to be developed, see Section 13. Experience from established markets is that timescales are longer for offshore projects then for onshore wind and solar projects.

In this report, we focus on projects with fixed foundations (as opposed to floating) in water depths of between 10 and 40 meters. Floating projects could be installed further from shore to further increase capacity, as the relative cost premium for this technology reduces to negligible, likely during the 2030s. We discuss some of the key considerations regarding floating OSW in Section 7.3.

TABLE 2.1 CHARACTERISTICS OF THE TWO MARKET DEVELOPMENT SCENARIOS EXPLORED FOR AZERBAIJAN

	Low growth scenario	High growth scenario
Cumulative operating capacity end 2030 **2035** **2040**	0.9GW 1.5GW 1.5GW	1.2GW 6.2GW 7.2GW
Maximum installation rate	0.7GW per year	1GW per year
Policy environment	• Good visibility of installation target • Single, competitive auction for lease, PPA and grid connection after early-stage Government development • No formal local content requirement, but developers present plans to government for creating and sustaining local benefit as part of auction process • Local focus encouraged	• As low growth scenario • Potential for further auctions • As low growth scenario • As low growth scenario

	Low growth scenario	High growth scenario
Regulatory environment	• Proportionate marine spatial planning and early development activity following Good International Industry Practice (GIIP) • Transparent and timely auction process • Robust permitting processes with environmental and social impact assessment (ESIA) requirements in line with International Finance Corporation (IFC), GIIP, and other lender standards • Bankable power purchase arrangements • Robust health and safety (H&S) regulations and culture	• All as low growth scenario
Supply chain	• Towers (from 2030), foundations, and offshore substation (OSS) topsides manufactured locally; OSSs assembled locally • Construction and operation using local ports and vessels	• As low growth scenario • As low growth scenario plus turbine and foundation jack-up installation vessel constructed locally (for use from 2031)[v]
Other prerequisites for scenario	• Experienced overseas OSW project developer and use of international finance	• As low growth scenario

2.2 LOCATION OF POTENTIAL OFFSHORE WIND DEVELOPMENT ZONES

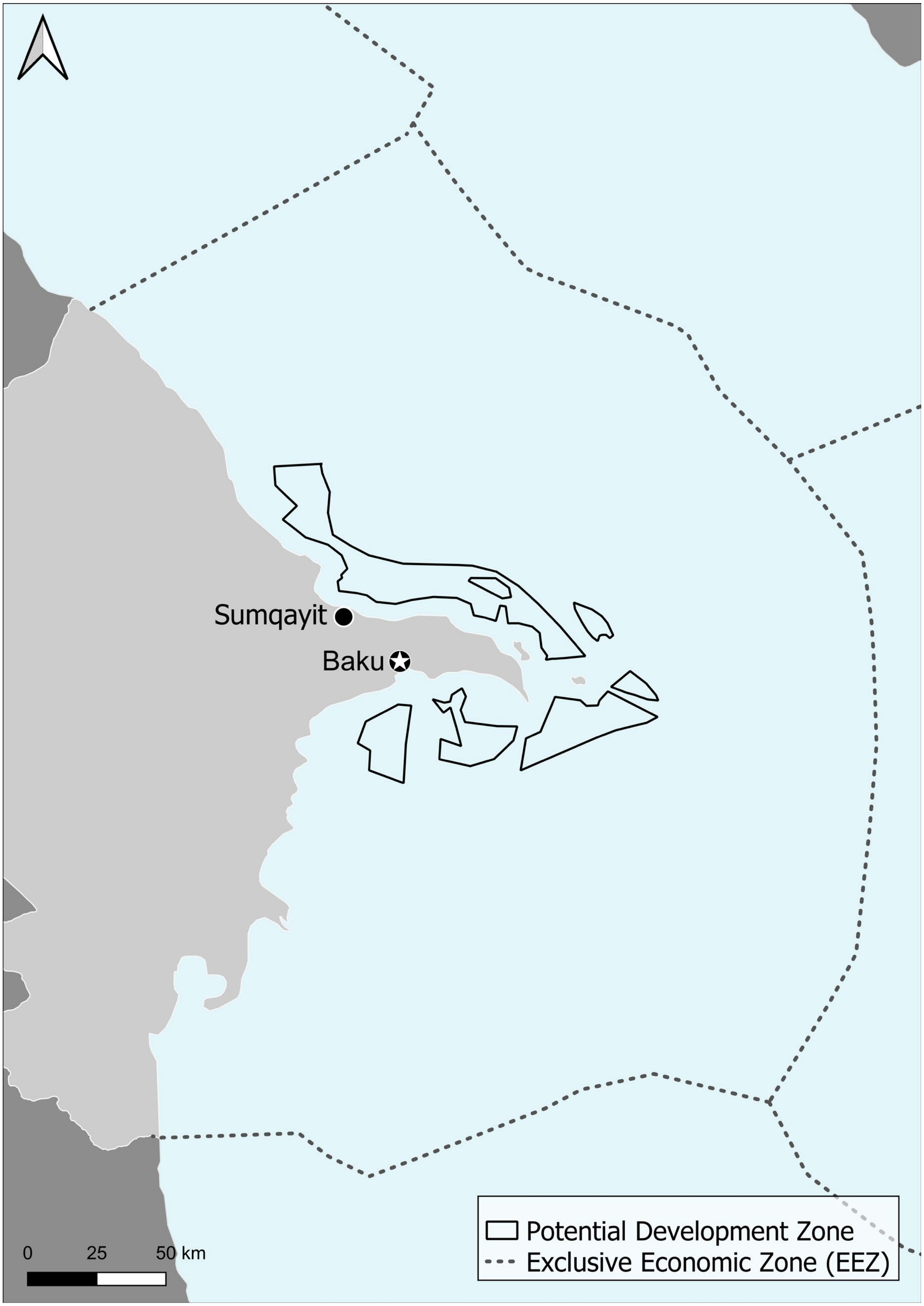
Based on an early assessment of the location of resource and demand, the broad areas for OSW development are relatively obvious, especially when focusing first on fixed OSW projects. Figure 2.2 presents potential OSW development zones[vi], following analysis summarized in Section 19. Projects under the low growth scenario are most likely to be developed in the development zones located to the north of the Absheron peninsula.

The process of defining zones is relevant to both scenarios but is seen as essential for the delivery of the high growth scenario. Their introduction and use are also further discussed in Section 3 and Section 4.

v It is not possible to transport an existing jack-up installation vessel into the Caspian Sea due to access restrictions on the northern and southern canal routes. It is recommended that due to the installation volumes in the high growth scenario, a jack-up installation vessel is fabricated in Azerbaijan for use on the Caspian Sea. See Section 17.6.

vi The impact of military zones on OSW development zones has not been considered in this roadmap. See Table 19.1.

FIGURE 2.2 POTENTIAL OFFSHORE WIND DEVELOPMENT ZONES



3 LOW GROWTH SCENARIO

3.1 DEVELOPMENT AREAS

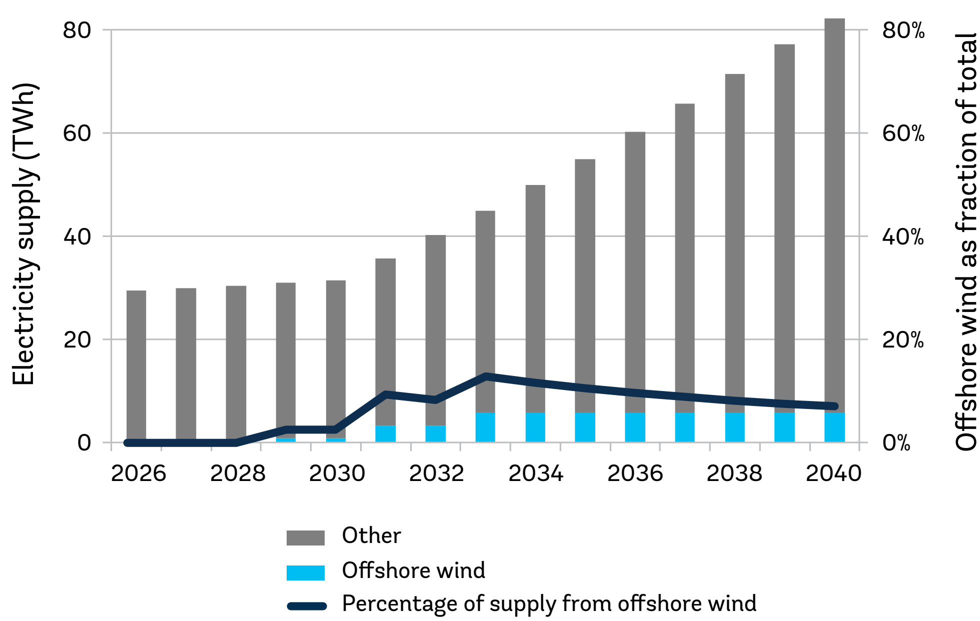
The low growth scenario involves fixed offshore (OSW) wind farms using jacket foundations. By the end of 2032, there will be just over 1.5GW operating, in three projects. Overall, projects cover only 8% of the potential OSW development zones identified in Figure 2.2. Should it be decided that further OSW capacity is advantageous, there is space for significantly more capacity to be added.

3.2 ELECTRICITY MIX

Figure 3.1 shows supply from OSW in the context of the demand for electricity in Azerbaijan over the period, including growth in electricity demand due to decarbonization of 30% of heat and transportation by the end of the period. In 2040, OSW will provide 7% of Azerbaijan's electricity supply. The remaining 93% of demand will be met mainly by gas generation, supported by renewables.

We discuss the future demand growth and electricity generation mix in Section 8.

FIGURE 3.1 ELECTRICITY SUPPLIED BY OFFSHORE WIND AND OTHER SOURCES TO 2040 IN THE LOW GROWTH SCENARIO



Source: BVG Associates.

3.3 SUPPLY CHAIN AND ECONOMIC IMPACT

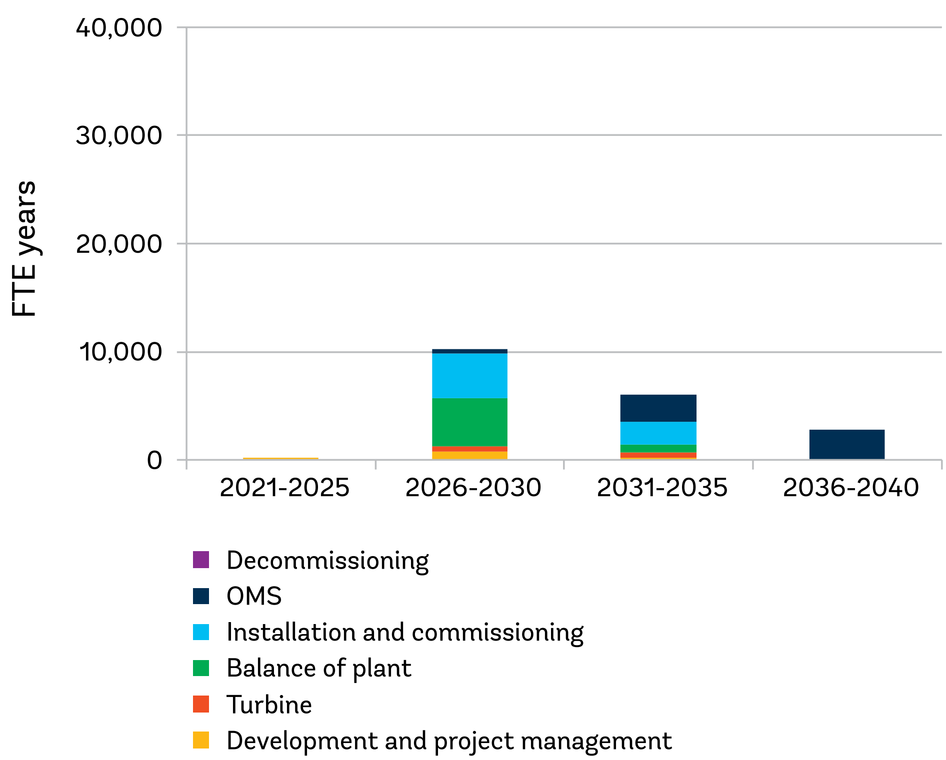
Under the low growth scenario, by 2032 Azerbaijan will have 53% local content in its OSW farms. It will be supplying towers and foundations and offshore substation (OSS) structures, plus large-scale construction and operations services. Foundations will be of jacket design, due to existing local manufacturing infrastructure and capability.

Details of the supply chain, economic benefits of OSW, and supply chain investment needs are discussed in Sections 9 and 10, including a description of how the local content is broken down.

Jobs

Figure 3.2 shows that by 2040, 19,000 full-time equivalent (FTE) years of employment will have been created by the OSW industry[vii]. In the 2030s, annual employment will be about 900 FTEs.

FIGURE 3.2 JOBS CREATED IN THE LOW GROWTH SCENARIO



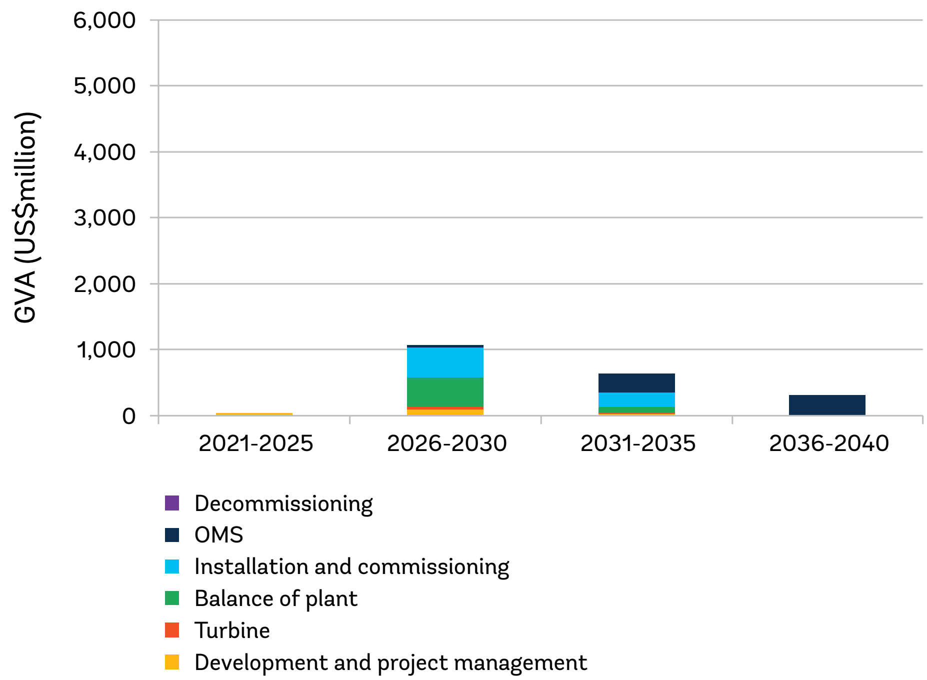
Source: BVG Associates.

vii Each FTE year of employment is the equivalent of one person working full time for a year. In reality the 19,000 FTE years of employment will be made 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 in Figure 10.1.

Gross value added

Figure 3.3 shows that by 2040, US$2 billion of gross value will have been added through supply to the OSW industry. In the 2030s, annual gross value added (GVA) will be US$0.1 billion.

FIGURE 3.3 LOCAL GROSS VALUE ADD IN THE LOW GROWTH SCENARIO



Source: BVG Associates.

Supply chain investment

Large-scale investment in the supply chain will relate to manufacture of towers and foundations. This will amount to US$55-130 million, with almost all investment in production facilities before 2030.

3.4 INFRASTRUCTURE

In this scenario, required modifications to the electricity transmission network will be minor, with upgrades limited to strengthening at a local level to accommodate grid connections and to allow improved balancing of supply and demand across the electricity system. The Azerbaijan electricity system benefits from inter-connection with neighboring countries, and future harmonization across these inter-connections will allow for increased electricity export. To optimize any system, with or without renewables, more dynamic demand management and active dispatching of generating plant will be advantageous as such technology progresses. Hydrogen production and the introduction of electric vehicles help manage the supply-demand balance. The transmission system is discussed in Section 16.

Bos Shelf could support both component manufacture and project construction with minor upgrades, depending on demand from the oil and gas sector. Baku Shipyard could provide support in periods of heightened demand from other sectors, also after minor upgrades. Port options are discussed in Section 17.

3.5 ENVIRONMENT & SOCIAL IMPACTS

By 2032, there will be about 95 large OSW turbines in Azerbaijan, installed in one pathfinder project and two large, fixed OSW farms.

Important environmental and social considerations in Azerbaijan include resident and migratory bird species, important bird and marine species habitats, and interaction with existing oil and gas infrastructure and activities.

Based on early assessment, the impacts will either be low or capable of being appropriately mitigated or compensated for through appropriate ongoing management measures as long as:

- Proportionate marine spatial planning (MSP) approaches are used to ensure that projects are located carefully in the potential OSW development zones to avoid areas of high environmental and social sensitivity
- Robust, project specific environmental and social impact assessments (ESIAs) are completed to Good International Industry Practice (GIIP) and integrated into the permitting process
- Cumulative environmental and social impacts are fully considered.

Key environmental and social considerations are discussed in Section 11.

The people of Azerbaijan will benefit from reduced local pollution, and the global environment will benefit from the displacement of 27mT carbon dioxide (CO_2) avoided by 2040. Azerbaijan is a signatory to the UNPCC Paris Agreement and has a ratified unconditional target to reduce greenhouse gas emissions.[3,4] Countries that remain heavily reliant on fossil fuels for electricity production are likely to come under increasing international pressure to decarbonize, as well having to pay more for their electricity. Environmental metrics are discussed in Section 7.1.

As discussed in Section 3.4, coastal communities may benefit from the projects in terms of economic activity and jobs although potential conflicts with fisheries, aquaculture, tourism, and other marine industries, and with cultural heritage will need to be considered and managed as part of MSP and ESIA. Residents of coastal communities, visitors, and tourists will be aware of the presence of the wind farms and their associated onshore infrastructure.

People working on OSW farm construction and operations will need to be kept safe from harm through a comprehensive approach to health and safety (H&S). We discuss this in Section 15.

3.6 FINANCE AND PROCUREMENT

In both scenarios, we propose OSW in Azerbaijan will be delivered through Government-led competitive processes. This structure will provide the best value to the economy of Azerbaijan. The existing renewable energy law in Azerbaijan provides a good framework for an OSW procurement process, although some adaptation will be required, including extending the period of project designation to eight years. This is discussed in Section 13.

The Government will invest in upfront project development activities, prior to offering the projects to the market through a competitive process. Developers that are awarded sites will compensate Government for the development expenditure. Projects will be developed by experienced international OSW project developers, potentially working in partnership with state owned entities and local private investors.

To minimize LCOE and keep to timescales in this scenario, the frameworks for permitting and energy procurement will need to be streamlined and developed. These areas are discussed in Sections 12 and 13.

Sources of public finance will be accessed to fund Government development work and vital project infrastructure including port upgrades and transmission assets. Around US$5 billion of capital will be required to develop and construct the OSW capacity in the low growth scenario. Private international investors will finance the later stages of OSW projects, possibly in partnership with local banks and state-owned entities. Financial instruments such as multilateral lending, credit enhancements, climate finance, and the adoption of green standards can be used to attract international finance and reduce the cost of OSW in Azerbaijan. This is discussed in Section 18.

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 11.

3.7 ACTIONS TO DELIVER THE LOW GROWTH SCENARIO

Our recommendations for government actions are listed in Section 5 and summarized in a Gantt chart in Figure 5.3. They are informed by the analysis of key ingredients of a successful OSW industry discussed in Section 6.

3.8 SWOT ANALYSIS FOR AZERBAIJAN IN THE LOW GROWTH SCENARIO

A strengths, weaknesses, opportunities, and threats analysis for Azerbaijan adopting this scenario is in Table 3.1.

TABLE 3.1 SWOT ANALYSIS FOR AZERBAIJAN IN THE LOW GROWTH SCENARIO

Strengths	Weaknesses
• Delivers local source of clean electricity supply, with long-term jobs and economic benefit. • Enables Azerbaijan to meet renewable energy targets and contributes towards decarbonization. • Attracts inward investment to Azerbaijan. • Going slower enables more time to react as industry and technology changes. • Less resource and urgency needed than in the high growth scenario. • Transmission system does not need significant upgrades beyond the types of upgrades already planned. • A full marine spatial plan with OSW development zones, and various other actions are not needed. However, spatial planning approaches should be used to ensure that projects are located carefully in the potential OSW development zones to avoid areas of high E&S sensitivity.	• Market size will not attract or sustain significant international developer interest. • Small market will not attract best prices or service provision from wind turbine suppliers. • Cost of energy higher than the high growth scenario, • Somewhat less Government enabling work will deliver 28% of the jobs and 29% of the GVA compared to the high growth scenario, by 2040. • Current ESIA processes do not fully follow GIIP or conform to environmental and social performance standards mandated by international lenders.
Opportunities	**Threats**
• Can accelerate to higher-growth scenario at any time, although at a higher cost than the high scenario and consequent project delays. • Reduce reliance on domestic gas for electricity production. • Accelerate reform of the energy market and regulatory mechanisms. • Diversify electricity suppliers to include independent power producers.	• All Government preparatory work on policy, frameworks, and site development has a fiscal impact, with payback only if the industry progresses as planned. • Does not address Azerbaijan's energy gap in route to decarbonization. • Developers not willing to invest due to limited size of the market. • Less motivation to solve local logistics challenges in constructing projects, adding cost. • If not pursuing energy decarbonization, Azerbaijani exports may be prohibited by carbon taxing. • In the absence of clear Government guidance and standards for ESIA aligned with GIIP and lender requirements, poor siting and development of projects could lead to adverse environmental and social effects, leading to delays in financing projects.

4 HIGH GROWTH SCENARIO

The high growth scenario delivers more energy, more jobs, faster pay back, and more carbon dioxide (CO_2) avoided than the low growth scenario. All measures improve due to the increased cost reduction delivered by a larger market, but government has to make a greater commitment and take more urgent action, including regarding its wider energy transition. The high growth scenario is based on the delivery of seven 1GW projects in seven consecutive years from 2030. This delivery profile is chosen to provide developers with the market visibility, continuity and momentum required to make investment decision and to drive development of the supply chain and reductions in LCOE.

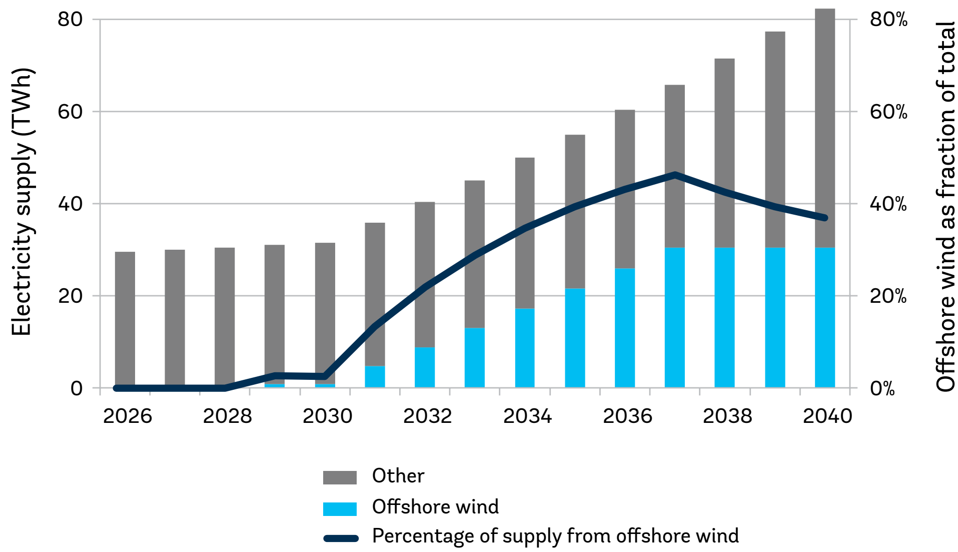
4.1 DEVELOPMENT AREAS

The high growth scenario involves fixed offshore wind (OSW) farms using monopile foundations. By the end of 2036, there will be 7.2GW operating. Overall, projects cover 38% of the potential OSW development zones identified in Figure 2.2. As for the low growth scenario, should it be decided that further OSW capacity is advantageous, there is space for as much OSW as is required. In the high growth scenario, much of this additional capacity will be floating, located in deeper water.

4.2 ELECTRICITY MIX

Figure 4.1 shows supply from OSW in the context of the demand for electricity in Azerbaijan over the period. In 2040, OSW will provide 37% of Azerbaijan's electricity supply. The remaining demand will be met by 7.3GW of gas generation (35%), and other renewables (28%). As the renewable energy capacity grows over the period, gas generation will be increasingly displaced by renewables in a flexible system with active dispatching of generating plant, and some OSW output will be converted to hydrogen for storage and use in transportation and industrial processes. We discuss the future electricity mix in Section 8.

FIGURE 4.1 ELECTRICITY SUPPLIED BY OFFSHORE WIND AND OTHER SOURCES TO 2040 IN THE HIGH GROWTH SCENARIO



Source: BVG Associates.

The high growth scenario assumes that Azerbaijan will develop a flexible electricity system with the ability to absorb a high penetration of variable renewable energy, and dynamically manage supply and demand. Such a system will include features such as:

- Flexible and dynamic plant dispatch
- Demand-side aggregation and control
- Smart metering technology enabling domestic and industrial consumers to respond to real-time price signals
- Embedded energy storage, including grid-connected batteries and aggregated battery capacity from EV networks
- The production and use of green hydrogen for applications such as industrial processes, heating networks, aviation and heavy transport vehicles.

Further feasibility studies on the macro-scale power and energy system and the potential role for hydrogen are required to determine the full range of solutions required. Many of these will be required in time as all countries move to a decarbonized energy system.

4.3 SUPPLY CHAIN AND ECONOMIC IMPACT

Under the high growth scenario, by 2032 Azerbaijan will have 51% local content in its OSW farms. It will be supplying towers and foundations and offshore substation (OSS) structures, plus large-scale construction and operations services and operating a purpose-built jack-up installation vessel. It is not possible to transport an existing jack-up installation vessel into the Caspian Sea due to access restrictions on the northern and southern canal routes. It is recommended that due to the installation volumes in the high growth scenario, a jack-up installation vessel is fabricated in Azerbaijan for use on the Caspian Sea. This is discussed in Section 17.6.

Increased market size has a significant impact on local economic benefit, as discussed in Section 6.6.

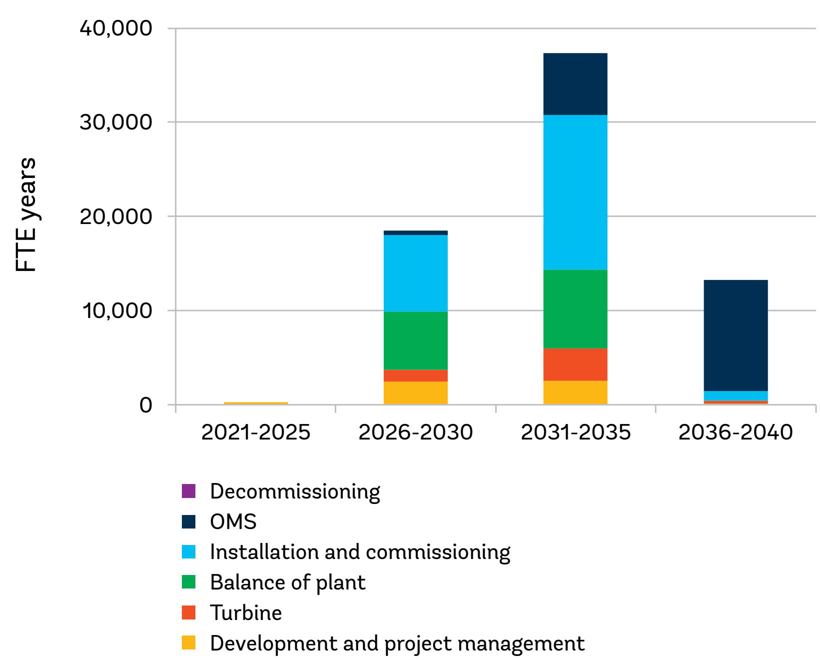
Local content in the high growth is slightly lower than in the low growth scenario (53%) due to the use of monopile foundations, which are less labor intensive to fabricate than jacket foundations.

Details of the supply chain, economic benefits of OSW and supply chain investment needs are discussed in Sections 9 and 10, including a description of how the local content is broken down.

Jobs

Figure 4.2 shows that by 2040, 69,000 full-time equivalent (FTE) years of employment will have been created by the OSW industry. In the 2030s, annual employment will be about 5,000 FTEs. In total to 2040, about 3.6 times as much employment will have been created than in the low growth scenario. This is because 4.7 times the volume is installed but due to efficiency and cost reduction, fewer jobs are created per MW.

FIGURE 4.2 JOBS CREATED IN THE HIGH GROWTH SCENARIO

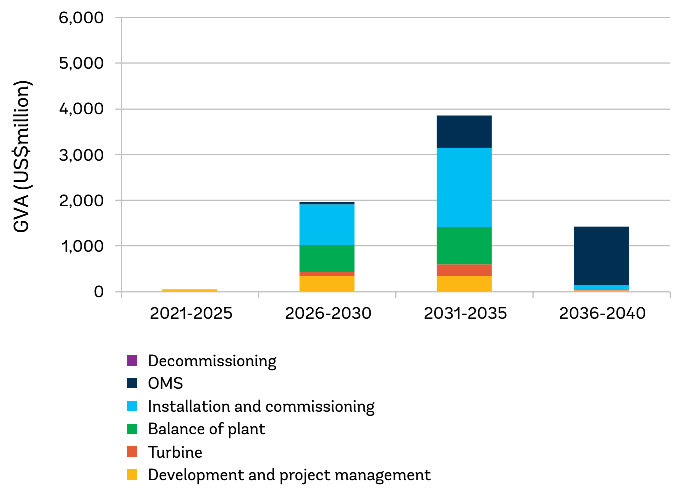


Source: BVG Associates.

Gross Value added

Figure 4.3 shows that by 2040, US$7.3 billion of gross value will have been added through supply to the OSW industry. In the 2030s, annual gross value added (GVA) will exceed US$0.5 billion, about five times higher than in the low growth scenario.

FIGURE 4.3 LOCAL GROSS VALUE ADD IN THE HIGH GROWTH SCENARIO



Source: BVG Associates.

Supply chain investment

Large-scale investment in the supply chain will relate to manufacture of towers and foundations and a turbine and foundation installation vessel. This will amount to US$250-450 million, again with almost all investment before 2030.

4.4 INFRASTRUCTURE

In this scenario a significant volume of new variable renewable energy capacity will be constructed, at times providing more energy than required to meet immediate electricity demand. The electricity transmission system will need significant local reinforcement to where power from OSW comes ashore. It is likely that hydrogen production is established close to some grid connection points. Transmission system upgrades can take considerable time in planning and installation, considering environmental, social, and technical considerations, so it is important to progress this early. There is a need also to increase the flexibility of the electricity system to allow improved balancing of supply and demand, including using the storage capacity of EVs and hydrogen, as well as export.

The amount of generation from OSW in the high growth scenario will only fit with the Azerbaijan energy system in a decarbonization pathway, as discussed in Section 8, which drives both an increase in electricity demand, as well as significant hydrogen production and use of electric vehicles to help manage the supply-demand balance. The transmission system is discussed in Section 16.

Bos Shelf and Baku Shipyard will be used after minor upgrades, and additional space is likely to be required, depending on demand from the oil and gas sector. Such space has been identified near Bos Shelf, else Zira port could be used after moderate upgrades.

4.5 ENVIRONMENT & SOCIAL IMPACTS

Under this high growth scenario, by 2036 there will be about 390 large OSW turbines in Azerbaijan, installed in one pathfinder project and seven large, fixed OSW farms.

Important environmental and social considerations in Azerbaijan include resident and migratory bird species, important bird and marine species habitats, and interaction with existing oil and gas infrastructure and activities. The scale of OSW development under the high growth scenario increases the need to carefully assess environmental and social impacts.

Based on early assessment, the development areas can be located outside of sensitive areas such as Protected Areas and Key Biodiversity Areas, therefore the impacts will either be relatively low or capable of being appropriately mitigated or compensated for through appropriate ongoing management measures as long as:

- Proportionate marine spatial planning (MSP) approaches are used to ensure that projects are located carefully in the potential OSW development zones to avoid areas of high environmental and social sensitivity
- Robust, project-specific environmental and social impact assessments (ESIAs) are completed to Good International Industry Practice (GIIP) and integrated into the permitting process
- Cumulative environmental and social impacts are fully considered.

If not carefully planned and permitted, this high level of development could give rise to significant adverse environmental and social effects, including on internationally important biodiversity. Comprehensive MSP will be required to ensure that projects are located carefully in the potential OSW development zones. Robust, project-specific environmental and social impact assessments (ESIAs) to the standard of Good International Industry practice (GIIP) and integrated into 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 are discussed in Section 11.

The people of Azerbaijan will benefit from reduced local pollution, and the global environment will benefit from the displacement of 107mT CO_2 avoided by 2040. This and other environmental metrics are discussed in Section 7.1.

As discussed in Section 4.3, coastal communities may benefit from the projects in terms of economic activity and jobs although potential conflicts with fisheries, aquaculture, tourism, and other marine industries, and with cultural heritage will need to be considered and managed as part of MSP and ESIA. Residents of coastal communities, visitors, and tourists will be aware of the presence of the wind farms and their associated onshore infrastructure.

People working on OSW farm construction and operations will need to be kept safe from harm through a comprehensive approach to health and safety (H&S). We discuss this in Section 15.

4.6 FINANCE AND PROCUREMENT

As in the low growth scenario, OSW in Azerbaijan will be supported through Government-led competitive processes. This structure will provide the best value to the economy of Azerbaijan. The existing renewable energy law in Azerbaijan provides a good framework for an OSW procurement process, although some adaptation will be required, including extending the period of project designation to eight years. This is discussed in Section 13.

The Government will invest in upfront project development activities, prior to offering the projects to the market through a competitive process. Developers that are awarded sites will compensate Government for the development expenditure.

Projects will be developed by international private developers, potentially working in partnership with state owned entities and local private investors.

To minimize LCOE and keep to timescales in this scenario, the frameworks for leasing, permitting, and power purchase will need some reform and improvement, including streamlining the permitting processes. An increase in capacity will be required within organizations administering frameworks and acting as consultees. These areas are discussed in Sections 11, 12, and 13.

Standards and processes that do not meet GIIP will limit the availability of international finance, particularly in the areas of environmental and social impact assessment and stakeholder engagement. There is more urgency to progress these than in the low growth scenario. These areas are discussed in Section 14.

Around US$20 billion of capital will be required to develop and construct the OSW capacity in the high growth scenario. 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. Private international investors will finance OSW projects, possibly in partnership with local banks and state owned entities. Financial instruments such as multilateral lending, credit enhancements, climate finance, and the adoption of green standards can be used to attract international finance and reduce the cost of OSW in Azerbaijan. These areas are discussed in Section 18.

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 11.

4.7 ACTIONS TO DELIVER THE HIGH GROWTH SCENARIO

Our recommendations for government actions are listed in Section 5 and summarized in a Gantt chart in Figure 5.4. They are informed by the analysis of key ingredients of a successful OSW industry discussed in Section 6. Due to the greater scale and faster pace of industry growth in this scenario compared to the low growth scenario, there is increased commitment needed and urgency for Government action.

4.8 SWOT ANALYSIS FOR AZERBAIJAN IN THE HIGH GROWTH SCENARIO

A strengths, weaknesses, opportunities, and threats analysis for Azerbaijan adopting this scenario is in Table 4.1.

TABLE 4.1 SWOT ANALYSIS AZERBAIJAN IN THE HIGH GROWTH SCENARIO

Strengths	Weaknesses
• Delivers local, eventual low cost, large scale-source of clean electricity supply, with long-term jobs and economic benefit. • Attracts inward investment to Azerbaijan. • Larger market size will sustain international developer interest, helping to drive innovation and lower LCOE than the low growth scenario. • Larger market size will sustain local supply chain, delivering 3.6 times more jobs and GVA compared to the low growth scenario, by 2040. • Azerbaijan maintains energy independence whilst decarbonizing,	• Requires substantial transmission upgrades and improvements in system flexibility to manage high penetration of variable renewables. • Requires wide co-ordination across energy sectors, on both demand and supply side, to realize the vision. • Requires greater commitment and resource across Government than in the low growth scenario. • Current ESIA processes do not fully follow GIIP or conform to environmental and social performance standards mandated by international lenders.
Opportunities	**Threats**
• Increase electricity export to inter-connected neighbors. • Regional hydrogen export. • Will enable wider electrification and decarbonization of energy system in Azerbaijan, including heat, industry, and transport. • Accelerate reform of the energy market and regulatory mechanisms. • Diversify suppliers to include independent power producers.	• All Government preparatory work on policy, frameworks, and site development has a fiscal impact, with payback only if the industry progresses as planned. More work is needed sooner than in the low growth scenario. • Electricity demand does not grow to meet increased supply from OSW, leading to a surplus of electricity production. • Significant cost per MWh if industry does not progress after the early years. • May not secure interest of developers due to risk around energy transition dependency. • Heat, industry, and transport transition could go slowly, lessening justification for high volumes. • In the absence of clear Government guidance and standards for ESIA aligned with GIIP and lender requirements, poor siting and development of projects could lead to adverse environmental and social effects, and delays in financing projects. This could be made worse with a higher number of turbines installed than in the low growth scenario. • Potential for cumulative environmental and social impacts.

5 ROADMAP FOR OFFSHORE WIND IN AZERBAIJAN: OUR RECOMMENDATIONS

Offshore wind (OSW) has seen tremendous growth in some parts of the world, most notably in northwest Europe and in 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 low cost 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.

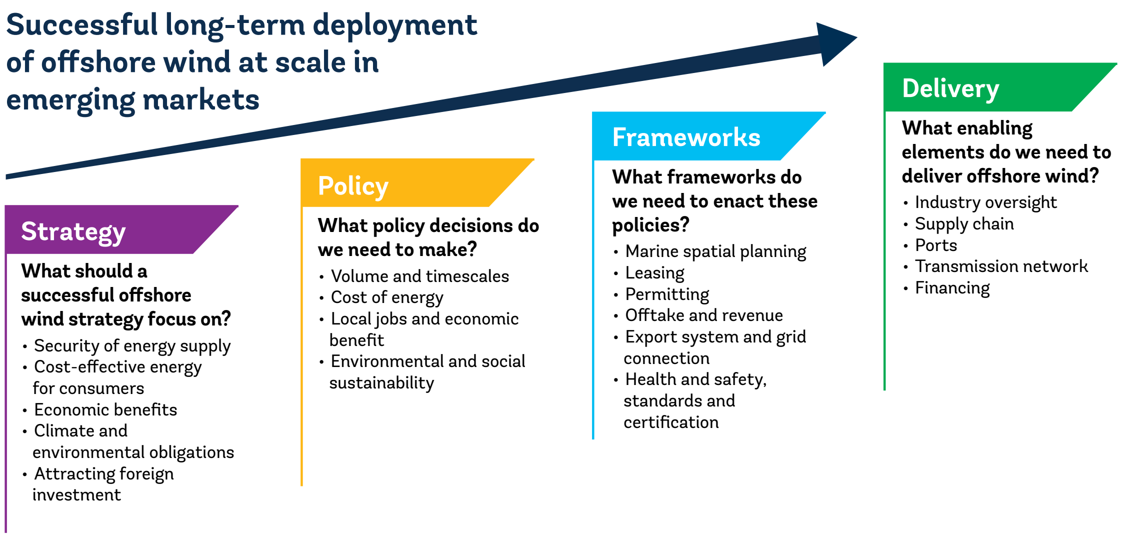
For OSW to be successfully established in Azerbaijan, it is essential Government designs and implements comprehensive policies and frameworks covering the identification, leasing, permitting, and contracting of OW projects that enable growth and are aligned with the needs of industry. This roadmap provides the Government of Azerbaijan with options that it can choose to implement, depending on its end goal and ambitions for the energy sector.

The low growth scenario allows Azerbaijan to initiate an OSW market with minimal disruption to its wider energy sector and to meet its 2030 renewable energy installation targets, setting it on course to meet higher future targets. It offers less of an opportunity to create jobs and economic value and drive costs down and contribute to decarbonization than the high growth scenario.

The high growth scenario allows Azerbaijan to deliver competitively-priced power and set the country on a path towards decarbonization of its energy system. It would require substantial upfront investment in project and infrastructure development, but with the creation of substantial employment and economic benefits.

Based on experience in a range of countries, Section 6 summarizes key ingredients for a successful OSW industry, taking much learning from World Bank Group's *Key Factors* report.[2] 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[2]



The key recommendations in the roadmap for OSW in Azerbaijan are presented in Sections 5.1 to 5.7 and summarized for the two scenarios in Figure 5.3 and Figure 5.4, showing suggested timing of activities.

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.[2]

Many of the recommendations stand for both the low- and high growth scenarios but can 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 5.3, giving a reduced list of roadmap actions.

The roadmap timelines presented in Figure 5.3 and Figure 5.4 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 in Azerbaijan and build confidence in that framework with stakeholders and industry
- The requirement for improved data to inform spatial planning, and social and environmental impact assessment
- The lack of experience in Azerbaijan of large scale renewables being developed by independent power producers
- The requirement to plan, finance, and build grid and port infrastructure in time for the planned OSW capacity
- The need to identify solutions to the access restrictions posed by the limited accessibility of the Caspian Sea, including the need to construct a specialist OSW installation vessel in the Caspian Sea.

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 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 Azerbaijan. We recommend that:

1. The Government publishes and communicates a vision for OSW in Azerbaijan and its role as part of a wider energy transition strategy and ensures that all subsequent policies and regulations consider this vision. (see Sections 6 and 8) (S)
2. The Government sets installation targets for OSW for 2030 and 2036 in line with the high growth scenario presented and ensures that all subsequent policies and regulations consider these targets. After this, we recommend that the Government tracks cost reductions as project build-out progresses and adjusts installation targets dependent on cost reductions being achieved. (see Sections 6 and 8) (P)

5.2 LEASING, PERMITTING, AND POWER PURCHASE

To develop a sustainable OSW energy industry Azerbaijan needs processes for leasing and permitting that are robust, transparent, and timely. International investment will be required to develop the potential volumes of OSW in Azerbaijan discussed in this report. A stable route to selling electricity is required to make this happen. We recommend that:

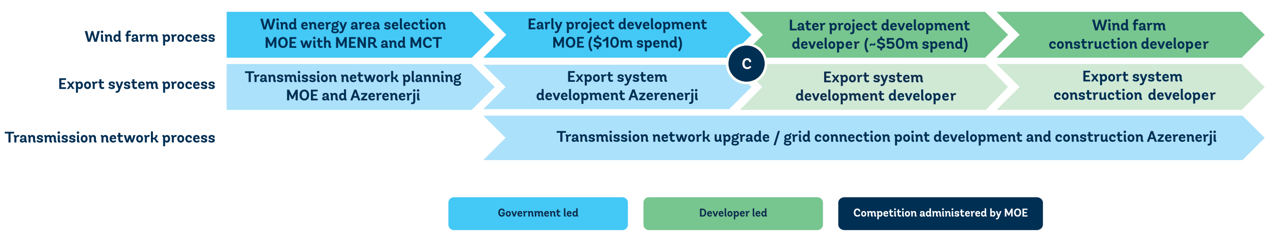
3. Ministry of Energy (MOE), in consultation with Ministry of Ecology and Natural Resources (MENR), Ministry of Defense (MOD), and Ministry of Culture (MOC), undertakes site screening and investigations on the potential OSW development zones to determine possible environmental and social and military constraints and hence level of suitability for further development of OSW as part of the wider OSW marine spatial planning activity, especially considering cumulative assessment. (see Section 11) (F)
4. MOE accelerates the identification and designation of OSW projects, taking advice on good practice and lessons learned from Governments that have implemented Government-led OSW procurement processes. (see Section 13) (D)
5. MOE initiates measurement and data gathering campaigns on key technical aspects of the potential OSW development zones including wind resource, metocean, geological, ecological, and social surveys to address any identified gaps in current knowledge. (see Section 19) (D)
6. MOE undertakes up front surveys and pre-front end engineering and design (FEED) work required to establish a project pipeline that will be subject to competitive bids. (see Section 13) (D)
7. MOE considers streamlining the permitting process and improving coordination between different Ministries and other bodies from whom consent and permissions are required whilst at the same time ensuring that permitting requirements including ESIA meet good international industry practice (GIIP) to help de-risk projects and facilitate access to international finance. (see Section 12) (F, D)

8. MOE extends the period of designation for a renewable energy location from a maximum of three years to eight years to allow necessary OSW survey, design, and development processes to be completed. (See section 12) (F)
9. MOE establishes a single competition solution solely for OSW, combining, leasing, grid connection, and PPA. (see Section 13) (F)
10. MOE sets out a clear timetable for work to deliver this solution, including dates of private-sector competitions, and keeps all stakeholders well informed of timing and locations of activities, coordinating across Government and private sector to deliver. (see Section 13) (D)

A summary of recommended government and project developer responsibilities for OSW activities through the project lifecycle, also showing the timing of the element of competition, is shown in Figure 5.2. This follows the format of Figure 3.4 of World Bank Group's *Key Factors* report which presents responsibilities in a range of established markets.[2] Indicative spend is for a 1GW project.

Further detail of early project development activities to be delivered by Government, their timing and expenditure are provided in Section 21.9.

FIGURE 5.2 SUMMARY OF RECOMMENDED GOVERNMENT AND PROJECT DEVELOPER RESPONSIBILITIES FOR OFFSHORE WIND ACTIVITIES THROUGH THE PROJECT LIFECYCLE IN AZERBAIJAN. INDICATIVE SPEND IS SHOWN FOR A 1GW PROJECT



5.3 FINANCE

Reducing the cost of capital for OSW projects in Azerbaijan is a key driver in reducing the cost of energy and in encouraging inward investment. We recommend that:

11. MOE and Azerenerji structure OSW PPA terms to be attractive to commercial lending, including direct foreign investment, and consider mechanisms that reduce investor risk and the cost of finance and deliver an acceptable sharing of risk between the developer and Azerenerji. (see Section 18) (F)
12. MOE, Ministry of Economy, and Ministry of Ecology and Natural Resources adopts international standards for environmental and social governance such that projects can attract international finance and Government considers the deployment of concessional, multilateral, and climate finance towards offshore wind and decarbonization in Azerbaijan. (see Section 18) (D)

5.4 TRANSMISSION NETWORK AND PORT INFRASTRUCTURE

This report shows that it makes sense for Azerbaijan to invest in a program of grid and port infrastructure upgrades to deliver large amounts of OSW. We recommend that:

13. MOE publishes 2050 vision for a nationwide electricity transmission network for a decarbonized energy system, including consideration of the impact of market reform and analysis of the offshore development zones, with milestone plans for 2030 and 2040. (see Section 16) (S)
14. MOE undertake country wide power systems studies to understand the potential impacts of OSW and other renewables on the future electricity system, including those directly related to decarbonization of transport and heat, such a hydrogen production close to OSW grid connection points and the opportunity for increased electricity export, considering potential environmental and social impacts of grid upgrades. (see Sections 8 and 16) (S)
15. Azerenerji prioritizes the modernization of systems required to perform system wide-generation supply and demand balancing and plant dispatch, needed for any efficient future energy system. (see Section 16) (D)
16. MOE and Azerenerji ensure clarity regarding grid code compliance, and consider compensation arrangements for delays to grid connection or project delivery timelines. (see Section 16) (F)
17. MOE works with the ports of Baku Shipyard, Bos Shelf, and Zira to determine their interest and availability to deliver manufacturing and construction services to the OSW industry and explore routes to necessary upgrades, considering potential environmental and social impacts of such expansion. (see Section 17) (D)

5.5 SUPPLY CHAIN DEVELOPMENT, INNOVATION, AND DIVERSITY

Azerbaijan possesses strong port infrastructure and industrial skills and OSW has the potential to deliver substantial economic benefit to Azerbaijan.

By committing to ambitious volume targets for OSW, putting in place a comprehensive procurement process and offering stable routes to market, Azerbaijan will attract interest from the international OSW development community. This will in turn lead to the development and growth of the OSW supply chain, sustaining existing jobs, delivering new employment, and leading to additional high-value economic activity in Azerbaijan. A coordinated, multi-agency approach will be required to maximize local benefits and grow local capabilities.

We recommend that:

18. MOE presents a balanced vision for local supply chain development, encouraging international engagement in key areas identified for local supply to ensure latest international good practice is accessed to keep costs down. (see Section 9) (D) (H)
19. MOE and relevant Government agencies enable education and investment in local supply chain businesses, including in training of onshore and offshore workers. (see Section 9) (D)
20. MOE enables investment in a local wind turbine installation vessel in the high growth scenario. (see Section 9) (D) (H)

21. MOE produces a roadmap of research priorities for advancing OSW in Azerbaijan, with focus on levelized cost of energy (LCOE) reduction and establishes an industry-academic board or national research and development (R&D) consortium/center to drive activities. (see Section 22) (F) (H)
22. Academic institutions start developing second-cycle courses and doctoral training programs specific to OSW. (see Section 22) (D) (H)
23. Industry and Government work together to encourage women into the sector, including in engineering, design, management, and operations. Opportunities should be well promoted and gender decoders and gender-balanced language used to make recruitment practices unbiased. (see Section 23) (D)
24. MOE requires that developers successful in auctions involve their supply chain in gender equality working groups, supported by women's rights organizations in Azerbaijan, GWEC, and GWNET. The Women in Renewable Energy Network also has a chapter in Azerbaijan. (see Section 23) (D)

5.6 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 environmental and social impact assessment standards, technical legislation, and design codes is an important element in establishing bankability and attracting and sustaining international interest and investment in the market. We recommend that:

25. MENR addresses any shortfalls in Azerbaijan environmental and social impact assessment (ESIA) requirements compared to those of International Finance Corporation (IFC), GIIP, and other lender standards. (see Section 11) (F)
26. Ministry of Emergency Situations adapts existing framework of technical codes and regulation, adopting international industry codes where appropriate. This is especially relevant for grid codes and the transmission network. (see Sections 15 and 16) (F)
27. MES develops H&S regulations specifically designed for application to the OSW industry, which would include reference to the international design and operational standards that should be followed. (see Section 15) (F)

5.7 CAPACITY BUILDING

Strong frameworks only deliver if they are implemented through agencies with clear roles, well-defined mandates, and sufficiently resourced staff. It is recommended that:

28. MOE leads in helping government departments including MENR and other key stakeholders to grow capacity and knowledge needed to process a growing volume of OSW projects. (see Section 6) (F)

FIGURE 5.3 LOW GROWTH SCENARIO ROADMAP FOR OFFSHORE WIND IN AZERBAIJAN

Low growth scenario	1: Set the vision										
	2: Evolve the frameworks										
	3: Develop and install first project										
						4: Stable build out					
Volumes	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**
Annual installation rate (GW/yr)							0.21		0.67		0.65
Cumulative operating capacity (at end of year) (GW)							0.21	0.21	0.88	0.88	1.53
Vision and volume targets											
1. Vision for OSW to 2050											
2. Installation targets for 2030 and 2036											
Leasing, permitting and power purchase											
3. Marine spatial planning and site screening											
4. Identify and designate the offshore wind projects											
5. Initiate measurement and survey campaigns											
6. Pre-FEED studies											
7. Streamline permitting processes											
8. Extend site designation period											
9. Establish procurement competition											
10. Set out procurement timetable				1.53							
Finance											
11. Structure OSW PPA											
12. Adopt environmental and social standards, access climate finance											
Transmission and port infrastructure											
13. Publish transmission network vision to 2050											
14. Undertake power system studies											
15. Power system modernization											
16. Clarify grid connection process and codes											
17. Enable port infrastructure investments											
Supply chain development, innovation and diversity											
19. Enable supply chain investment and training											
23. Encourage gender balance											
24. Gender equality working groups											
Standards and regulations											
25. ESIA requirements											
26. Technical code frameworks											
27. H&S regulations											
Capacity building											
28. Grow capacity and knowledge											

FIGURE 5.4 HIGH GROWTH SCENARIO ROADMAP FOR OFFSHORE WIND IN AZERBAIJAN

High growth scenario	1: Set the vision														
	2: Evolve the frameworks														
	3: Develop and install first project														
						4: Stable build out									
Volumes	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**	**2033**	**2034**	**2035**	**2036**
Annual installation rate (GW/yr)							0.21		0.99	0.99	0.99	1.00	1.00	1.00	1.00
Cumulative operating capacity (at end of year) (GW)							0.21	0.21	1.20	2.19	3.18	4.18	5.18	6.18	7.18
Vision and volume targets															
1. Vision for OSW to 2050															
2. Installation targets for 2030 and 2036															
Leasing, permitting and power purchase															
3. Marine spatial planning and site screening															
4. Identify and designate the offshore wind projects															
5. Initiate measurement and survey campaigns															
6. Pre-FEED studies															
7. Streamline permitting processes															
8. Extend site designation period															
9. Establish procurement competition															
10. Set out procurement timetable				5.18				2.00							
Finance															
11. Structure OSW PPA															
12. Adopt environmental and social standards, access climate finance															
Transmission and port infrastructure															
13. Publish transmission network vision to 2050															
14. Undertake power system studies															
15. Power system modernization															
16. Clarify grid connection process and codes															
17. Enable port infrastructure investments															
Supply chain development, innovation and diversity															
18. Present vision for supply chain development															
19. Enable supply chain investment and training															
20. Enable installation vessel investment															
21. Produce R&D roadmap															
22. Develop courses and doctorate programs															
23. Encourage gender balance															
24. Gender equality working groups															
Standards and regulations															
25. ESIA requirements															
26. Technical code frameworks															
27. H&S regulations															
Capacity building															
28. Grow capacity and knowledge															

SUPPORTING INFORMATION

Photo Courtesy of Fred Olsen

6 KEY INGREDIENTS FOR A SUCCESSFUL OFFSHORE WIND INDUSTRY

This section summarizes key ingredients for a successful offshore wind (OSW) industry based on experience in a range of markets, mainly captured in World Bank Group's *Key Factors* report.[2]

It is recognized that each market will have different strategic drivers and considerations, so whilst generic *key factors* are important, learning always needs to be applied in context. In response to the *key factors*, we have included a commentary specific to Azerbaijan and reference to recommendations presented in Section 5.

6.1 A CLEAR ENERGY STRATEGY

OSW should be considered as part of a long-term energy strategy alongside other forms of energy production, in the context of the electrification and decarbonization of national energy systems looking towards 2050. By then, the majority of fossil fuel use in electricity production, transport and heat will have ended, and most energy production will be from renewable sources — wind, solar, and hydro. Typically, OSW projects provide large-scale electricity generation, with higher capacity factors than onshore wind and solar projects. As it stands today, storage of energy is likely to be mainly through hydrogen and electric vehicles (EVs). Utility-scale battery storage will be used to provide additional system flexibility. Hydrogen is likely to be an important vector for some forms of energy use, including in larger vehicle transport and industrial applications.

This means countries should ask themselves:

- Where will our energy come from, in future?
- How do we manage the cost and risk of this supply?
- How will we get energy from where it is extracted to where it is used?
- Should OSW be a big part of our energy future?

Section 1 of the World Bank Group's *Key Factors* report discusses this area in more detail.[2] Azerbaijan is well placed, with World Bank Group and other support, to develop the next iteration of its energy strategy.

Our recommendations 1 and 13 relate to this point.

6.2 STABLE OFFSHORE WIND POLICIES AND PIPELINE VISIBILITY

Sufficient, attractive lease areas for development

OSW project developers and their supply chains need to have confidence in a sufficiently large and visible pipeline of projects to facilitate investment, ongoing learning, and competition.

For Azerbaijan, with a relatively low energy demand compared to many countries developing OSW, this means giving a small number of players a large share of the market in order that they and their supply chains have enough visibility to invest. We have structured industry growth with early focus on fixed OSW projects, with the prospect of further development of floating OSW in the 2040s, but should developers argue that they can deliver floating projects at competitive cost earlier, and supply is needed, then it could be that floating activity is accelerated. It will be important, however, not to reduce certainty and volumes for developers of fixed projects through changing plans for floating projects.

This roadmap suggests a solid basis for establishing a healthy pipeline of OSW projects, especially through early Government development of projects.

Our recommendations 2, 3, 4, 5, 6, 25, and 28 relate to this point.

Streamlined permitting process

Many countries have learnt that a clear, efficient, well-resourced permitting process incorporating good practice for ESIA and led by a single organization with clear accountabilities and basis for decisions is key, both in terms of minimizing environmental and social harm and facilitating project financing by meeting the performance standards of international lenders.

Although there will not be many developers seeking permits and Government will have done all preliminary work, it is still important to have clear processes in line with Good International Industry Practice (GIIP).

Our recommendations 7, 8, 25, and 28 relate to this.

A regime that de-risks developers' exposure to long-term energy price fluctuation

Wind farm owners are exposed to significant project development and construction risk, and ongoing risks relating to wind speeds and project performance. Additional risks due to grid curtailment and variable sales price of electricity generated adds financing cost to projects, increasing the cost to consumers. There are also risks related to retrospective changes to tariffs. Countries that have progressed OSW deployment quickly have managed exposure to this risk via robust, government-backed contracts and stable policy.

Our recommendations 9 and 11 relate to this.

Stable and transparent investment environment

As well as confidence in the OSW frameworks, wind farm developers and investors need confidence in the legal, financial, and tax regimes in any market to consider investments bankable.

Having a recognized framework of technical legislation and design codes and standards also helps establish bankability and attract international investment. There is a balance to find between adapting existing national standards relevant to other industries and adopting international OSW good practice, which reduces risk and cost for international players to supply in Azerbaijan.

Our recommendations 12, 25, 26, 27, and 28 relate to this.

6.3 A STRONG AND ACCESSIBLE TRANSMISSION NETWORK

Transmission network

A robust transmission network to take power to areas of demand and with low risk of uncompensated curtailment is key for project developers. Often, waiting for a grid connection and associated transmission upgrades are the longest-lead item in an OSW project development.

Our recommendations 13, 14, 15, and 26 relate to this.

Timely grid connections

At an individual project level, project developers need to be confident that as they increase project spend, they will be able to connect to the grid on the date agreed as part of the competitive procurement process. Delays between large capital spend and first generation add significantly to LCOE, due to the cost of finance.

Our recommendation 16 relates to this.

6.4 A COHERENT INDUSTRIAL POLICY

Policies that encourage realistic levels of local supply whilst keeping close focus on cost

OSW can provide valuable jobs and local economic benefit. Good industrial policy balances cost to the consumer and job creation. Industry can help find the optimal ways to work with the Government to achieve these objectives, ensuring sufficient staff are trained. Gender equality is key to development of an excellent pool of capability, both within stakeholders and within the OSW industry, and is an important area for a new and future-focused industry.

Research and development (R&D) also offers opportunities to reduce cost of energy through innovation, especially in relation to local conditions.

Our recommendations 18, 19, 20, 21, 22, 23, and 24 relate to these points.

Ports

There is always a way to install any given OSW project from available ports, but often compromises have to be made that add cost. Early, strategic investment can both reduce cost for a range of projects and in some cases help establish clusters of suppliers in a given area, with benefits in terms of collaboration and shared learning.

Our recommendation 17 relates to this.

6.5 RESOURCED, JOINED-UP INSTITUTIONS

OSW introduces new leasing, permitting, and other regulatory considerations. Azerbaijan can address this by ensuring that its public institutions have the necessary skills and resources to give robust and timely decisions, and that these organizations and their processes work well together.

These organizations will be involved in marine spatial planning, environmental management, designating sites, permitting, and administering revenue mechanisms. When well-resourced, these institutions create an environment where industry has confidence to make business decisions and governments can plan public spending and have confidence that its policy objectives are being achieved.

It is not just the organizations directly involved in the support of the OSW industry that need resources. OSW projects have implications for military and aviation organizations, environmental protection agencies, and a range of non-governmental organizations and stakeholders.

Staff need training to use knowledge and implement good practice learnt elsewhere in the world over the previous 20 or so years of the OSW industry.

Our recommendations 10 and 28 relate to this.

6.6 CONFIDENT, COMPETITIVE ENVIRONMENT

Confidence

We have discussed the importance of confidence and ways to build it in many of the sub-sections above. One further way of building confidence is to establish ongoing Government-industry collaboration involving local and international project developers and key suppliers to work together to address challenges and opportunities over the years, as the industry matures.

Our recommendation 10 relates to this.

Competition

Competition increases efficiency and innovation between developers and across the supply chain. This reduces cost of energy and improves value to consumers.

Energy markets around the world range from fully liberalized to state-controlled markets. Regardless of the system, experience shows that competition can have a significant impact on power price reduction.

Good competition for enough sites and PPAs means the best projects get built and offer best value. Competition for finance is also important, as the cost of finance contributes significantly to LCOE.

Our recommendations 9, 10, 11, and 12 relate to this.

6.7 SUPPORTIVE AND ENGAGED PUBLIC

OSW farms affect the lives and cares of many, and it is important that the voices of individuals, communities, and organizations are heard and are involved at an early stage of the development process, and that they understand the potential environmental, social, and economic impacts of the industry.

Governments can provide an important channel for these voices and the industry will listen. Governments and other enabling organizations can also educate on the benefits of OSW, including environmental benefits, academic opportunities, job creation, and local economic development.

The process of public and stakeholder engagement, for example with fishing communities, can start much earlier than project development and will be an ongoing process including marine spatial planning, ESIA, and ongoing construction and operational management.

Our recommendations 3, 6, and 25 relate to this.

6.8 A COMMITMENT TO SAFETY

Working in OSW by nature is potentially hazardous due to the location, the need to work at height, the size of components involved, and the presence of medium and high voltage electrical systems.

The OSW industry protects its workers by seeking to get it 'right first time' — its aim is to anticipate mistakes rather than just learn from them.

Azerbaijan has a platform to build on, with its offshore oil and gas and onshore wind industry, but there is work to do to ensure regulatory clarity and reinforce safety practices. It is important also to ensure strong communication and collaboration across industry. The G+ Global Offshore Wind Health and Safety Organization is the key international organization to engage with. The Global Wind Organization (GWO) provides a robust framework for OSW health and safety training and certification.

Our recommendations 25 and 27 relate to this.

6.9 USING THE BEST LOCATIONS

For Azerbaijan to realize all the positive benefits that OSW has to offer, it has to strike the right balance between the cost of energy from OSW farms with impact on the natural environment, local communities, and other users of the sea.

Azerbaijan should provide clear direction to project developers and investors that responsibly and respectfully developed OSW.

Making use of natural resources

Azerbaijan has valuable OSW resource. Identifying the right places in the Caspian Sea to locate OSW farms is an important aspect of developing a sustainable and long-term industry.

The cost of energy from OSW farms varies from site-to-site, depending on factors including local wind and sea-bed conditions, water depth, and distance from shore. Data sets relating to these considerations are limited at present.

Our recommendations 3, 5, and 6 relate to this.

Protecting the environment

One of the driving motivations behind developing OSW as an energy source is its positive environmental benefit as a source of carbon-free electricity.

Nonetheless, it is important to recognize that OSW farms are large industrial developments and that their construction must be achieved in a way that minimizes harmful localized impacts on the natural and human environments. A wide range of environmental and social considerations are examined in detail in Section 11. The Government should avoid areas of highest environmental and social sensitivity through spatial planning, through spatial planning and implementation of a robust permitting process where the design, construction, and operation of OSW farms is delivered in accordance with good international industry practices and standards, including those for ESIA.

Our recommendations 3, 4, 5, 6, 7, 8, 25, and 28 relate to this.

Respecting communities

For OSW to have a sustainable future, the rights of people and communities whose lives and activities interact with OSW farms must be respected.

OSW farm sites in Azerbaijan must be identified, assessed, permitted, and developed in a way that is sensitive to people’s livelihoods,recreational interests, and their cultural heritage.

Our recommendations 3, 4, 5, 7, 8, 25, and 28 relate to this.

6.10 CONTINUED FOCUS ON COST REDUCTION

It is expected that the first OSW farms will be more expensive than conventional generation but will become more cost-competitive over time. The following *key factors* will be critical to accelerating OSW cost reduction in Azerbaijan:

- The use of larger offshore turbines with rotors designed for lower wind sites. It is not certain yet that these turbines will be developed. Clear market signals from countries needing such turbines will help investment happen. These countries include Japan and Korea. Across the leading turbine suppliers, the investment needed to develop these low-wind turbines could be up to about US$1 billion, but the potential market is huge.
- Availability of a local solution for efficient installation of OSW foundations and turbines. Conventional fixed OSW farms use specialist jack-up vessels built almost exclusively for OSW use. These vessels will not be able to access the Caspian Sea so by necessity, Azerbaijan OSW farms will use vessels drawn from the Caspian Sea fleet. With sufficient installation activity, an installation vessel with state-of-the-art features could be built locally to support the OSW industry from 2031.
- Ensuring low weighted average cost of capital (WACC). WACC is a function of a wide range of market risks and issues. Achieving a low WACC requires the establishment of stable, transparent, and robust frameworks and regulations for OSW, meeting lender's standards, confidence in the long-term pipeline of projects and growth of the industry in Azerbaijan, and access to concessional finance.
- Learning by doing. Players in all OSW markets advise that significant efficiencies are obtained through repeat activity, both within a single project and in delivering multiple projects, one after another. The larger the project pipeline, the greater the cost reduction, as long as players continue to invest, responding to learning by improving processes in a culture of cost of energy reduction.

7 BENEFITS AND CHALLENGES OF OFFSHORE WIND

7.1 BENEFITS

More and more countries are understanding the benefits of offshore wind (OSW), including:

- *Local.* Once installed, it does not rely on fuel imported from other countries, so increases energy security.
- *Low cost.* Lifetime costs are still reducing quickly, while for traditional fossil fuel options, costs are rising. It is becoming easier to finance OSW projects at the same time as it becomes more difficult to finance fossil fuel generation.
- *Large scale.* GW-scale projects can be constructed quickly.
- *Long-term jobs.* Both leading up to and during operation, OSW creates and sustains local jobs and local economic benefit, especially in coastal regions.
- *Clean.* OSW is low carbon, low air pollution, low water use, and low land use.

Local

Azerbaijan has significant gas, wind, and solar resources. It can expect to export gas until decarbonization programs in its export markets reduce this demand. It can expect to export electricity far into the future. The largest exploitable renewable energy resource it holds is OSW. Without exploiting OSW, one day, Azerbaijan will need to import electricity from neighbors.

Low cost

In Europe, OSW is cost competitive with new-build fossil fuel options that have LCOE around US$70/MWh. In Azerbaijan, OSW built at scale may be cost-competitive with conventional generation over time.

Large scale

OSW projects in mature markets are regularly between 0.5GW and 1.5GW in capacity, with the largest projects in some markets approaching 4GW. Larger OSW turbines continue to be brought to market, the largest now at 15MW, further enabling large projects to be constructed rapidly. Large turbines and large projects are two key drivers of cost reduction.

Long-term jobs

OSW offers local job opportunities in developing, manufacturing, construction, and operation of OSW projects, over their life cycle of over 30 years. Section 10 explores the scale of the opportunities, based on an analysis of the supply chain in Section 9.

Clean

OSW produces less CO_2 and other pollution and uses less water and land than fossil and nuclear sources of generation.

Carbon

Natural gas releases on average 500 metric tons of CO_2 per GWh of electricity generated.[viii,ix,5,6] A typical 1GW wind farm saves over 2.2 million metric tons of CO_2 per year. In the high growth scenario, by 2040 OSW will have produced 215TWh, saving about 107 million metric tons of CO_2, cumulatively. In the low scenario, the saving is just over 27 million metric tons. Note that these savings are indicative and are not the result of a market-specific analysis considering Azerbaijani carbon intensities and plans to reduce these over time. We recognize that while OSW will mainly displace gas, there may be times when lower-carbon technologies are displaced, or when renewables capacity needs to be curtailed to meet demand. This could be analyzed via more detailed sectoral and economic analysis.

Pollution

Sulphur dioxide (SO_2) and nitrogen oxides (NO_x) are air pollutants known for creating smog and triggering asthma attacks.

Fossil fuels release on average 1.1 metric tons of SO_2 and 0.7 metric tons of NO_x per GWh of electricity generated.[7] In the high growth scenario, OSW saves 236,000 metric tons of SO_2 and 150,000 metric tons of NO_x, cumulatively by 2040.

Water

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.[8] Wind farms require very little water. In the high growth scenario, OSW saves 3.2 trillion liters of water by 2040, with a 1GW wind farm saving 65 billion liters of water per year.

Land

Onshore renewable energy projects are often constrained by local population density and competing land uses. The onshore footprint of OSW is limited to grid infrastructure and port facilities. OSW, located and developed properly, typically does not have a large impact on other marine users.

viii Used a value of 500 metric tons of CO_2 per GWh, for generation from natural gas.

ix Offshore wind lifetime emissions of 12 metric tons of CO_2 per GWh are insignificant compared to the 500 metric tons from fossil fuels.

7.2 CHALLENGES

OSW, like any new technology and infrastructure investment has significant challenges. These include:

- *Variability*. The wind does not blow all the time.
- *Technology*. Cost of energy reduction depends on the development of technology overseas that is both reliable and well suited to local conditions.
- *Cost in the early years*. Initially, costs will be higher than in more mature OSW markets and can be higher than traditional forms of electricity generation.
- *Young, rapidly growing industry*. This introduces both risks and opportunities that need to be managed.
- *Government commitment*. Cost reduction and especially local economic benefits increase with volume, which requires greater government commitment.
- *Environmental and social considerations*. The local, regional, and international adverse impacts of OSW need to be recognized and carefully managed.
- *Impact of climate change*. How OSW could be impacted by climate change.

The challenges identified here are based on a high-level consideration of general industry risks only. Further technical, environmental, or social challenges may be identified through detailed future studies and surveys. These challenges may be relevant at a strategic or project level and will need to be considered and mitigated by Government, developers, and relevant stakeholders as the industry develops and projects are progressed.

Variability

Seasonal variations in average wind speeds are well understood in mature markets, but total annual energy production (AEP) can still vary by 10% from year to year. In these markets, forecasts for a few days ahead are relatively accurate, but predictions of energy production still then need either supply or demand-side action on the time scale of hours ahead to ensure balance and continuity of power supplies.

Investment in the energy transition inevitably involves investment in smart grid technology, flexible sources of generation, storage, and management solutions, including the use of hydrogen and electric vehicles (EVs), each helping to manage the challenge of variability of generation from wind and solar. Azerbaijan's existing gas generation, hydro power plants and inter-connection with neighboring countries afford a high degree of system flexibility, subject to improvements to system dispatching capability. With many other markets having far higher penetration of variable renewables than Azerbaijan, it will be able to take advantage of technology and commercial learning in other markets as these areas develop over the next 20 years. The analysis presented in this roadmap is not based on any power system modelling rather; it provides a vision that needs to be backed up in time through such modelling.

Technology

The continued reduction in cost of energy from OSW in Azerbaijan relies on further development and support of new technology, especially:

- Larger offshore turbines, plus all the logistics and equipment related to their use;
- Ongoing global improvement in the manufacture, installation, operation, and reliability of OSW farms; and
- Solutions to address site conditions and logistics considerations specific to the Caspian Sea.

The first two points relate to OSW, globally; the last relates specifically to Azerbaijan.

For the last 30 years, the wind industry has continued to innovate rapidly, and we anticipate that this will continue. There is, however, a risk that local markets are not large enough to drive some areas of innovation.

Cost in the early years

In Europe, OSW used to be much more expensive than traditional technologies. With competition, innovation, and learning, the cost has been reduced by a factor of more than three in the last decade.

In new markets, not all this cost reduction will be available, as the supply chain and experience will take time to grow, and solutions to country-specific challenges will take time to develop.

This means that in Azerbaijan, costs will start higher but come down faster than in an established market. Our suggested approach in Azerbaijan is designed to maximize industry confidence and consistency in order to drive down cost.

Our analysis shows that the getting through this period of higher costs takes less time via the high growth scenario.

Government commitment

As seen in Figure 3.2 and Figure 4.2, more benefits are unlocked for Azerbaijan by the high growth scenario, but this requires more urgency and commitment from Government to delivery, bringing challenges of cost and resources. These areas are discussed in subsequent sections of this report and in World Bank Group's *Key Factors* report.[2]

Environmental and social considerations

As with any large infrastructure project, OSW farms do have local adverse impacts on ecosystems, habitats, and species, other sea users and on local communities. These impacts can be international in scale, considering cumulative impacts, which are difficult to manage. OSW should not be located in areas of highest environmental and social risk, which can be identified at an early planning stage.

In established OSW markets, robust environmental and social impact assessment processes and high levels of stakeholder engagement are used to ensure that these impacts are identified and managed carefully. This requires considerable environmental and social baseline data collection, some of which can take two years or more to collect.

Impact of climate change

It is recognized that the Azerbaijan has relatively high vulnerability to climate change impacts, especially as temperatures are projected to rise at a faster rate than the global average, impacting especially water supplies and agricultural productivity. We do not believe that OSW will be significantly impacted by climate change. Key considerations include:

- Temperature rise. OSW projects are not susceptible to even increases in mean temperature of two degrees or more, based on typical project specifications and our understanding of key design drivers.
- Sea level rise. OSW projects are not susceptible to even increases in mean sea level of one meter or more, again, based on typical project specifications and our understanding of key design drivers. In Azerbaijan, the challenge is the opposite, with water level in the Caspian Sea dropping by around 1m per decade. Again, if this is built into designs of access systems and lifting devices, then the implications are insignificant. A fall in water depth should, in fact, increase energy production through increasing wind turbine hub height above water level.
- Changes in weather patterns. There is a risk to the viability of OSW projects should the long-term trend in mean wind speeds be downwards, or if most extreme high wind speeds increase. So far, there has been no compelling evidence regarding mean wind speeds. Globally, there is evidence of more extreme weather patterns.

7.3 FLOATING OFFSHORE WIND

We consider floating OSW as an option for Azerbaijan beyond the high growth scenario, but recognize that floating technology could be deployed earlier, depending on relative cost. In some countries, areas of water deeper than 60m may have higher mean wind speeds or be located closer to population centers than areas of shallower water. In Azerbaijan, floating sites have lower mean wind speeds and are further from population centers. Some markets have an established fixed OSW pipeline of projects but no floating pipeline. This means that however fast the technology is available, the market will be delayed by the establishment and use of frameworks covering floating projects:

- Leasing rounds need to be in different areas
- Permitting, including environmental and social impact assessment, has different considerations, some of which will need precedent set through early projects
- Power purchase, potentially to differentiate from fixed projects in markets that support both technologies.

In Azerbaijan, these barriers are unlikely to slow progress as long as the Government plans ahead.

Beyond the benefits and challenges discussed above, there are some important additional considerations relating to floating OSW that are discussed below.

Minimal differences between floating and fixed offshore wind hardware

- **Typically, turbine design, operation, and reliability are almost the same**. This means that technology can be fully shared across the markets. The only significant difference is in tower design, where the same principles and suppliers are used for both markets.
- **Turbine routine maintenance activities are almost thesame**. Activities using crew transfer vessels (CTVs) and service operation vessels (SOVs) are unchanged. Only unplanned service of major components is different, due to the inability to use bespoke jack-up installation vessels for floating OSW activities.
- **Export system electrical hardware is the same, except for some mechanical aspects of cabling**. The way that cables are designed and supported near foundations and substations changes due to relative movement between foundations and compared to the seabed, otherwise, some aspects of cable laying can ebb, made easier due to deeper water.

Additional benefits beyond fixed offshore wind

- **Floating OSW allows access to a wider range of sites.**
- **Floating OSW allows for more onshore construction work.** Turbines can be fully installed on foundations in port. This offers the long-term prospect of reduced cost and risk, as offshore activities typically have a cost and risk premium. It also enables the use of low-cost, readily available installation vessels, rather than the use of bespoke jack-up installation vessels. This is especially relevant in Azerbaijan, where any such vessels need to be fabricated locally.
- **Floating foundation hull design is less dependent on ground conditions.** This increases the potential for standardization of foundation designs, enabling further cost reduction.
- **Floating foundations are less susceptible to seismic activity and associated extreme wave events.** Due to the dynamic separation between foundation and seabed, and the ability of the foundation to float, early experience in Japan has been of a good resistance to extreme events.
- **Floating OSW generally has less-invasive activity on the seabed during installation.** This potentially reduces aspects of local environmental impact.

Additional challenges beyond fixed offshore wind

- **Higher costs in early years.** Fixed OSW has seen significant cost reduction over time, as designs are optimized for greater volume and the application is better understood. The same is anticipated in floating OSW, based on early experience.

- **Have to build new confidence in the technology and supply chain.** Many aspects of the technology and supply chain are almost the same, but floating foundation hulls, mooring systems, installation and major component replacements, and the use of dynamic subsea cables, are key areas of difference.

  - Steel and concrete hull designs and a range of mooring systems have been used in oil and gas and other marine applications, but not at the volumes that will be used in OSW, challenging supply chain growth especially later in the decade.
  - The challenge for replacement of major components is that in fixed OSW, relative movement between a jack-up vessel crane hook and turbine tower top is already significant in medium wind speeds. The dynamic challenge of synchronizing movement of a floating vessel crane hook with a floating turbine tower top is significantly greater, giving rise to two possible strategies:
    - Mechanically and electrically disconnect the turbine and its foundation and tow it to shore for component replacement, potentially replacing the turbine straight away with a spare system, to minimize lost generating time
    - Overcome this dynamic challenge and use a floating crane vessel.

  Typically, developers assume the former solution, with a potential future upside when (potentially at any point in a project lifecycle), new solutions become available.

- **Dynamic subsea cables are used in oil and gas, and supplied by similar suppliers in OSW, but not at the power levels needed for OSW.** Practical design and testing projects have been underway for some time to address the new challenges, and early floating projects have demonstrated solutions.

Overall, this means that projects do have to carry more early project technology risks, and owners and lenders will price this, but by the current pace of technology activity, such risk will have been removed before first floating projects in Azerbaijan.

8 OFFSHORE WIND AS PART OF AZERBAIJAN'S FUTURE ENERGY SYSTEM

8.1 WIND AND SOLAR TO DATE

Azerbaijan has only recently secured its first larger-scale onshore wind (240MW) and solar (230MW) capacity and is taking its first steps in offshore wind (OSW). It is at a similar stage to countries around the Mediterranean and Black Seas, where there are few OSW projects beyond the earliest stages of development.

8.2 A VISION FOR ELECTRICITY SUPPLY AND DEMAND TO 2040

Developing an OSW project is a long-term infrastructure investment. Developing a national program of many projects needs to be considered within the context of strategic energy plans over decades.

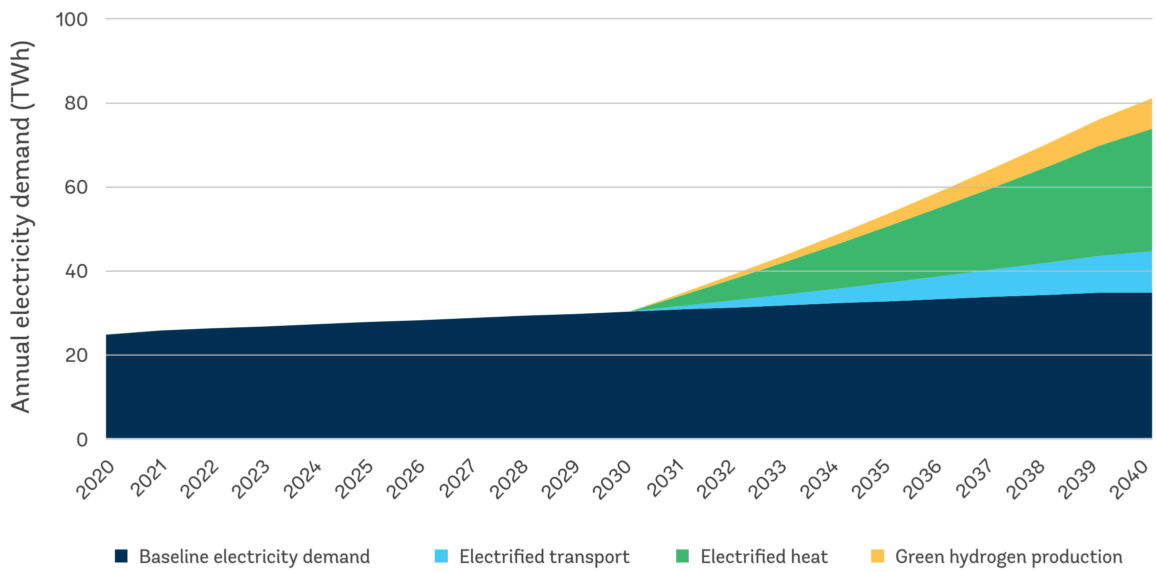
Azerbaijan can accelerate OSW projects rapidly over the next few years. The success of this acceleration will depend on the clarity of the Government's long-term ambition and the actions that the Government takes to facilitate growth. The high growth scenario that we model incorporates 7.2GW of OSW installed by the end of 2036. The analysis below is not based on any power system modelling rather, it provides a vision that needs to be backed up in time through such modelling. Under this roadmap, the electricity demand in 2040 in a decarbonization pathway was estimated to be approximately 82 TWh per year. This was derived from a high-level set of assumptions and was intended to estimate the magnitude of potential change in demand over the coming decades. Recent net-zero modelling (separate to this study) however, suggests that electricity demand by 2040 might only reach 46 TWh. If a lower electricity demand is likely by 2040 then it is assumed that excess electricity generated by offshore wind could be exported to neighbouring countries and/or used for green hydrogen production.

Figure 8.1 shows indicative electricity demand in Azerbaijan from 2020 to 2040. Historical data from 2020 is from the State Statistical Committee (SSC) of the Republic of Azerbaijan.[9] We have based the forecast on a combination of extrapolating electricity demand (based on the historical trend from 2007 to 2020) with assuming an increasing fraction of gasoline, diesel, fuel oil, and kerosene is displaced with the use of hydrogen (for large vehicle transport and aviation) and electric vehicles (EVs) (for small vehicle transport). We have assumed no decarbonization in 2030, rising to approximately 30% decarbonization of transport and heat[x] by 2040, just under 20 years from now, on a trajectory to 80% decarbonization by 2050.

This decarbonization is indicative only, showing a possible pathway. It is not aligned with any plan from the Ministry of Energy. Further detailed energy system planning studies will be required to deepen understanding of technical details, options, and cost impacts, with the aim of defining a long-term decarbonization roadmap.

x Indicative demand from decarbonisation derived as follows:
- Future demand for electricity, heat, and fuels extrapolated from historic growth trends from State Statistical Committee of the Republic of Azerbaijan.
- 30% of motor gasoline demand, 27% of diesel demand, 30% of natural gas, and 100% of heat network energy use is electrified by 2040.
- 30% of kerosene demand, 13% of diesel demand, and 100% of fuel oil demand is replaced with green hydrogen by 2040.

FIGURE 8.1 ELECTRICITY DEMAND IN AZERBAIJAN (HISTORICAL AND VISION TO 2040)

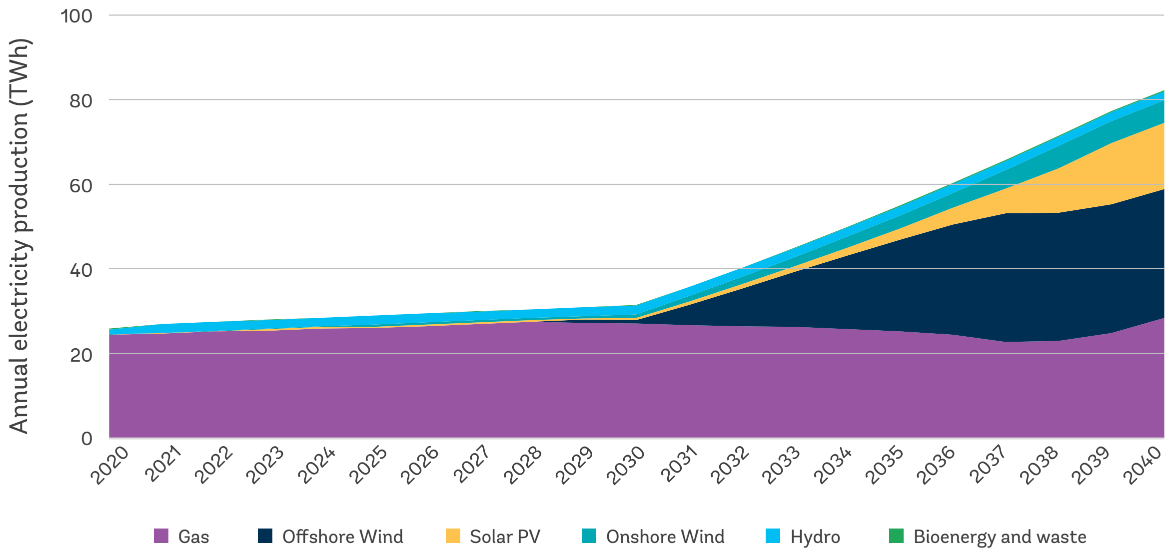


Source: SSC and BVG Associates

Figure 8.2 shows electricity supply in Azerbaijan over the same period, assuming the OSW high growth scenario. Historical data again is from the State Statistical Committee of the Republic of Azerbaijan. The forecast is indicative, seeking to present a best-value transition, but without energy system modeling and optimization at this point. It assumes:

- 7.2GW of OSW installed by 2036, following the high growth scenario
- 12GW of solar PV installed by 2040, about half of Azerbaijan's solar PV potential[10]
- 3GW of onshore wind installed by 2040, the maximum estimated potential for onshore wind in the country[10]
- Hydroelectric plant will remain at current installed capacity of 1.2GW until 2040
- Excess production drives a reduction in generation using natural gas.

FIGURE 8.2 ELECTRICITY SUPPLY IN AZERBAIJAN SPLIT BY GENERATION TYPE (HISTORICAL AND VISION TO 2040, FOLLOWING OSW HIGH GROWTH SCENARIO)



Source: MOE and BVG Associates

New generation other than OSW is indicative, timed to match the indicative growth in demand in the decarbonization pathway.

Figure 8.2 shows that the new OSW capacity coming online up to 2037 along with other renewables, starts to enable a reduction in generation using natural gas. If further OSW was installed, then this trend could be continued.

8.3 AZERBAIJAN'S POTENTIAL ENERGY TRANSITION BY 2050

We explore Azerbaijan's potential energy transition through looking at four snapshots:

A. 2020: Recent view: 2020 snapshot

B. 2040: Decarbonization pathway (with OSW high growth scenario)

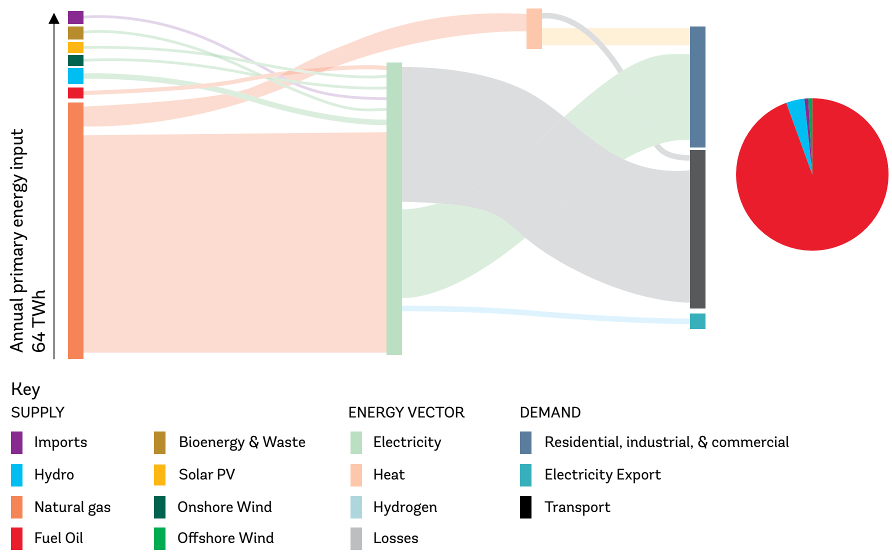
C. 2040 alternative: No decarbonization pathway (with OSW low growth scenario)

D. 2050: Near the end of energy transition, following decarbonization pathway.

A. 2020: Recent view

In 2020, 98% of primary energy input for Azerbaijan's electricity was from its own natural gas. Some of this was used to provide heat; much was used to generate electricity, resulting in significant losses (shown in grey, below). 96% of its electricity was used in the residential, industrial, and commercial sectors, with 4% exported. The primary supply, interim vector and end use is shown in Figure 8.3.

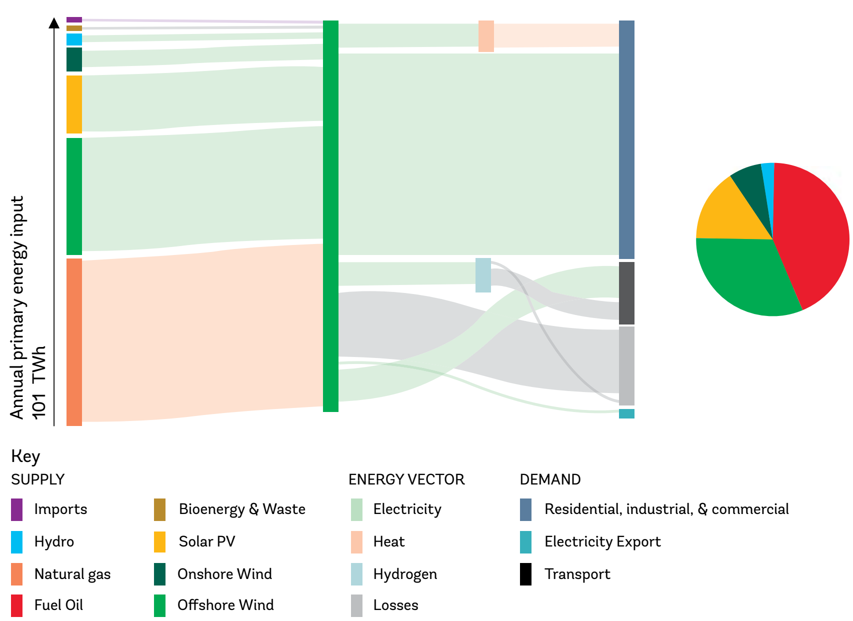
FIGURE 8.3 ENERGY SUPPLY, INTERIM VECTOR, AND END USE IN AZERBAIJAN (LEFT), PLUS PRIMARY INPUT FOR ELECTRICITY (RIGHT), 2020



B. 2040: Decarbonization pathway (with offshore wind high growth scenario)

In 2040, based on the assumptions incorporated in the high growth scenario for OSW and 30% decarbonization of transport and heat, 45% of primary energy input for Azerbaijan's electricity will be from its own natural gas, 31% will be from OSW, and 24% from other renewables. Electricity is the interim vector for all energy and 9% of end use is also via hydrogen. 80% of end use is in static applications,19% is in transport, and 1% is exported. The primary supply, interim vector and end use is shown in Figure 8.4. Note that a detailed assessment of the types of energy needed is likely to show some demand for hydrogen for industrial uses (high-grade heat). This is not shown.

FIGURE 8.4 ENERGY SUPPLY, INTERIM VECTOR, AND END USE IN AZERBAIJAN (LEFT), PLUS PRIMARY INPUT FOR ELECTRICITY (RIGHT), 2040 (DECARBONIZATION PATHWAY WITH OSW HIGH GROWTH SCENARIO)



Decarbonization

In effect, this will mean a significant change in four key areas:

- The transition to EVs is likely to be faster than 30% by 2040, as many suppliers do not anticipate selling diesel or gasoline vehicles in major markets past 2035. In 2021, battery EVs (excluding hybrids) are expected to be about 10% of total passenger vehicle registrations in Europe.[11] Development of charging infrastructure will be critical. An additional advantage of EVs is that these vehicles introduce significant volumes of electricity storage into the energy system. Demand management can be used to drive when vehicles are charged and grid operators can agree terms with owners that allow connected vehicles to be used to provide electricity to the grid in times of need. A key focus for technology companies in this space is the development of faster-charging, higher energy storage batteries with lower mass and cost.
- Heavy goods transport is more likely to be via hydrogen, with higher power density than batteries (more energy stored per unit mass of storage system) meaning that less energy is needed to transport the energy storage system in a vehicle. There is much work underway exploring the synergies between renewable energy generation (including OSW) and green hydrogen production. The development of lower-cost electrolyzers, hydrogen distribution systems, and demand-side technologies is key to adoption. An additional advantage of using electricity to produce hydrogen is that it can be stored then used as a transport or industrial fuel and this introduces significant volumes of storage into the energy system.
- Air transport eventually is likely to be mainly via hydrogen, again from a motivation of minimizing vehicle mass, as storing enough energy for a given flight is lighter with hydrogen than batteries. Aviation is included in net zero commitments and by nature is an international consideration, so by 2040 is likely to be well advanced.
- Heat is likely to be mainly electrical, except for some industrial processes where the use of hydrogen is preferable.

With the global focus on such technologies, it is highly likely that Azerbaijan will be able to benefit from them as it accelerates decarbonization in the 2030s and 2040s.

Export of electricity and hydrogen

Azerbaijan also has opportunities for export of both electricity and hydrogen, depending on the competitiveness of its supply.

Options include:

- Use of existing transmission interconnectors and construction of increased capacity in order to supply electricity to (and through) neighboring markets
- Injecting hydrogen into existing gas supplies to Europe to increase calorific value, or to extract at destination hubs
- Building of a new hydrogen-only pipeline, or conversion of existing Southern Gas Corridor as demand for natural gas decreases.

Depending on renewable energy developments in neighboring markets, there are likely to be increased opportunities for Azerbaijan to trade electricity to Georgia, Iran, and Russia. Azerbaijan's inter-connection capacity of 1.9GW is projected to increase in the next decade, and the planned system synchronization with Iran will lead to greater opportunity to trade electricity. With significant OSW capacity, net trading will be export. Expansion and synchronization of Azerbaijan's inter-connections is discussed in Section 16.

Early assessment suggests that hydrogen export from Azerbaijan is unlikely to be competitive and will face technical and commercial barriers. The cost of green hydrogen is heavily dependent on the LCOE of the electricity used to produce it. The market for hydrogen is likely to be at a continental or global level. For Azerbaijan to produce competitive hydrogen from OSW for high-volume export it would need to compete in international markets with green hydrogen produced elsewhere.

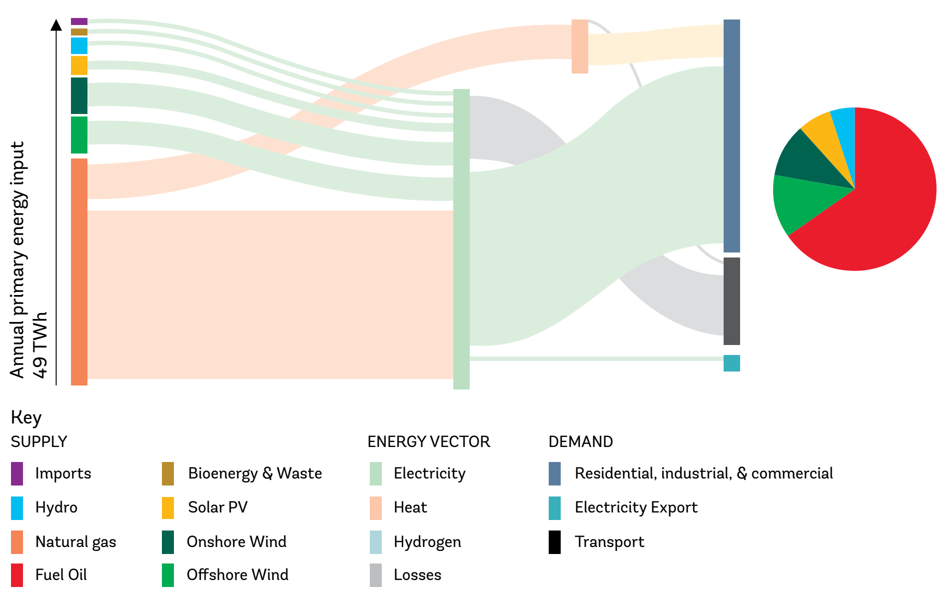
Whilst OSW offers Azerbaijan a cost effective way to produce its own low carbon energy there are less populated locations (such as in North Africa or Kazakhstan) where costs of large-scale onshore wind or solar generation are likely to be as low as US$25/MWh. In addition, the cost of transportation of hydrogen from Azerbaijan through existing pipeline infrastructure will add a further approximate 10% to the delivered price, further impacting its competitiveness in export markets.

Further barriers to high-volume hydrogen export exists as existing pipelines would require technical adaption to carry pure or blended hydrogen, and because the existing pipeline capacity currently is fully contractually committed to natural gas export through to 2040.

C. 2040 alternative: No decarbonization pathway (with offshore wind low growth scenario)

In this alternative view, the low growth scenario for OSW is assumed, there is low deployment of Solar PV (2GW by 2040), and there is no decarbonization of transport and heat. There is no significant role for hydrogen. Again, the primary supply, interim vector and end use is shown in Figure 8.5.

FIGURE 8.5 ENERGY SUPPLY, INTERIM VECTOR, AND END USE IN AZERBAIJAN (LEFT), PLUS PRIMARY INPUT FOR ELECTRICITY (RIGHT), 2040 (NO DECARBONIZATION PATHWAY WITH OSW LOW GROWTH SCENARIO)



D. 2050: Near the end of energy transition

By 2050, assuming progress on the decarbonization pathway from A to B, then with continued focus, the energy transition will be almost complete and any fossil fuel will be decarbonized at point of use, through carbon capture technologies. This will enable some use and export of natural gas, but legislation in many countries will have driven a technology step to the use of electricity or hydrogen, removing the market for gas.

Based on Azerbaijan's domestic supply of gas, it is likely to be cost effective to use 'clean' gas as a key element in balancing electricity supply with demand, along with demand management and the ability to store electricity in utility scale batteries, EVs and hydrogen.

Even before the 2040s, it is likely that floating OSW will be competitive with fixed OSW, enabling Azerbaijan to develop a second tranche of OSW further from shore, but still in areas of good wind resource.

Energy mix to 2040 in the decarbonization and no decarbonization pathways

OSW data is combined with installed capacity and supply for other generating technologies in Table 8.1.

TABLE 8.1 ELECTRICITY INSTALLED CAPACITY AND SUPPLIED BY ALL TECHNOLOGIES TO 2040 IN THE DECARBONIZATION AND NO DECARBONIZATION PATHWAYS

	2020	2030 OSW high (low) growth scenario*	2040 decarbonization and OSW high growth scenario* (no decarbonization and OSW low growth scenario)**
Installed capacity			
Gas (GW)	6.3	7.3	7.3
Hydro (GW)	1.2	1.2	1.2
Offshore wind (GW)	0	1.2 (0.9)	7.2 (1.5)
Onshore wind (GW)	0.1	0.5	3.0
Solar (GW)	0.04	0.5	12.0 (2.0***)
Other (GW)	<0.1	0.2	0.4
Total (GW)	7.7	10.7 (10.3)	31.0 (15.4)
Generation			
Gas (TWh)	24.4	27.1	28.4 (19.9)
Hydro (TWh)	1.1	2.1	2.1
Offshore wind (TWh)	0	0.8 (0.8)	30.4 (5.8)
Onshore wind (TWh)	0.1	0.9	5.3
Solar (TWh)	0.05	0.5	15.8 (2.6***)
Other (TWh)	0.2	0.1	0.3
Total (TWh)	25.8	31.5 (31.5)	82.2 (36.0)

* As shown in B, above, and Figure 8.4
** As shown in C, above, and Figure 8.5
*** Note that reduction in electricity demand in the no-decarbonization pathway is reflected simply as a reduction in installed solar capacity (and output), as well as reduction in offshore wind capacity (and output) and reduction in generation from gas. In more detailed power-system modelling to obtain a least-cost result, another combination of generation may be more advantageous.

8.4 'WHAT-IF' SCENARIOS FOR AZERBAIJAN'S ENERGY FUTURE

The above snapshots for Azerbaijan assume:

- An energy transition almost complete by 2050; and
- A decreasing export of energy, as electricity and hydrogen replace gas.

In order to manage risks and opportunities relating to OSW, Table 8.2 qualitatively considers a range of what-if scenarios.

TABLE 8.2 WHAT-IF SCENARIOS FOR AZERBAIJAN RELATING TO OFFSHORE WIND

Scenario	Consequence	Potential action / mitigation
1. Follow OSW low growth scenario, then decide to accelerate OSW later.	Delays to localization and decreased early focus on cost reduction means higher LCOE and less local economic benefit, but ultimately, industry will catch up.	Develop and keep updated clear vision of Azerbaijan's energy future, in order to make informed, strategic decisions early.
2. OSW cost reduction slows down / floating OSW never cost effective.	Need other technologies — can do more onshore wind and solar, but likely will need to build more 'clean' gas at relatively high price, else import energy.	Keep holding more onshore wind and solar auctions. Implement 'clean' technology on existing gas plant. Keep interconnect relations good.
3. Climate concerns decrease and decarbonization delayed.	Will have excess OSW capacity at times — export via interconnects.	Keep interconnect relations good.
4. Climate concerns increase and decarbonization accelerated.	Can accelerate OSW, as well as follow 2.	Establish floating OSW development zones and offer to developers if they can match price for fixed OSW. It is likely to take 6-10 years from establishing zones to delivery of first projects. Keep increasing flexibility of electricity system, including via storage, including that gained through decarbonization. Also as 2.
5. Able to export hydrogen competitively.	Gives more flexibility in electricity system, improves balance of trade, and gives room for more OSW and other technologies.	Ensure have sufficient electrolyzer capacity. Consider reserving pipeline capacity. As 4.
6. Gas price rises / demand increases.	Drives demand to minimize gas use in country, increasing challenges of matching supply and demand.	As 4.
7. Gas price falls / demand decreases faster than expected.	Continue to use gas to stabilize electricity system. Push export of electricity / hydrogen to compensate.	As 4.

8.5 AZERBAIJAN OFFSHORE WIND ENERGY PRODUCTION

Table 8.3 and Table 8.4 show key data for both scenarios for the period 2028 to 2040, supporting calculations throughout the study. We assume no generation from projects in the year of installation.

Annual energy production (AEP) is the sum across all wind farms operating in the year, considering the different capacity factors for each annual capacity installed. Cumulative energy production is the sum of this, over time.

TABLE 8.3 ENERGY PRODUCTION DATA FOR LOW GROWTH SCENARIO

Year	Annual installed capacity (GW)	Cumulative operating capacity at end of year (GW)	Capacity factor for projects installed in the year (%)	Annual energy production (TWh)	Cumulative energy production (TWh)
2028	0.21	0.21	44%	0.0	0.0
2029		0.21		0.8	0.8
2030	0.68	0.89	43%	0.8	1.6
2031		0.89		3.3	5.0
2032	0.65	1.53	44%	3.3	8.3
2033		1.53		5.8	14.1
2034		1.53		5.8	19.9
2035		1.53		5.8	25.7
2036		1.53		5.8	31.5
2037		1.53		5.8	37.4
2038		1.53		5.8	43.2
2039		1.53		5.8	49.0
2040		1.53		5.8	54.8
2041		1.53		5.8	60.6
2042		1.53		5.8	66.4
2043		1.53		5.8	72.2
2044		1.53		5.8	78.0
2045		1.53		5.8	83.9
2046		1.53		5.8	89.7
2047		1.53		5.8	95.5
2048		1.53		5.8	101.3
2049		1.53		5.8	107.1
2050		1.53		5.8	112.9

TABLE 8.4 ENERGY PRODUCTION DATA FOR HIGH GROWTH SCENARIO

Year	Annual installed capacity (GW)	Cumulative operating capacity at end of year (GW)	Capacity factor for projects installed in the year (%)	Annual energy production (TWh)	Cumulative energy production (TWh)
2028	0.21	0.21	44%	0.0	0.0
2029		0.21		0.8	0.8
2030	0.99	1.20	45%	0.8	1.6
2031	0.99	2.19	47%	4.7	6.4
2032	0.99	3.18	47%	8.8	15.2
2033	1.00	4.18	49%	13.0	28.2
2034	1.00	5.18	50%	17.3	45.4
2035	1.00	6.18	50%	21.6	67.1
2036	1.00	7.18	50%	26.0	93.0
2037		7.18		30.4	123.4
2038		7.18		30.4	153.8
2039		7.18		30.4	184.1
2040		7.18		30.4	214.5
2041		7.18		30.4	244.9
2042		7.18		30.4	275.3
2043		7.18		30.4	305.6
2044		7.18		30.4	336.0
2045		7.18		30.4	366.4
2046		7.18		30.4	396.7
2047		7.18		30.4	427.1
2048		7.18		30.4	457.5
2049		7.18		30.4	487.9
2050		7.18		30.4	518.2

9 SUPPLY CHAIN ANALYSIS

9.1 PURPOSE

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

We also explore potential bottlenecks that could slow the industry in each of the scenarios.

Ports, a potential supply chain bottleneck, are covered in Section 17 and the findings in Section 17 inform the analysis here.

This analysis is important as it underpins work on economic benefits in Section 10.

9.2 METHOD

We established a categorization of the supply chain and robust criteria for assessing capability. These are presented in Table 9.1 and Table 9.2. The level 2 categories broadly correspond the packages for principal suppliers (also known as tier 1 suppliers) if a developer is multi-contracting.

TABLE 9.1 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 (OSS) supply	Supply of the completed OSS 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	Turbine installation	Work undertaken in the final port before installation and the installation and commissioning of the turbines, including vessels
	Foundation installation	Work undertaken in the final port before installation and the installation of the 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 OSS and the civil works for the onshore substation. Includes commissioning of 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 OSS maintenance and service
Decommissioning	Decommissioning	Removal of all necessary infrastructure and transport to port; excludes recycling or re-use

Criteria for assessing capability

We developed a set of criteria for assessing the current and future capability of the Azerbaijani supply chain. They relate to the likelihood that existing Azerbaijani companies can be successful in the industry and the likelihood that new companies can be attracted to invest in Azerbaijan. 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 offshore wind 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 supply chain assessment at a detailed company level.

The criteria were scored for each level 2 category, as shown in Table 9.2. In the analysis we distinguished between principal suppliers (equivalent to tier 1) and lower tier suppliers. We discussed with key stakeholders (see Section 20) and gathered feedback and additional data, as well as views on bottlenecks, recognizing Azerbaijan's place in a regional and global market.

TABLE 9.2 CRITERIA FOR ASSESSING CURRENT AND FUTURE AZERBAIJANI CAPABILITY

Criterion	Score	Description
Azerbaijan capability in parallel sectors	1	No relevant parallel sectors
	2	Relevant sectors with relevant workforce only
	3	Companies in parallel sectors that can enter market with high barriers to investment
	4	Companies in parallel sectors that can enter market with low barriers to investment
Benefits of Azerbaijani supply for Azerbaijani projects	1	No benefits in supplying Azerbaijani projects from Azerbaijan in terms of transport cost or risk
	2	Some benefits in supplying Azerbaijani projects from Azerbaijan but no significant impact on transport cost or risk
	3	Work for Azerbaijani projects can be undertaken from outside Azerbaijan but only with significant increased transport cost and risk
	4	Work for Azerbaijani projects must be undertaken locally
Additional cost of Azerbaijan supply (excluding transport)*	1	More than 25% more expensive than supply in Europe
	2	15%≤25% more expensive than in Europe
	3	5%≤15% more expensive than in Europe
	4	Less than 5% more expensive than in Europe
Investment risk in Azerbaijan	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 ≤US$50 million that can also meet demand from other small sectors
	4	Low investment ≤US$50 million that can also meet demand from other major sectors with market confidence
Size of the opportunity	1	<2% of lifetime expenditure
	2	2%≤3.5%
	3	3.5%-5%
	4	>5% of lifetime expenditure

** In the high growth scenario in 2032, roughly halfway through the pipeline of projects in this scenario. Some scores would be lower in the low growth scenario.*

9.3 RESULTS

Table 9.3 summarizes our analysis. Some categories have been considered together to avoid duplication. The sections below discuss our findings in more detail. The list of companies is not exhaustive. We have listed some companies active in the global OSW market that are known already to have been active in parallel activity in Azerbaijan and local companies with relevant capability. Scoring relates to general capability at a country level and not to individual-named companies.

TABLE 9.3 SUMMARY OF THE SUPPLY CHAIN ANALYSIS

Level 2 category	Potential Azerbaijan suppliers*	Azerbaijan capability in parallel sectors	Benefits of Azerbaijani supply for Azerbaijani projects	Additional cost of Azerbaijan supply (excluding transport)	Investment risk in Azerbaijan	Size of the opportunity
Project development	Caspian Geo, Caspian Geomatics, Fugro, Geoengineering, GeoGlobe, Kent, Wood, Worley	3	3	3	4	2
Nacelle, hub and assembly	-	1	3	2	1	4
Blades	-	1	3	2	1	4
Tower	ADO-G, Sumqayit Technologies Park	3	4	3	3	3
Foundation supply	Baku Shipyard SOCAR BOS-Shelf, Cimtas	2	4	3	3	4
Array and export cable supply	Sumqayit Technologies Park	2	2	3	1	3
Offshore substation supply	Azfen, Baku Shipyard SOCAR, BOS-Shelf	4	4	4	3	3
Onshore infrastructure	ADO-G, SOCAR	4	4	4	4	2
Turbine installation	ASCO, Shah Deniz consortium	2	2	3	3	3
Foundation installation	ASCO, Cimtas, Shah Deniz consortium	3	2	4	3	3
Array and export cable installation	ADO-G, ASCO, Caspian Marine Services	3	4	3	2	4

Level 2 category	Potential Azerbaijan suppliers*	Azerbaijan capability in parallel sectors	Benefits of Azerbaijani supply for Azerbaijani projects	Additional cost of Azerbaijan supply (excluding transport)	Investment risk in Azerbaijan	Size of the opportunity
Offshore and onshore substation installation	ASCO, Cimtas, Shah Deniz consortium, ADO-G, AZENCO, BCC Group, Glensol, and SOCAR	3	4	4	4	2
Wind farm operation	Wind farm owner, Caspian Marine Services	2	4	4	3	3
Turbine maintenance and service	Glensol	1	4	3	4	4
Balance of plant maintenance and service	Azfen, Glensol, Rapid Solutions, SOCAR, Wood	4	3	4	3	3
Decommissioning	(See installation contractors)	3	1	3	2	4

** An Azerbaijan supplier is one which would deliver most of the work for the project in Azerbaijan. It includes foreign-headquartered companies operating in Azerbaijan.*

The analysis shows that there is relevant capability in most parts of the supply chain. The main opportunities for local supply lie where:

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

The opportunity is therefore greatest in categories such as tower, foundation, and substation production, and in installation. There is significant capability in the Azerbaijani oil and gas supply chain with relevance to OSW. In some cases, such as geophysical surveys, the transition is straightforward; in others, such as fabrication and installation, oil and gas companies will need to adapt to the volumes of components needed for OSW.

Project development

Azerbaijan has local companies with the potential to undertake surveys and some engineering studies. These will have been active in other maritime sectors such as shipping, oil, and gas. Environmental-impact assessments can also be undertaken by Azerbaijani companies. Project development is likely to be led by established OSW developers with experience of operations in the Caspian Sea, potentially with a local partner, and the work is likely to be split between a local office and the locations of the partner, drawing on its project management, engineering, and procurement skills.

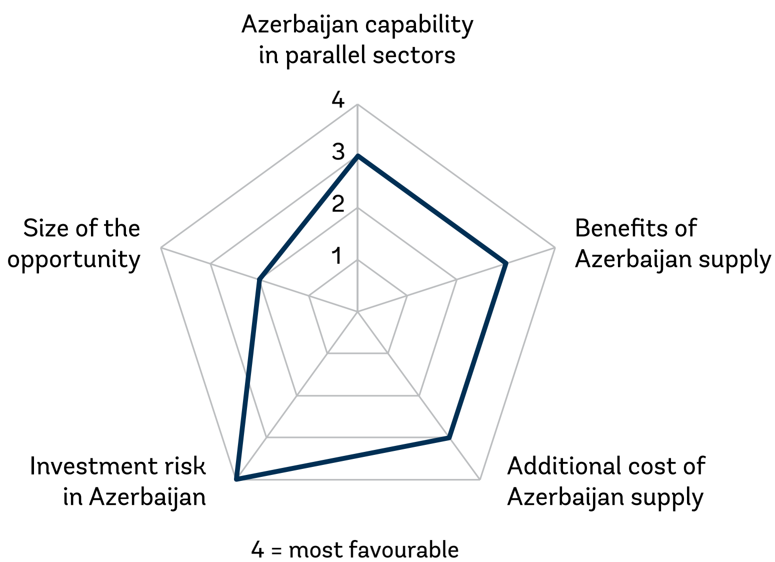
Surveys are likely to be undertaken by companies based in Azerbaijan, which may be global companies operating in the country. SOCAR-Fugro is a joint venture (JV) formed in 2013 to undertake onshore and offshore surveys in the region and would be well placed to undertake OSW work. Others include Caspian Geomatics, Geoengineering, and GeoGlobe.

Oil and gas companies with an existing interest in OSW such as BP, Equinor, and TotalEnergies can draw on significant procurement, project management, and engineering capability in Azerbaijan.

Engineering companies in Azerbaijan include Arup, DNV, Encotec, Kent, Wood, and Worley.

There are benefits of using a local supply chain during development because these companies will have a good understanding of relevant Azerbaijani regulations and receptors 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 companies when it comes to undertaking environmental and social impact assessment to Good International Industry Practice 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 9.1.

FIGURE 9.1 ASSESSMENT OF SUPPLY CHAIN FOR PROJECT DEVELOPMENT



Source: BVG Associates.

In the high growth scenario, Azerbaijani companies are likely to play an increasing role in development, while in the low growth scenario, Azerbaijani projects are likely to draw significant expertise from other countries, particularly for highly-specialized engineering work.

Turbine

With the involvement of global developers, we anticipate that Azerbaijani wind farms will use turbine suppliers that dominate the European market, since these are likely to offer the lowest cost of energy. There is also a possibility to use Chinese-supplied offshore wind turbines.

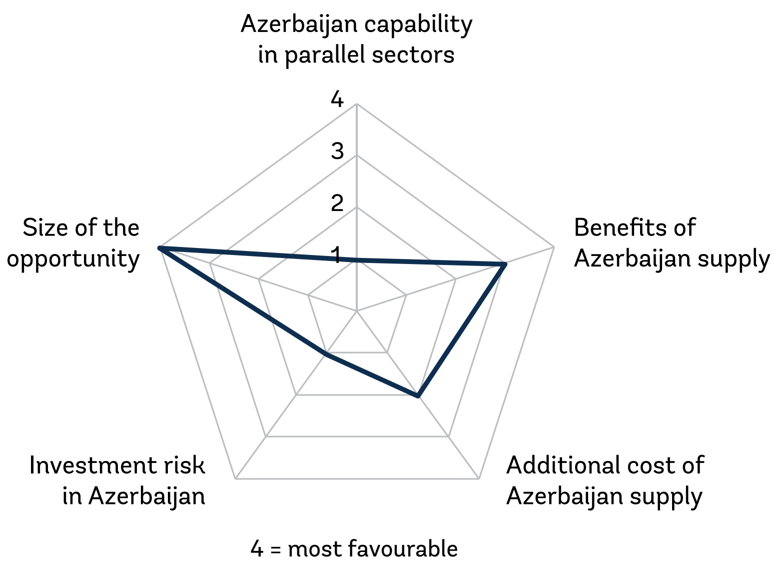
Nacelle, hub, and assembly

Azerbaijan has no turbine manufacturing facilities and any business case investment in new facilities would need to be based on a long-term market in the Caspian Sea of at least 2GW per year. This is not achieved even in the Azerbaijan high growth scenario and there is unlikely to be much market outside Azerbaijan, so it is highly likely that all nacelles and hubs will be imported.

Azerbaijan has manufacturing capability for electrical components, such as from ATEF. It is possible that in the high growth scenario, turbine suppliers will look to source power take-off equipment such as switchgear from Azerbaijan. Turbine suppliers are more likely to switch supply in power take-off equipment since this is typically housed in the base of the tower and is likely to be assembled in-country in the high growth scenario.

These conclusions are summarized in Figure 9.2.

FIGURE 9.2 ASSESSMENT OF SUPPLY CHAIN FOR NACELLE, HUB, AND ASSEMBLY



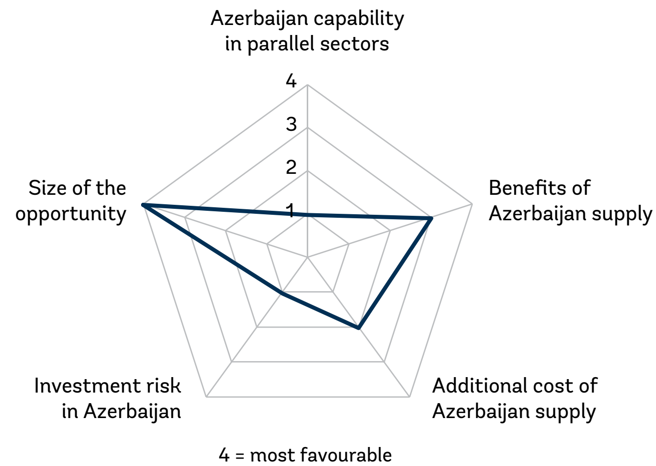
Source: BVG Associates.

Blades

Azerbaijan has no blade production facilities. Transport costs of blades through the canal system are high. Based on typical decisions elsewhere, any investment in local blade manufacturing would likely need to be based on a long-term market of at least 1.5GW per year in the Caspian Sea for over seven years. If there were coastal onshore blade production facilities in Azerbaijan, these could be repurposed. In their absence and despite the logistical challenges of transporting blades to the Caspian, importing is the most likely solution even in the high growth scenario.

These conclusions are summarized in Figure 9.3.

FIGURE 9.3 ASSESSMENT OF SUPPLY CHAIN FOR BLADES



Source: BVG Associates.

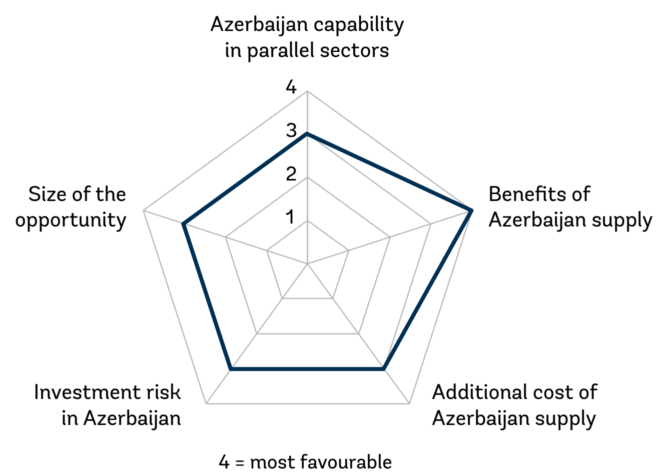
Tower

There are no wind turbine tower production facilities in Azerbaijan. Transport costs of towers to the Caspian Sea are high and the supply chain is not complex. While production is unlikely to be optimized, the transport costs make local supply financially attractive. We have therefore concluded that towers are manufactured locally from 2030 in both scenarios.

Investment in a tower factory is likely to be made by an established wind turbine tower manufacturer, possibly in a JV with an Azerbaijani company such as ADO-G or Sumqayit Technologies Park (STP).

These conclusions are summarized in Figure 9.4.

FIGURE 9.4 ASSESSMENT OF SUPPLY CHAIN FOR TOWERS



Source: BVG Associates.

Balance of plant

Foundation supply

In the low growth scenario, Azerbaijani projects use jackets because the market is too small to justify investment in a local monopile factory. Jackets can be produced at existing coastal fabrication yards and there is significant relevant existing capability in the offshore oil and gas industry. While local production is unlikely to be as efficient as at established OSW jacket facilities, local production of jackets is likely to be cheaper due to lower logistics costs to import plate steel rather than semi-completed foundations. Complete jacket foundations are too large to import.

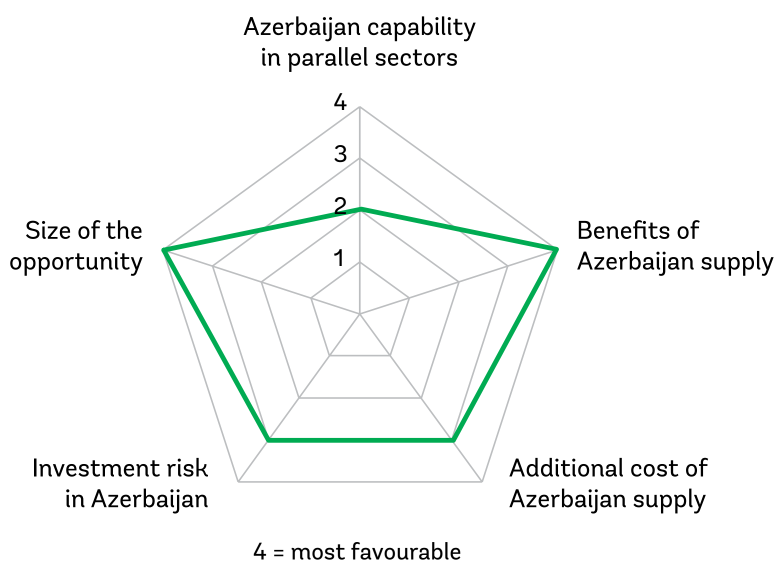
Companies that could undertake jacket fabrication include Baku Shipyard (a JV between State Oil Company of the Azerbaijan Republic (SOCAR), Azerbaijan Investment Company, and Keppel Offshore Marine), BOS-Shelf, and SOCAR's Heydar Aliyev Baku Deep Water Jackets Plant. All have suitable coastal infrastructure to manufacture jackets for OSW. They may benefit from JVs with established OSW suppliers that have experience of serial production.

In the high growth scenario, there is a case for investment in the rolling equipment needed to make OSW monopiles in Azerbaijan, which offer a lower overall cost solution. The suppliers are likely to be the same as for jacket manufacture, but significantly more investment in manufacturing would be required.

Foundations are supplied from Azerbaijan in both scenarios, as transport of such large structures through the canal system is impractical.

These conclusions are summarized in Figure 9.5.

FIGURE 9.5 ASSESSMENT OF SUPPLY CHAIN FOR FOUNDATIONS



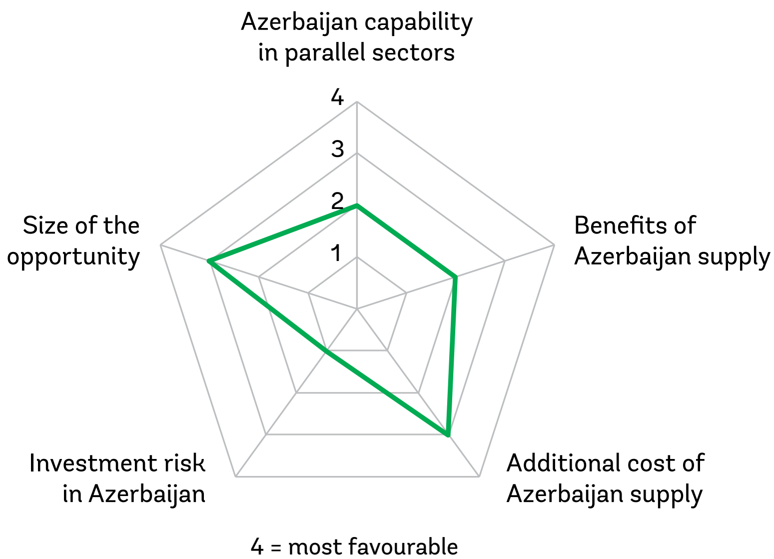
Source: BVG Associates.

Array and export cable supply

Azerbaijan has no subsea cable production capability. OSW in other markets has led to little investment by manufacturers at new locations. They have typically preferred to invest at their existing manufacturing sites, exporting globally at relatively low transportation cost. Historically, investments were made to fulfil interconnector contracts. With no known large interconnectors planned locally and the relatively low cost of transporting cable (most of the cable could be transported on a small number of barges), the business case for investment in local subsea cable production is weak. STP has a cable plant producing land cables and this could supply the onshore export cable. It could invest in subsea cable production but a business case would need to be built around export to the wider OSW market. This is unlikely, however, due to outwards logistics costs, and so there is no Azerbaijani subsea cable supply in either scenario. Supply of onshore cables, however, is included in both scenarios.

These conclusions are summarized in Figure 9.6.

FIGURE 9.6 ASSESSMENT OF SUPPLY CHAIN FOR ARRAY AND EXPORT CABLES



Source: BVG Associates.

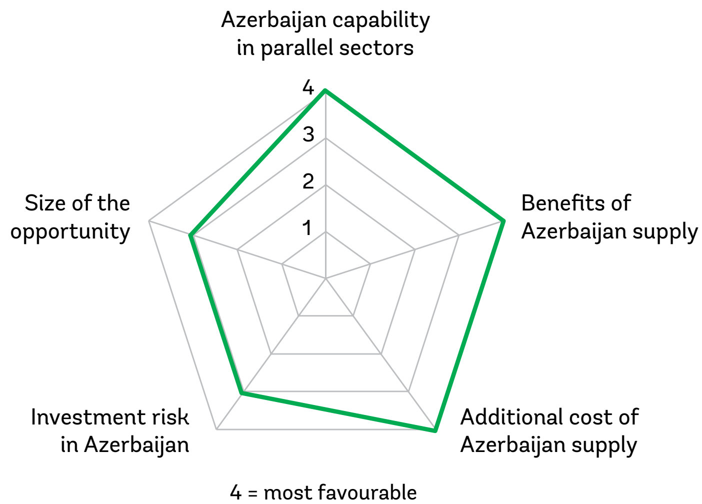
Offshore substation supply

OSS supply has many parallels with the production of offshore oil and gas platforms. Both require complex, large platform fabrication and systems integration. Several Azerbaijani companies have experience of producing oil and gas platforms, including Azfen (a JV between SOCAR and the Turkish construction company Tekfen) and Bos Shelf. SOCAR's Heydar Aliyev Baku Deepwater Jackets Factory could also undertake the work. These companies could also supply the OSS jacket foundation.

We assumed an Azerbaijani-manufactured and assembled OSS in both scenarios. An OSS for Azerbaijan is also likely to draw on a significant local supply chain for such items as secondary steel, platforms and walkways, cable trays, and low voltage systems. High voltage equipment is likely to be imported from global suppliers such as Hitachi ABB and Siemens Energy.

Figure 9.7 summarizes our conclusions.

FIGURE 9.7 ASSESSMENT OF SUPPLY CHAIN FOR OFFSHORE SUBSTATIONS



Source: BVG Associates.

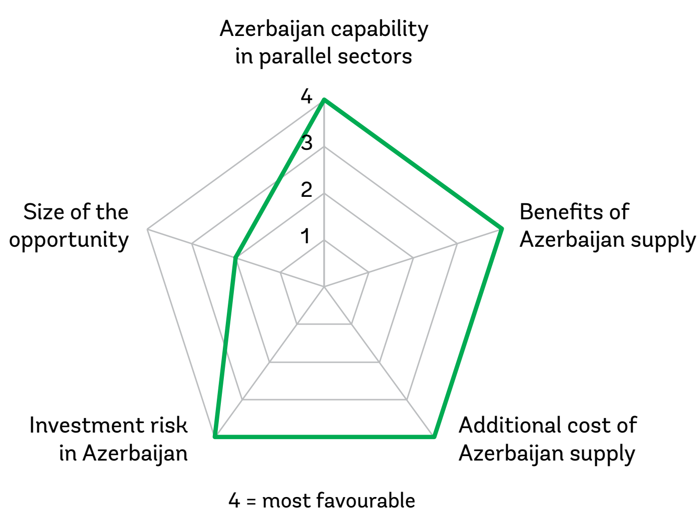
Onshore infrastructure

Onshore infrastructure includes the onshore substation and the operations base. For the substations, all high voltage electrical equipment is likely to be imported but low voltage systems are likely to be available in Azerbaijan. The materials and construction skills for the onshore infrastructure are available a wide range of local suppliers.

No significant investment by Azerbaijani companies is likely to be necessary because there are similar needs in the power and construction sectors. There is no difference in this area between the scenarios.

Figure 9.8 summarizes our conclusions.

FIGURE 9.8 ASSESSMENT OF SUPPLY CHAIN FOR ONSHORE INFRASTRUCTURE



Source: BVG Associates.

Installation and commissioning

Turbine and foundation installation

Pre-assembly at the port and final assembly at the wind farm site are undertaken by the turbine supplier. Conventional fixed OSW farms use specialist jack-up vessels built almost exclusively for OSW use. These vessels will not be able to access the Caspian Sea and so by necessity, Azerbaijan OSW farms will use vessels drawn from the Caspian Sea fleet. While there is a significant oil and gas fleet in the Caspian Sea, this sector does not have the same requirement for heavy lift-vessels. In the North Sea, oil and gas platforms are typically installed with large semisubmersible heavy-lift vessels. The more benign weather conditions in the Caspian Sea mean that float-over solutions are more economic. Azerbaijani OSW installation will therefore require installation strategies based on the available fleet and this is likely to mean a suboptimal process with costs typically higher than OSW farms in other European markets.

In the low growth scenario, installation is undertaken by existing Azerbaijani vessels. The Caspian Sea does have a small number of jack-up vessels. One solution for turbine installation is to install a crawler crane on one of these vessels. A suitable 1250t capacity crawler crane is available in Azerbaijan. Components could be transported to the OSW site on feeder vessels. Feeder solutions have been avoided in Europe because of the challenge of lifting components off a floating vessel using a jacked-up crane, potentially in rough sea conditions. The more benign weather conditions in the Caspian Sea make this a more viable option.

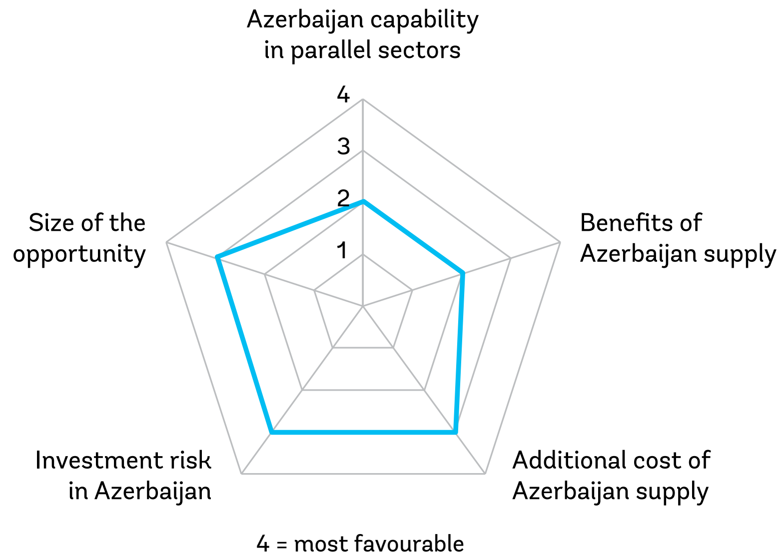
Normally, foundations are installed by a jack-up vessel (which may also be used for turbines) or a floating heavy-lift vessel. Azerbaijan has floating construction vessels with cranes with the lifting capacity (up to 2,000t) needed for OSW foundations. These have limited deck space and it is most likely that feeder barges will be used. Given the limited availability of vessels and cranes, we have assumed installation techniques using launch barges, as used in the Caspian Sea oil and gas.

Regardless of the installation solution adopted for Azerbaijani OSW farms, local vessels, ports, and crew will be used in all cases, although the work may be undertaken under contract from an experienced OSW marine contractor.

In the high growth scenario, an installation vessel with state-of-the-art features is built locally to support the OSW industry from 2031, as there is sufficient installation activity to justify this. The vessel will also be used for large-component exchange during operation of all OSW projects constructed in the Caspian Sea and could also be used for hydrocarbon applications.

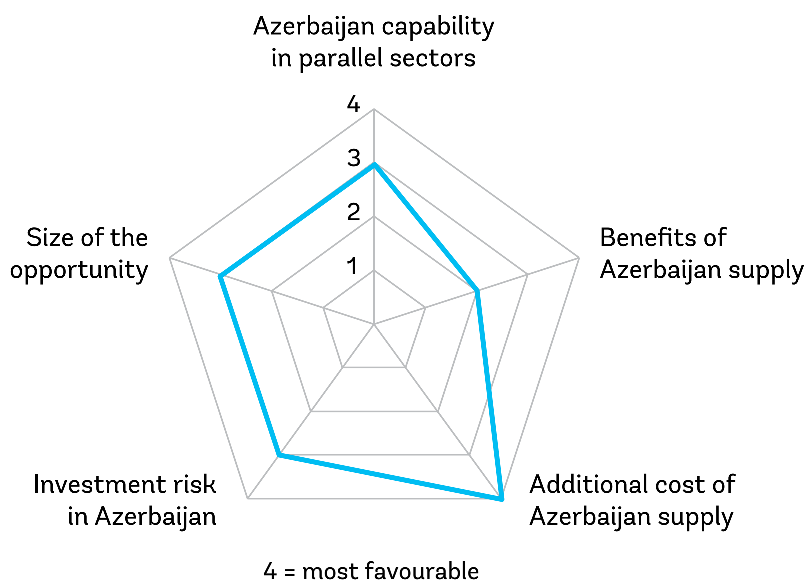
Figure 9.9 and Figure 9.10 summarize our conclusions.

FIGURE 9.9 ASSESSMENT OF SUPPLY CHAIN FOR TURBINE INSTALLATION



Source: BVG Associates.

FIGURE 9.10 ASSESSMENT OF SUPPLY CHAIN FOR 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 in order to bring cable close to shore.

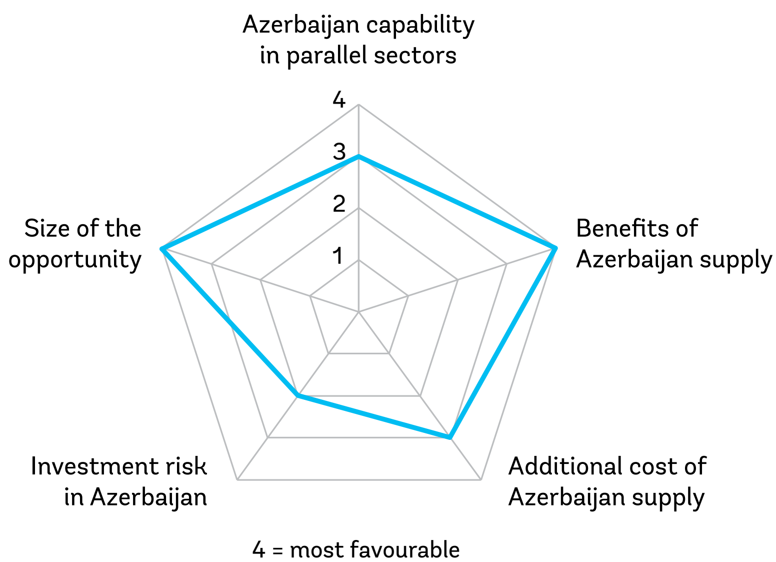
European OSW cable-laying is increasingly undertaken by specialist vessels designed for the OSW sector. With Azerbaijani projects inaccessible for these vessels, oil and gas vessels may be fitted with a cable spread to undertake the work.

There are several vessel operators with suitable vessels, including ADO-G, Azerbaijan Caspian Shipping Company (ASCO), and Caspian Marine Services.

Cable installation also requires subcontractors for the supply of cable protection and entry systems, remotely operated vehicles (ROVs), cable storage and cable termination, and testing. Cable protection and entry systems and termination and testing are specialized and Azerbaijani projects are likely to use established companies in the sector. Other services are likely to be provided locally in both scenarios from companies such as Azerbaijan Energy Construction (AZENCO), BCC Group, Glensol, Oil & Gas Construction Trust (OGCT) Rapid Solutions, and Wood.

Figure 9.11 summarizes our conclusions.

FIGURE 9.11 ASSESSMENT OF SUPPLY CHAIN FOR ARRAY AND EXPORT CABLE INSTALLATION



Source: BVG Associates.

Offshore and onshore substation installation

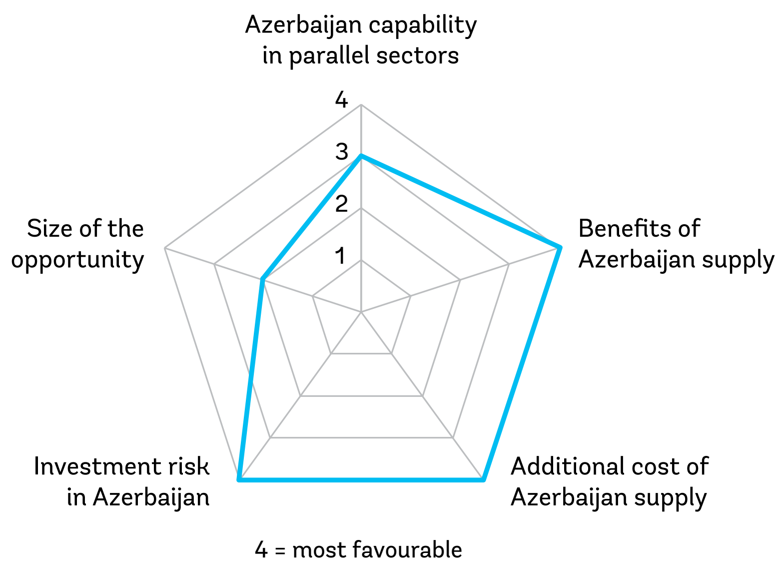
OSS installation includes the foundation (usually a jacket) installation and the substation platform installation. The OSS foundation is typically installed in the same way as a turbine foundation. It may use similar vessels and may be delivered as part of the turbine foundation installation contract. Our conclusions for OSS foundation installation are therefore the same as for turbine foundation installation. The substation platform is likely to weigh more than 2,000t. In the Caspian Sea, they are likely to be installed using a float-over solution, well proven already in the Caspian Sea oil and gas sector.

For the onshore substation, there are significant synergies with the rest of the civil engineering sector and this work is invariably provided by local companies. ADO-G, AZENCO, BCC Group, Glensol, and SOCAR are among those capable of undertaking the work.

There is no difference between the scenarios for both offshore and onshore substation installation.

Figure 9.12 summarizes our conclusions.

FIGURE 9.12 ASSESSMENT OF SUPPLY CHAIN FOR OFFSHORE AND ONSHORE SUBSTATION INSTALLATION



Source: BVG Associates.

Operations, maintenance, and service

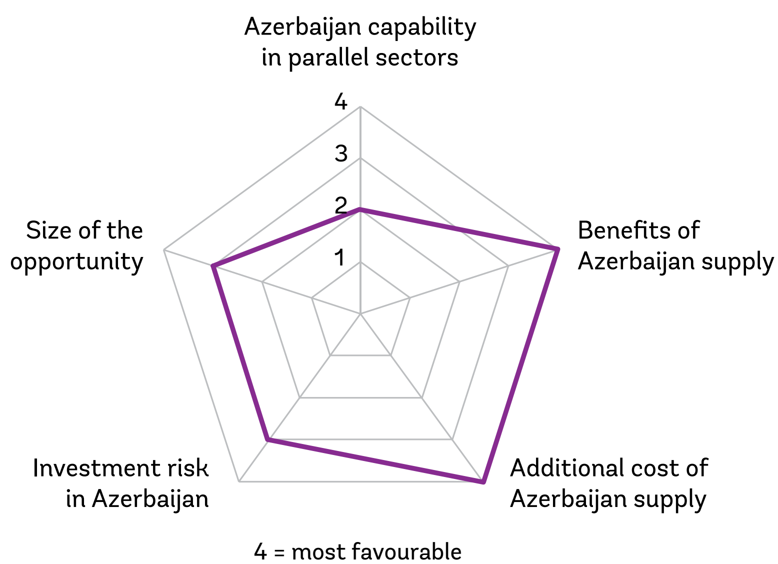
Wind farm operation

Wind farm operation combines much of the asset management expertise in onshore wind along with offshore logistics. Azerbaijan has only a limited onshore wind sector. In the low growth scenario, most asset management is likely to be done remotely by the owners and the turbine supplier under the service agreement. In the high growth scenario, more local asset management is likely but owners and turbine suppliers are still likely to use some central resource in European offices.

OSW typically uses bespoke crew vessels and it is likely that these will be built by Azerbaijani shipyards and managed by local companies such as ADO-G and Caspian Marine Services.

Figure 9.13 summarizes our conclusions.

FIGURE 9.13 ASSESSMENT OF SUPPLY CHAIN FOR WIND FARM OPERATION



Source: BVG Associates.

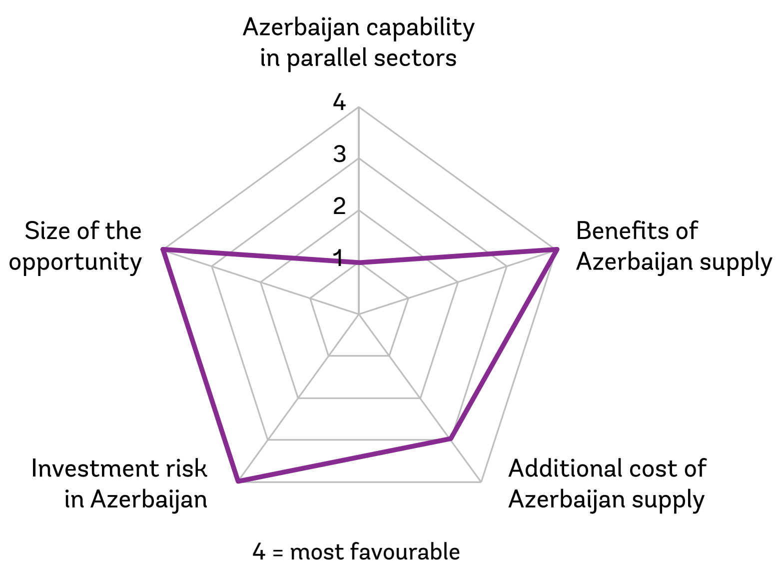
Turbine maintenance and service

Turbine planned maintenance and unplanned service in response to component failures (or prognosis of failure) is typically managed by the turbine supplier, generally under a service agreement of length up to 15 years, though some experienced project owners take on much more responsibility themselves. Either way, a local workforce will be used for much of the work, and there is an opportunity for local companies, such as Glensol, offering inspection services and technicians during planned maintenance and unplanned service activities in response to turbine faults. In the early days of operation, there is likely to be a significant number of overseas technicians used but the numbers will decline as a local workforce is trained.

Spare parts and consumables will be imported in the absence of any wind manufacturing supply chain in Azerbaijan, due to the importance of using proven, reliable products. There may be some opportunity for local refurbishment of some components.

Figure 9.14 summarizes our conclusions.

FIGURE 9.14 ASSESSMENT OF SUPPLY CHAIN FOR TURBINE MAINTENANCE AND SERVICE



Source: BVG Associates.

Balance of plant maintenance and service

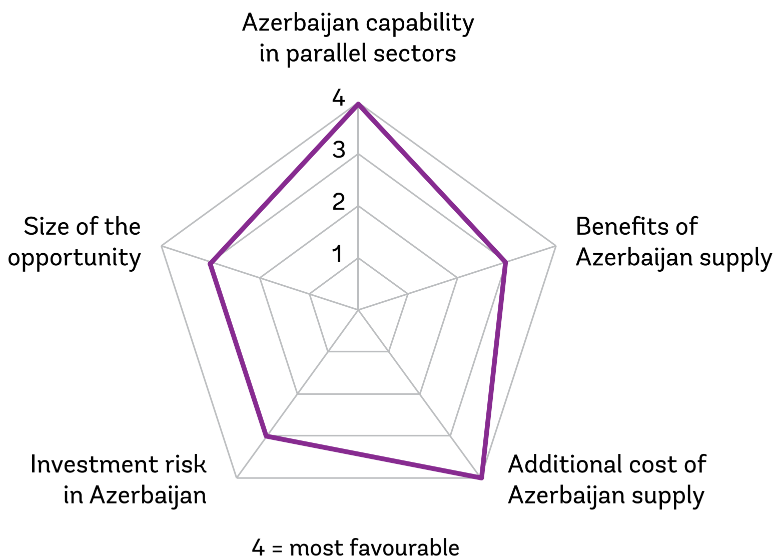
Balance of plant maintenance and service covers the foundations, array and export cables and substations. Cable maintenance and service is the most significant, with cable failures the biggest source of insurance claims in OSW, typically due to mechanical damage caused to the cables during installation or subsequent OSW or other marine activity. It uses similar equipment to cable installation as array cables are often replaced rather than repaired, and the same companies could undertake the work.

Foundation maintenance and service includes inspections for corrosion or structural defects above and below the water line, and cleaning and repairing areas above the water line. Azerbaijani companies such as Azfen, Glensol, OGCT, and Wood could undertake this work.

Substation maintenance and service may be undertaken by the electrical system supplier, or utilities such as Azerenerji could undertake this work.

Figure 9.15 summarizes our conclusions.

FIGURE 9.15 ASSESSMENT OF SUPPLY CHAIN FOR BALANCE OF PLANT MAINTENANCE AND SERVICE



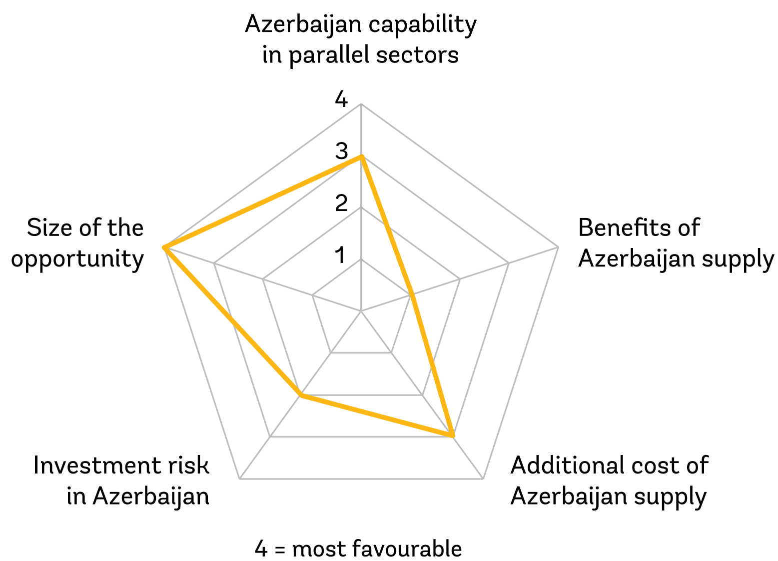
Source: BVG Associates.

Decommissioning

Decommissioning strategies have not yet been developed in established European markets. It is most likely that vessels that have been used for installation will also support decommissioning.

Figure 9.16 summarizes our conclusions.

FIGURE 9.16 ASSESSMENT OF SUPPLY CHAIN FOR DECOMMISSIONING



Source: BVG Associates.

9.4 DISCUSSION

Azerbaijan has good port infrastructure that could host local manufacturing. It has supply chain capability relevant to many areas of OSW, including in development and project management, fabrication of towers, jackets and OSS topsides, and offshore logistics.

The logistical challenges of building wind farms in the Caspian Sea are likely to mean local supply of towers and foundations, the use of local vessels for installation and the development of OSW installation capability. Given the lack of a regional market, the supply chain required for operations, maintenance, and servicing will develop locally, with many transferable skills and capabilities from the existing oil and gas sector. In the high growth scenario, we anticipate local manufacture of monopile foundations and a large foundation and turbine installation vessel.

These activities will create the economic benefits discussed in Section 10. There are, however, limited opportunities to export to a regional market, due to logistics constraints and lack of any other likely OSW market in the Caspian Sea.[xi]

9.5 RECOMMENDATIONS

Based on this analysis, it is recommended that:

- Ministry of Energy (MOE) presents a balanced vision for local supply chain development, encouraging international engagement in key areas identified for local supply to ensure latest international good practice is accessed.
- MOE enables investment in a local wind turbine installation vessel.
- MOE and relevant Government agencies enable education and investment in local supply chain businesses, including in the training of onshore and offshore workers.

xi Azerbaijan has good mean wind speeds in its sector of the Caspian Sea. To the southwest and northwest, Iran and Russia do not have such good wind speeds in their sectors, so are unlikely to develop OSW. To the east, Kazakhstan and Turkmenistan both have good wind speeds in their sectors and conditions suitable for OSW, but plenty of unpopulated space for onshore wind and solar, which will likely deliver at lower LCOE, meaning these countries are less likely to choose OSW.

10 JOBS AND ECONOMIC BENEFIT

10.1 PURPOSE

In this work package, we determine the economic impact of offshore wind (OSW) in Azerbaijan, looking at the potential for job creation and direct investment in the country's OSW industry under the scenarios described 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 aims to establish the economic impacts created by Azerbaijani wind farms globally, as well as in Azerbaijan.

10.2 METHOD

We considered two types of impact:

- Total impacts from Azerbaijani projects
- Azerbaijan impacts from Azerbaijani projects.

Direct and indirect impacts were modelled. 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.

Total impacts from Azerbaijani projects

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% Azerbaijani content (that is, there is no import of materials, components, and services):

- Low growth scenario (885MW by 2030 and 1,533MW by 2036)
- High growth scenario (1,200MW by 2030 and 7,180MW by 2036).

We used an in-house model that has been verified through use on many projects that converts lifetime expenditure to FTE years and GVA, based on a top-down assessment of costs and adjustment to local conditions. Details of the methodology are provided in Appendix E.

For each scenario, we calculated the impacts for each planned project in each year of the analysis.

Azerbaijan impacts from Azerbaijani projects

We established the impacts in Azerbaijan by considering the current and potential future capability of the Azerbaijani supply chain and assessed the likely percentage of Azerbaijani content for each scenario. The capability of the Azerbaijani supply chain and opportunities for growth are discussed in Section 9. A non-exhaustive list of notable relevant suppliers is provided in Section 20.

10.3 RESULTS

Total impacts from Azerbaijani projects

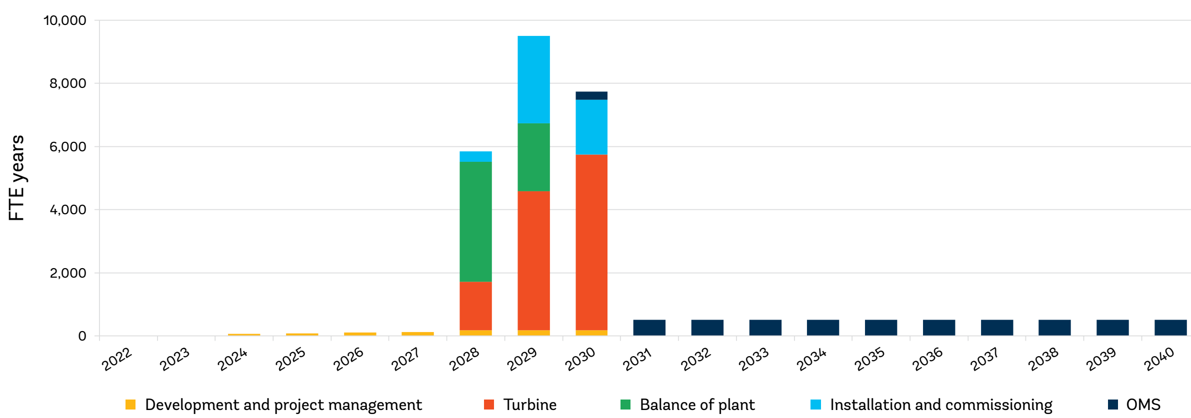
Single project

Figure 10.1 shows the total FTE years employment created annually for a single 1GW project installed in 2030 in the high growth scenario, independent of whether those jobs are created in Azerbaijan or elsewhere. It shows that employment peaks in 2029, the first full year of construction at about 9,500 FTE years, when there is significant turbine and balance of plant manufacture, as well as installation.

Total employment for the project is about 42,000 FTE years. As a comparison, another study undertaken by the International Renewable Energy Agency (IRENA) in 2018 estimated that a 500MW wind farm created about 2.1 million person days (about 10,000 FTE years). This was based on an industry survey and likely to miss jobs created in the lower tiers of the supply chain and the jobs from investing in equipment and infrastructure. It was also based on European working practices.[12]

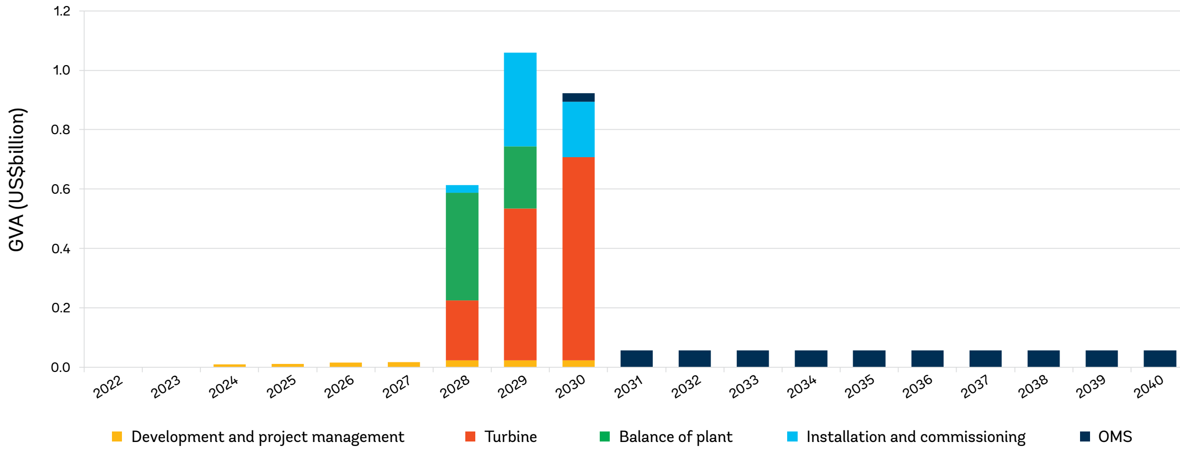
Figure 10.2 shows the GVA generated by this single project. The peak GVA in 2029 is about US$1.1 billion. The total GVA over the lifetime of the project is about US$3.2 billion.

FIGURE 10.1 TOTAL ANNUAL FTE YEARS EMPLOYMENT FOR A SINGLE 1GW PROJECT INSTALLED IN 2030, SPLIT BY COST ELEMENT



Source: BVG Associates.

FIGURE 10.2 TOTAL ANNUAL GVA FOR A SINGLE 1GW PROJECT INSTALLED IN 2030, SPLIT BY COST ELEMENT



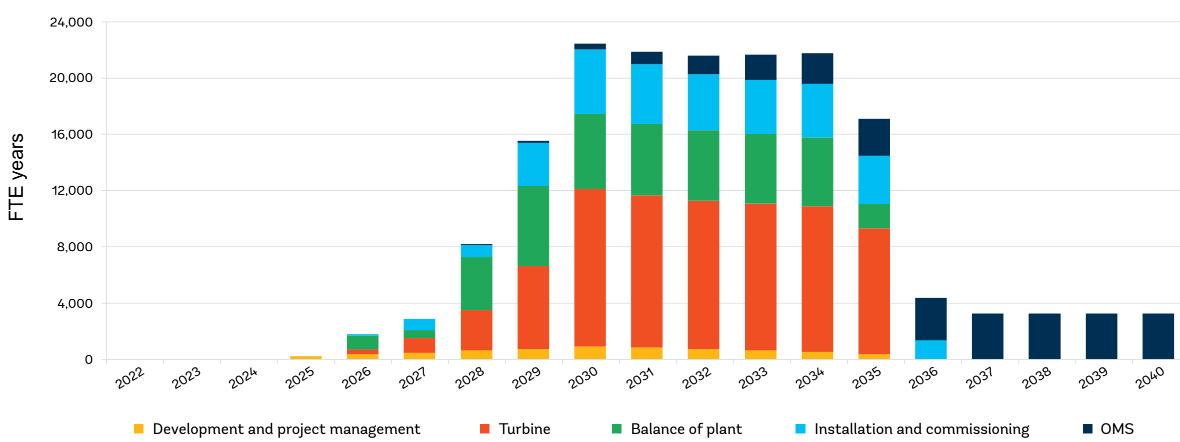
Source: BVG Associates.

High growth scenario

Figure 10.3 shows the global annual FTE years employment from OSW projects in Azerbaijan. It shows that the number of jobs grows steadily to 2030 before plateauing at about 22,000 FTE years per year. This is because in this scenario, annual installed capacity reaches a steady state in 2032. Although there is an increase in operations, maintenance, and service (OMS) jobs after 2034, this is offset by reductions in other parts of the supply chain because no new projects are completed after 2036. Between 2022 and 2040, more than 175,000 FTE years are created.

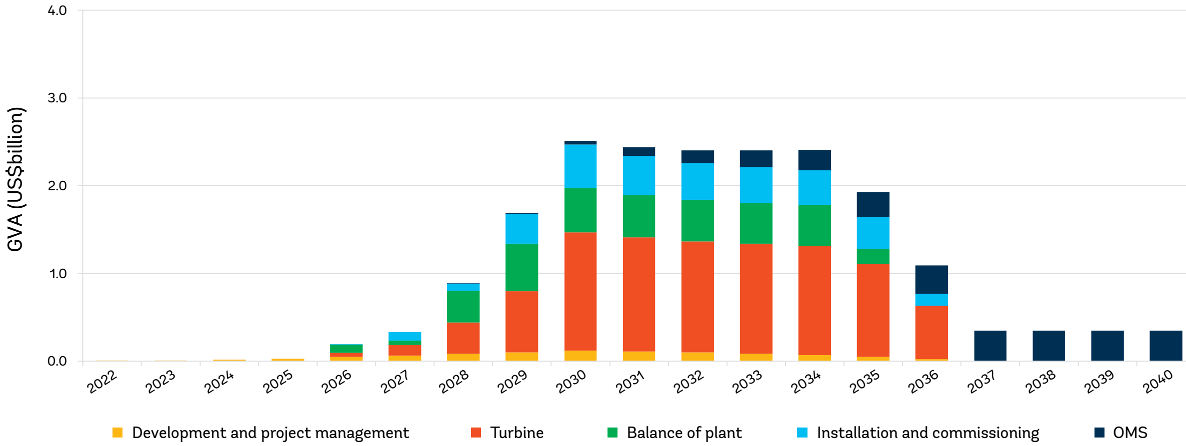
In Figure 10.4, the GVA created by all projects shows a similar pattern, with GVA reaching about US$2.5 billion per year in the 2030s. Between 2022 and 2040, more than US$20 billion GVA is generated.

FIGURE 10.3 TOTAL ANNUAL FTE YEARS EMPLOYMENT CREATED BY ALL AZERBAIJANI PROJECTS IN THE HIGH GROWTH SCENARIO, SPLIT BY COST ELEMENT



Source: BVG Associates.

FIGURE 10.4 TOTAL GVA CREATED BY ALL AZERBAIJANI PROJECTS IN THE HIGH GROWTH SCENARIO, SPLIT BY COST ELEMENT



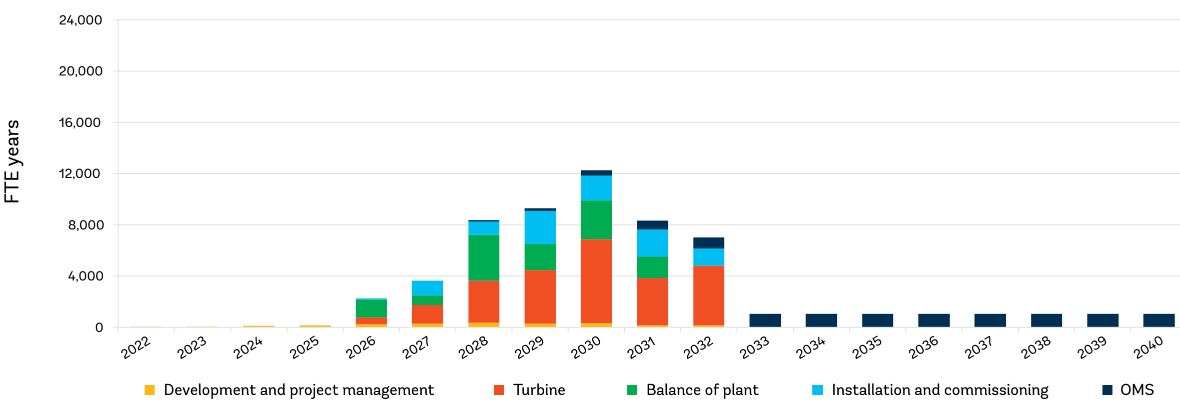
Source: BVG Associates.

Low growth scenario

For the low growth scenario, the global number of FTE years from OSW projects in Azerbaijan grows to about 12,200 then declines because there are no projects built after 2032. Between 2022 and 2040, about 60,000 FTE years are created. This is shown in Figure 10.5.

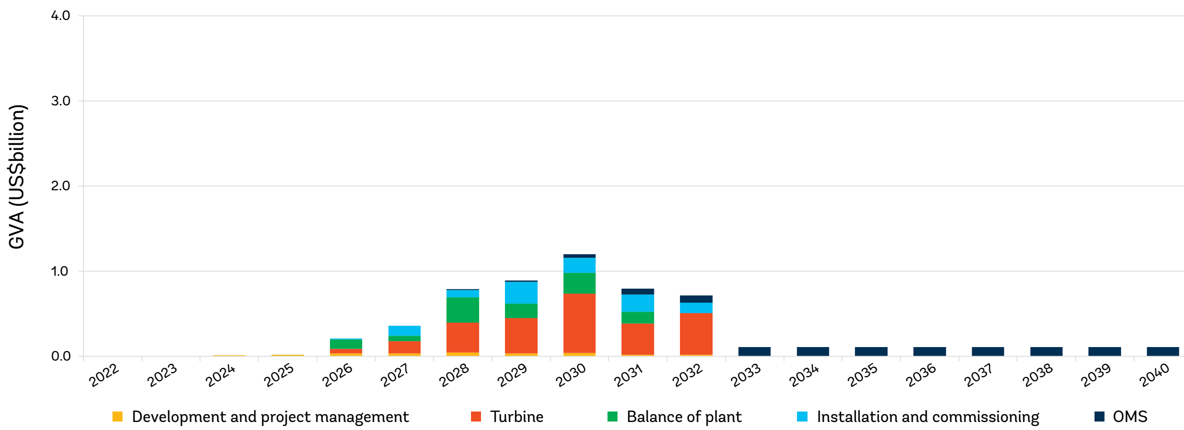
In Figure 10.6 the GVA created by all projects in the low growth scenario shows a similar trend. Between 2022 and 2040, about US$5.9 billion is generated.

FIGURE 10.5 TOTAL ANNUAL FTE YEARS EMPLOYMENT CREATED BY ALL AZERBAIJANI PROJECTS IN THE LOW GROWTH SCENARIO, SPLIT BY COST ELEMENT



Source: BVG Associates.

FIGURE 10.6 TOTAL GVA CREATED BY ALL AZERBAIJANI PROJECTS IN THE LOW GROWTH SCENARIO, SPLIT BY COST ELEMENT



Source: BVG Associates.

Azerbaijani impacts from Azerbaijani projects

Table 10.1 shows how Azerbaijani content changes over time as investments are made. In both scenarios we show the assumed local content percentage in 2028, 2030, and 2032. These are the years when the projects in the low growth scenario are completed. The local content is stable over the years modelled as it is assumed that the investments required to increase local content are made for the early projects, and that all subsequent projects benefit. For those parts of the supply chain where no additional investment is justified, the local content will similarly remain relatively stable for all projects.

Investing early in supply chain capability is the best way for Azerbaijan to capture local content, as costs will reduce more quickly as a result, allowing Azerbaijan to narrow the gap in capability and competitiveness with established global suppliers and reduce external competition. Further projects are installed in the high growth scenario after 2032, but we assumed that all major investments will have been made by 2032.

These assumed investments reflect the assumptions about the current and future Azerbaijani supply chain for the low and high scenarios developed in Section 2 and consider the elements of the supply chain that will reply on imports and which will be delivered locally. There are few differences between the scenarios, either because the logistics costs are too high to import in either scenario or the market is not big enough to enable local supply in either scenario.

The important difference is that in the high growth scenario, there are investments in a monopile factory and an installation vessel ready for a project in 2031.

Note that because a higher proportion of monopile cost is steel, rather than labor, the Azerbaijan content in foundation supply is lower in the high growth scenario. The increased volume in the high growth scenario means that its absolute impact is greater than the low growth scenario, even if the Azerbaijan content is lower.

In the high growth scenario, a new installation vessel is built in Azerbaijan. This does not affect the local content as the vessels it is replacing are likely to have been built in Azerbaijan too. The GVA from the construction of the vessel is distributed in our model across the projects for which the vessel is being used.

In general, local content is relatively high, because the logistical challenges in the Caspian Sea favor Azerbaijani supply. Azerbaijani content in the high growth scenario is lower than in the low growth scenario because there is investment in a monopile factory which has a lower local labor content. In some cases, local content drops from one year to the next. This is due to the change in relative cost of different OSW project elements over time, rather than any reduction in scope or fraction of supply.

TABLE 10.1 AZERBAIJANI CONTENT FOR AZERBAIJAN OFFSHORE WIND PROJECTS COMPLETED IN 2028, 2030, AND 2032

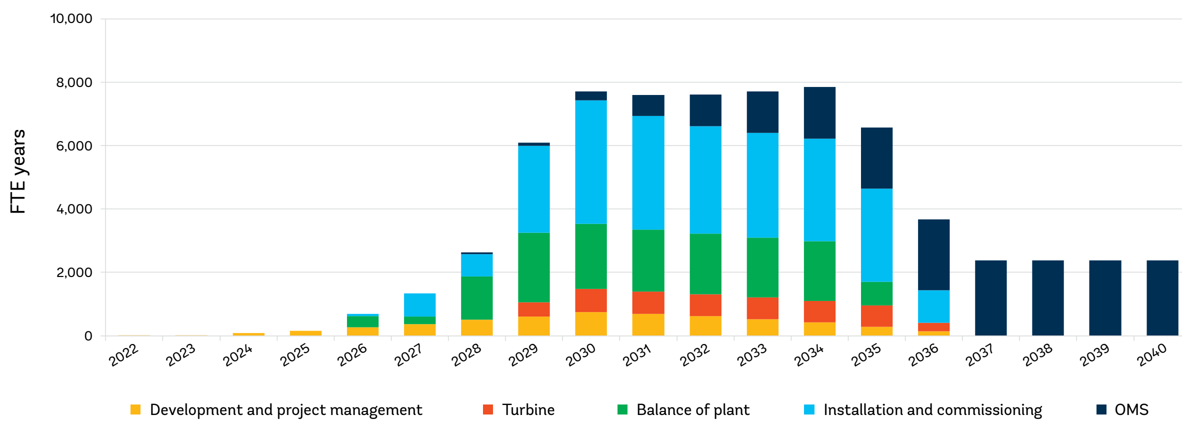
		Low growth			High growth		
		2028	2030	2032	2028	2030	2032
Development and project management		70%	70%	70%	70%	80%	85%
Turbine	Nacelle, rotor, and assembly	0%	0%	0%	0%	0%	0%
	Blades	0%	0%	0%	0%	0%	0%
	Tower	0%	40%	40%	0%	40%	40%
Balance of plant	Foundation supply	75%	75%	75%	40%	40%	40%
	Array cable supply	0%	0%	0%	0%	0%	0%
	Export cable supply	0%	0%	0%	0%	0%	0%
	Onshore and offshore substation supply	65%	65%	65%	65%	65%	65%
Installation and commissioning	Turbine installation	70%	70%	70%	70%	70%	70%
	Foundation installation	90%	90%	90%	90%	90%	90%
	Array cable installation	90%	90%	90%	90%	90%	90%
	Export cable installation	90%	90%	90%	90%	90%	90%
	Onshore and offshore substation installation	90%	90%	90%	90%	90%	90%
O&M	Wind farm operation	85%	85%	85%	85%	85%	85%
	Turbine maintenance and service	70%	70%	70%	70%	70%	70%
	Foundation maintenance and service	90%	90%	90%	90%	90%	90%
	Subsea cable maintenance and service	80%	80%	80%	80%	80%	80%
	Substation maintenance and service	90%	90%	90%	90%	90%	90%
Decommissioning	Decommissioning	90%	90%	90%	90%	90%	90%
Total local content		**55%**	**54%**	**53%**	**52%**	**52%**	**51%**

High growth scenario

Figure 10.7 shows the Azerbaijani annual FTE years employment created by all projects in the high growth scenario. It shows that the number of FTE years reaches about 7,700 in the 2030s. Between 2022 and 2040, about 70,000 FTE years are created, about 40% of the total created globally.

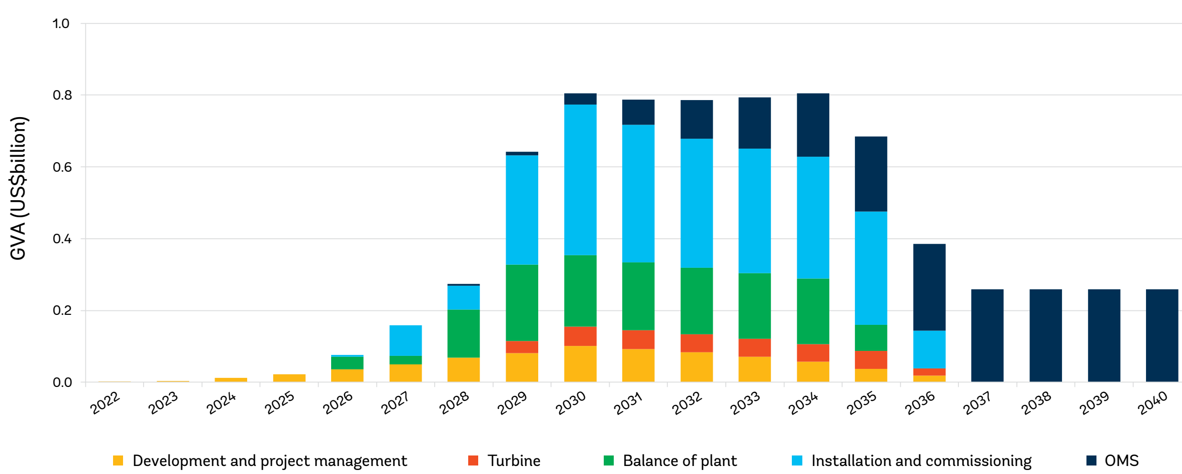
Figure 10.8 shows that annual GVA reaches about US$800 million in the 2030s. Between 2022 and 2040, over US$7.3 billion GVA is generated.

FIGURE 10.7 AZERBAIJANI ANNUAL FTE YEARS EMPLOYMENT CREATED BY ALL AZERBAIJANI PROJECTS IN THE HIGH GROWTH SCENARIO, SPLIT BY COST ELEMENT



Source: BVG Associates.

FIGURE 10.8 AZERBAIJANI ANNUAL GVA CREATED BY ALL AZERBAIJANI PROJECTS IN THE HIGH GROWTH SCENARIO, SPLIT BY COST ELEMENT



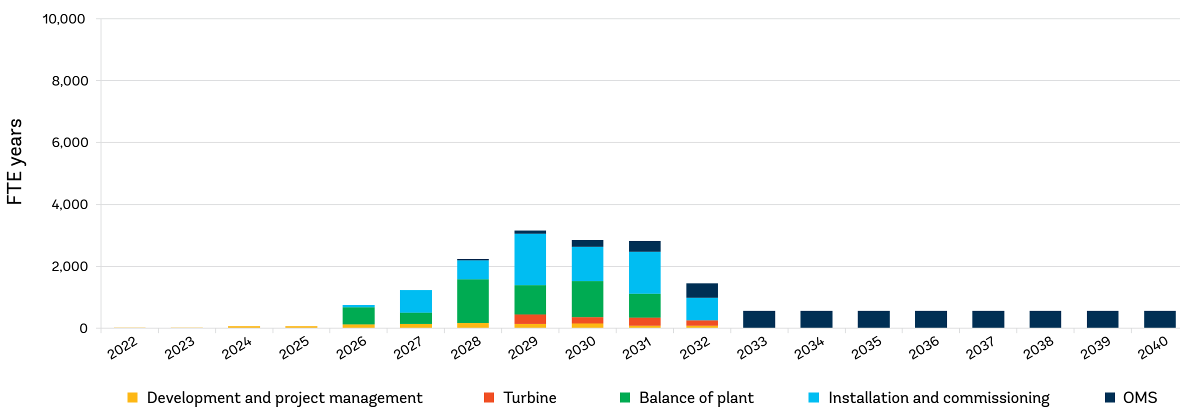
Source: BVG Associates.

Low growth scenario

Figure 10.9 shows the Azerbaijani annual FTE years employment created by all projects in the low growth scenario. It shows that the number of FTE years peaks at about 3,200 in 2029. It decreases after 2029 because there is not a sustained pipeline of projects. The number of FTE years created between 2022 and 2040 is about 19,200.

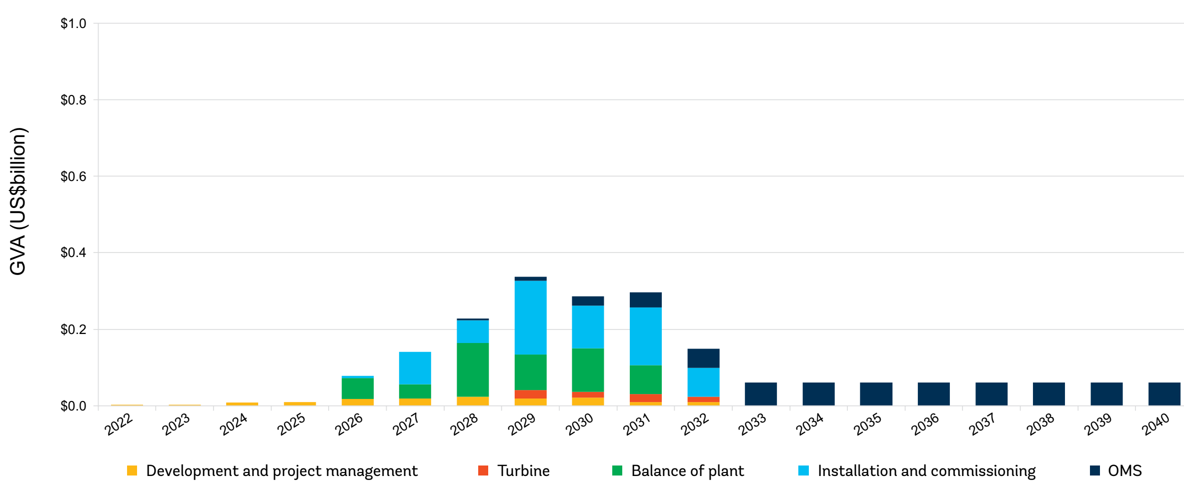
Figure 10.10 shows that annual GVA reaches about US$350 million in 2029. The GVA generated between 2022 and 2040 is about US$2 billion.

FIGURE 10.9 AZERBAIJANI ANNUAL FTE YEARS EMPLOYMENT CREATED BY ALL AZERBAIJANI PROJECTS IN LOW GROWTH SCENARIO, SPLIT BY COST ELEMENT



Source: BVG Associates.

FIGURE 10.10 AZERBAIJANI ANNUAL GVA CREATED BY ALL AZERBAIJANI PROJECTS IN LOW GROWTH SCENARIO, SPLIT BY COST ELEMENT



Source: BVG Associates.

Investment in the local supply chain

Table 10.2 presents the likely investment needed to deliver the supply chain development described above. Investments are highly indicative, as they depend on where investment occurs and what existing infrastructure can be used.

Total investment is in the range US$40 million to US$100 million in the low growth scenario and could be over US$500 million in the high growth scenario. Investments in ports have not been included, so will be additional.

TABLE 10.2 LOCAL SUPPLY CHAIN INVESTMENTS TO FACILITATE AZERBAIJAN OFFSHORE WIND

Investment	Low growth scenario	High growth scenario
Turbine towers	Upgrade to existing steel fabrication facility for project in 2030 Investment decision by 2028 Cost: US$50-100 million	Same as low growth scenario
Foundations	Upgrade to fabrication yard(s) for project in 2028 Investment decision by 2026 Cost: US$5-30 million	Investment in monopile factory for project in 2028 Investment decision by 2026 Cost: US$50-100 million
Installation vessel	None	New turbine installation vessel for project in 2031 Investment decision by 2027 Cost: US$150-250 million

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
- A commercial and financial environment that enables investment, whether inward investment or indigenous
- A sufficient level of commitment to buy a reasonable amount of supply over a long enough period.

11 ENVIRONMENTAL AND SOCIAL CONSIDERATIONS

11.1 PURPOSE

In this work package we consider the environmental and social considerations that are relevant to the future development of Azerbaijan's offshore wind (OSW) market.

11.2 METHOD

Applicable national laws, policies, regulations, and environmental and social considerations associated with the development, installation, and operation of OSW were reviewed, with a focus on offshore rather than onshore aspects. This included information provided by The Biodiversity Consultancy (TBC), shown in Appendix D. TBC provided this input under contract to ESMAP.

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 of offshore wind in Azerbaijan. This will be required at both a country-wide marine spatial planning level and at a project-specific scale. Future studies and surveys should include the consideration of cumulative impacts between projects over their operating lifetime.

We have assessed conditions in general and in the potential OSW development zones shown in Figure 2.2. The locations of these zones are derived in Section 19. Section 11 is limited to discussing each consideration.

The zones have been included in the maps in this Section to show their location relative to specific environmental and social considerations.

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.

TABLE 11.1 RAG SCALE FOR ENVIRONMENTAL AND SOCIAL 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 own knowledge and professional judgement of considerations relevant to OSW in other markets, and through desk study and early engagement with relevant stakeholders in Azerbaijan. Beyond this roadmap, further work is needed to provide a view of environmental and social considerations.

The inputs from local stakeholders have been assessed for their relevance and incorporated to ensure that the preliminary assessment is in line with good international industry practice.[13]

For each constraint we have:

- Determined to what extent the constraint applies to the future development of OSW in Azerbaijan;
- Assessed how the constraint is considered in law and applied in practice in Azerbaijan;
- Defined how similar constraints have been addressed in other OSW markets; and
- Discussed options for how Azerbaijan can address the key constraints.

Early and constructive stakeholder engagement is an essential component of identifying priority biodiversity values, 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 MSP and ESIA processes. A full list of stakeholders is provided in Section 20. An initial list of key stakeholders for environmental and social considerations relevant to developing OSW are listed below:

- Government:
  - Azerbaijan Energy Regulator
  - Azerbaijan Renewable Energy Agency
  - Ministry of Culture (MOC)
  - Ministry of Defense (MOD)
  - Ministry of Ecology and Natural Resources (MENR)
  - Ministry of Emergency Situations (MES)
  - Ministry of Energy
  - Ministry of Transport, Communications and High Technologies
  - State Civil Aviation Agency
  - State Maritime Agency.
- Non-governmental organizations (NGOs) and Other:
  - Azerbaijan Ornithological Society
  - Azerbaijan Technical University
  - Azerbaijan University
  - Baku State University
  - Caspian Centre for Energy and the Environment.

Consideration has also been given to the World Bank's Environmental and Social Framework (ESF).[14] It consists of 10 core environmental and social standards (ESS) as listed below:

- 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 (H&S)
- ESS5: Land Acquisition, Restrictions on Land Use and Involuntary Resettlement
- ESS6: Biodiversity Conservation and Sustainable Management of Living Natural Resources
- ESS7: Indigenous Peoples/Sub-Saharan African Historically Underserved Traditional Local Communities
- ESS8: Cultural Heritage
- ESS9: Financial Intermediaries
- ESS10: Stakeholder Engagement and Information Disclosure.

11.3 RESULTS

The key environmental and social considerations are outlined in Table 11.2. Considerations are aligned with World Bank ESS1 and ESS6 where relevant.[15]

TABLE 11.2 SUMMARY OF ENVIRONMENTAL AND SOCIAL CONSIDERATIONS

Consideration	Category	Rating	Definition and potential OSW impact
A. Protected Areas and Key Biodiversity Areas	Environmental	A	Environmentally-designated sites of regional, national, and international significance. 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.
B. Important natural habitats	Environmental	A	Coastal habitats such as seagrass beds, intertidal areas, mud volcanos, and sand dunes. Construction in coastal areas and marine ecosystems can lead to biodiversity disturbance and possibility of local increased erosion caused by scour 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.

Consideration	Category	Rating	Definition and potential OSW impact
C. Sensitive marine species	Environmental	A	Caspian seals, endemic fish and mollusk species and other species sensitive to survey, construction and operational activities. Noise, acoustic vibration, and light produced during OSW construction and noise, vibration and electro-magnetic emissions produced in operations 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.
D. Birds and bats	Environmental	R	Habitats for resident and migratory bird species, particularly water bird wintering grounds which support internationally important populations of threatened species. OSW poses risk of injury or death from turbine collision, habitat displacement, disruption of feeding grounds, and changes in breeding patterns.
E. Oil and gas operations	Social	R	Oil and gas fields, supply lines, port facilities, and pipelines. OSW construction, operations and infrastructure could interfere with oil and gas operations.
F. Energy and communication infrastructure	Social	A	Subsea power cables, communications, internet. OSW construction, operations, and infrastructure could interfere with energy and communications operations.
G. Commercial fishing grounds and artisanal fisheries	Social	A	Areas used for fishing. 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.
H. Landscape, seascape	Social	A	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.
I. Historical and cultural heritage	Social	A	Little information about confirmed presence of historical or cultural heritage, however its potential presence cannot be ruled out. OSW construction can pose risks to potential offshore artifacts that may have cultural or tourist value. Visual considerations are also relevant.
J. Tourism activities	Social	A	There is potential for OSW turbines to be visible from tourism hotspots onshore. Construction activities can cause disruption. Visual considerations are also relevant. Early OSW projects can create new local tourism opportunities.

Consideration	Category	Rating	Definition and potential OSW impact
K. Ships and navigation routes*	Technical	R	Shipping routes, anchoring areas, and transshipment area, particularly in areas around the Absheron peninsula. 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.
L. 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). Firing ranges can also include unexploded ordnance (UXO) which can impact OSW activities.
M. 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.

Note: Constraints marked * are not considered to be environmental or social considerations according to World Bank ESS definitions but are included here as technical constraints that will need to be addressed in project development.

A. Protected Areas and Key Biodiversity Areas

There are several designated areas with marine components in Azerbaijan, but none of them are likely to be of interest to OSW developers, as they are located away from OSW development zones. For future wind development, the areas that might have considerations are located in the districts of Azizbeyov, Salyan, and Lankaran.

The designated sites are:

- Ecologically or biologically significant areas (EBSAs);
- Key biodiversity areas (KBAs);
- Legally protected areas (LPAs);
- Marine national parks;
- National parks;
- Ramsar protected wetlands; and
- State nature sanctuaries.

Many of these designations overlap, especially between LPAs and national parks.

While there are no designated UNESCO Natural nor World Heritage Sites (WHS) in Azerbaijan with a coastal or marine component currently, any sites designated in the future could potentially impact OSW development.

Legally protected areas

The Law of the Republic of Azerbaijan on Specially Protected Natural Territories and Objects determines the legal basis for protected natural areas in Azerbaijan, which comprise 10% of the total area of the country.

There are four LPAs in Azerbaijan with marine components:

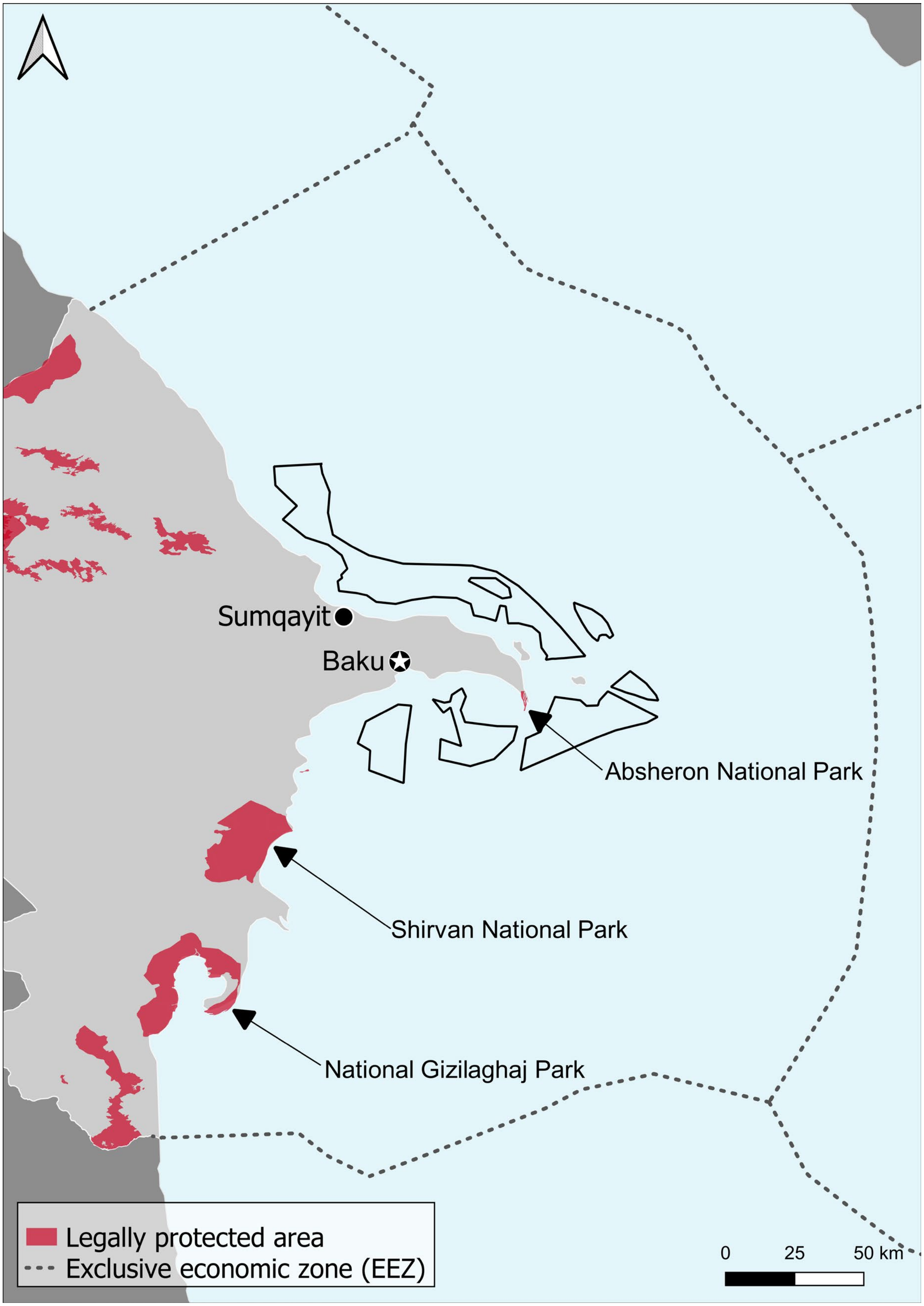
- Absheron National Park
- Baku and Absheron Peninsula Mud Volcano Group State Nature Sanctuary
- Gil Island State Nature Sanctuary
- Gyzylagach Marine National Park, which is the only designated Marine national park.

It is unlikely that the development of OSW projects is compatible with the conservation objectives of the Gyzylagach Marine National Park and the Absheron National Park. This is also likely to be the case for the Ghizil-Agaj Ramsar site, which is a critical wetland site for wintering and breeding waterbird species, and largely overlaps with the Gyzylagach Marine National Park.

The State Nature Sanctuaries Gil Island and Baku and Absheron Peninsula Mud Volcano Group are likely to have considerations for OSW development as well.

These LPAs are considered as exclusions and fall outside of the OSW development zones identified in this Roadmap. Figure 11.1 shows the location of LPAs in Azerbaijan.

FIGURE 11.1 LEGALLY PROTECTED AREAS IN AZERBAIJAN



Key Biodiversity Areas

KBAs have been designated to cover the most important places in the world for species and their habitats. KBAs are identified using a global standard that includes criteria that were developed through a multi-stakeholder process.

Azerbaijan has 14 designated KBAs with marine components in the Caspian Sea.[xii] Four of these areas protect Caspian seals (*Pusa capsica*). These are Absheron Archipelago (north) and Pirallahi, Shahdidi Spit, Kura Delta, and Gyzylagach.

Twelve of the KBAs with marine components have also been identified as International Bird and Biodiversity Areas (IBA). These sites meet a specific set of international criteria in terms of character, habitat, or ornithological importance, and six of these IBAs benefit from the legal protection provided by the national protected area network of LPAs. While there are no marine IBAs in Azerbaijan, ten of the existing areas have marine components and need to be considered during OSW development.

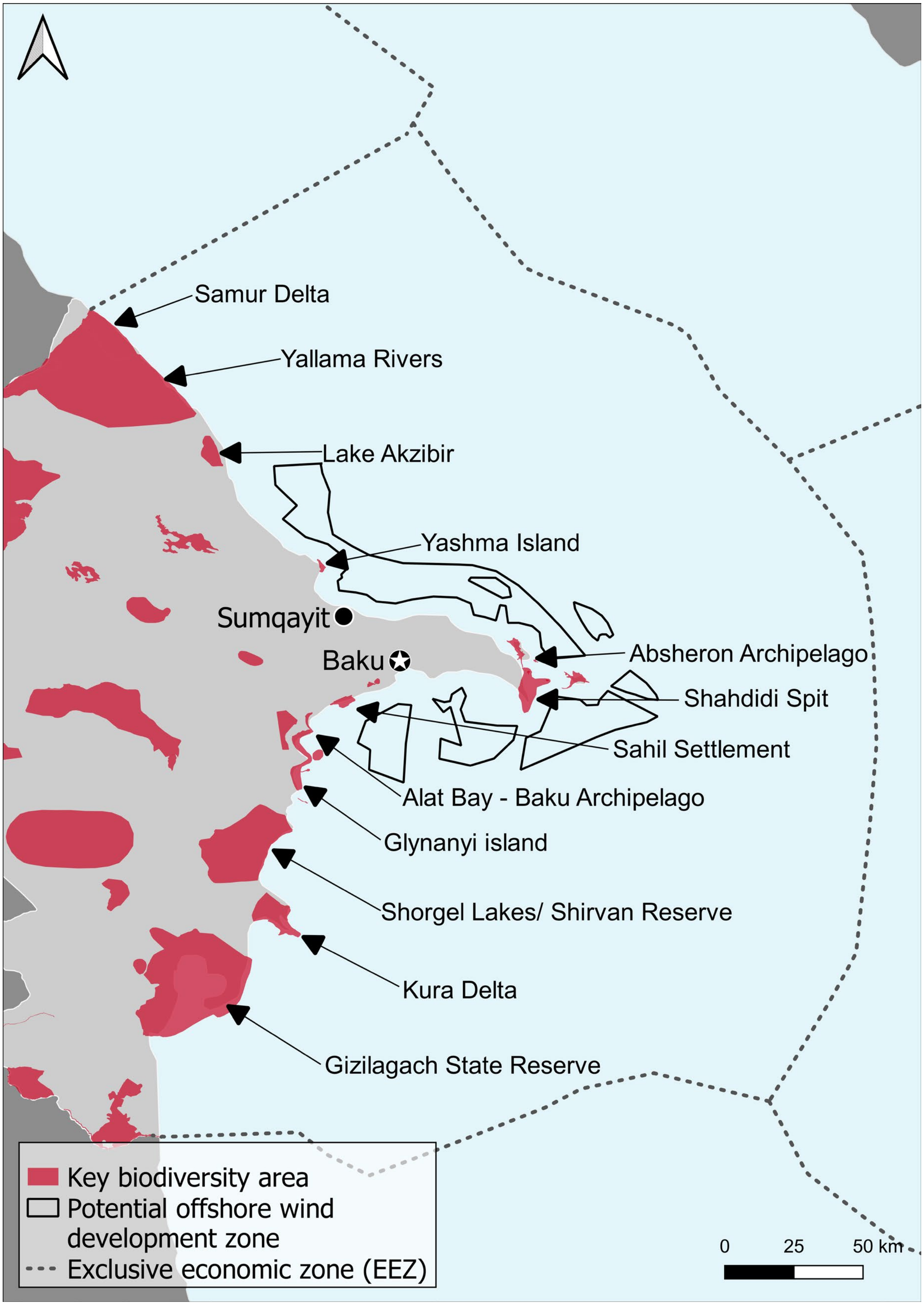
OSW development in KBAs should not proceed. Also, for OSW development zones near KBAs, it is important to consider further evaluation and to determine appropriate mitigating measures.

Several of the ports identified in Section 17 are located in or near KBAs or other risk areas. Care must therefore be taken when assessing any greenfield expansions needed for these ports.

All the KBAs mentioned are considered as exclusions. Figure 11.2 shows the location of KBAs in Azerbaijan.

xii Designated by the International Union for Conservation of Nature (IUCN), but not always designated under national legislation.

FIGURE 11.2 KEY BIODIVERSITY AREAS IN AZERBAIJAN



Ecologically or Biologically Significant Areas

EBSAs are discrete areas supporting the healthy functioning of oceans and the services that they provide.

There are three EBSAs of relevance to OSW development in Azerbaijan. These are the Ghizil-Agaj Bay Complex, Samur-Yallama, and Kura Delta. These areas were selected for their importance in supporting the health of the sea and providing ecological services. They include wetland areas used for wintering and breeding by waterbirds (Ghizil-Agaj Bay Complex); foraging, spawning, and reproduction areas for sturgeons (Kura Delta); and migrations corridors for both bird and fish species (Samur-Yallama).

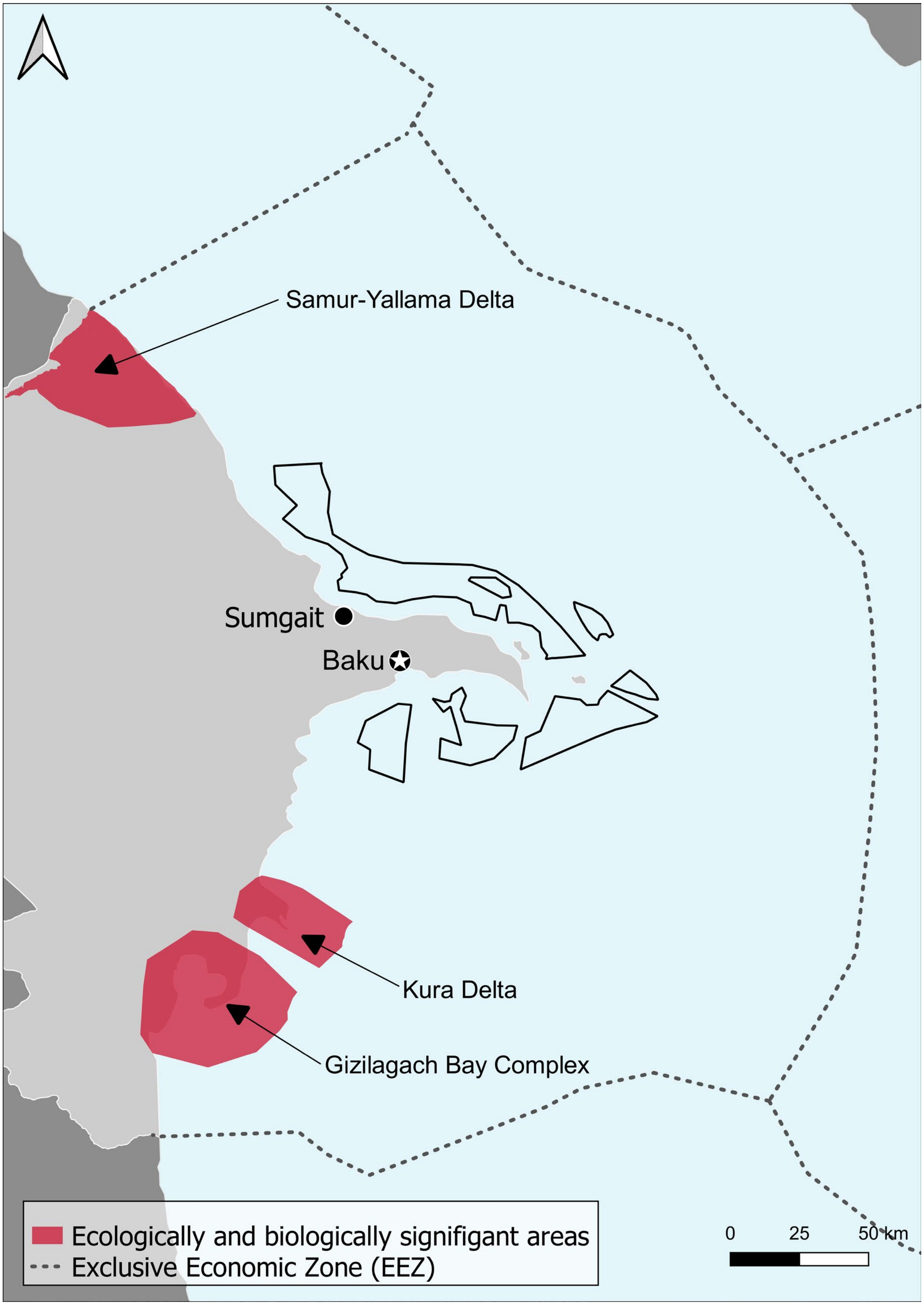
While the scientific criteria to identify EBSAs follows an international standard set by the Convention on Biological Diversity, the actual identification of EBSAs and the selection of conservation and management measures is a matter for individual states, and thus for Azerbaijan to determine. The international criteria to select EBSAs are:

- Uniqueness or rarity
- Special importance for life history stages of species
- Importance for threatened, endangered or declining species, and/or habitats
- Vulnerability, fragility, sensitivity, or slow recovery
- Biological productivity
- Biological diversity
- Naturalness

All EBSAs are considered as exclusions.

Figure 11.3 shows the location of EBSAs in Azerbaijan.

FIGURE 11.3 ECOLOGICALLY OR BIOLOGICALLY SIGNIFICANT AREAS IN AZERBAIJAN



B. Important natural habitats

There are at least four important natural marine and coastal habitats that are sensitive to impacts arising from developments such as OSW. These habitats include mud volcanos, seagrass beds, shifting sand dunes, and the intertidal areas at the Kura Delta. The latter supports internationally important populations of birds. The seagrass beds of Zostera *noltii* have only been recorded in notable size at Sangachal Bay, with much smaller seagrass patches at other locations. Additional surveys are required to identify the areas of important natural habitats in Azerbaijan.

The national legislation relevant for protected areas is the Law of the Republic of Azerbaijan on Specially Protected Natural Territories and Objects; and the Law of the Republic of Azerbaijan on Protection of the Environment № 678-IQ, June 1999.

Critical natural habitats are considered as exclusions where they are present within a protected area or a key biodiversity area. № spatial data defining important natural habitats is available.

C. Sensitive marine species (Priority diversity values)

Some marine species in Azerbaijan are sensitive to survey, construction, and operational activities. These species are, in general, those that are particularly sensitive to underwater noise, vibration, smothering, or loss of seabed habitat.

Marine mammals, such as seals, are particularly sensitive to underwater noise, such as piling noise during the wind farm construction phase. Noise from maintenance vessels and physical alteration of habitat can also impact seal populations.

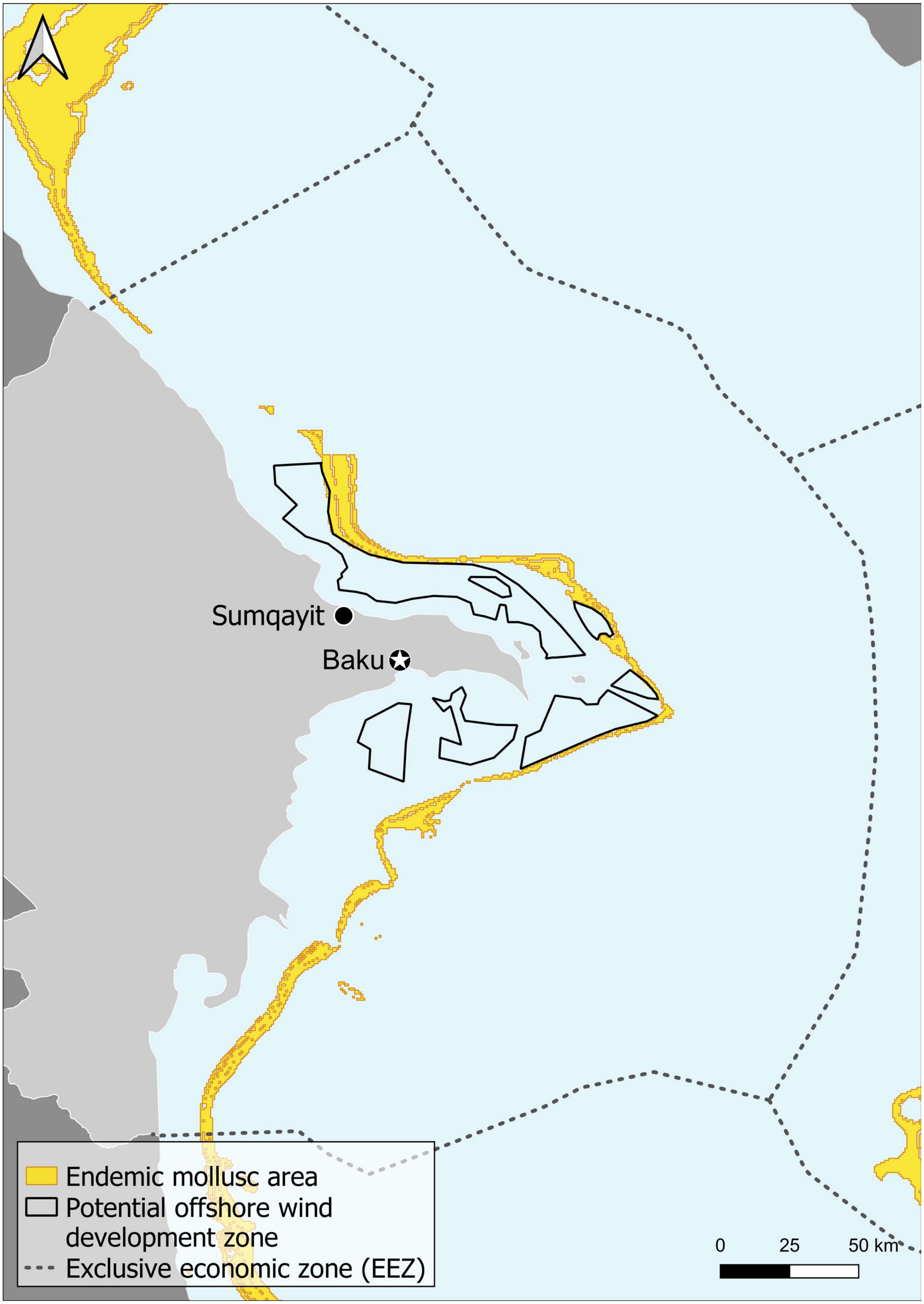
Both the anchovy sprat (*Clupeonella engrauliformis*) and southern Caspian sprat (*Clupeonella grimmi*) are Endangered species present in Azerbaijan. The critically endangered sturgeon species uses the Kura Delta and Gyzylagach Bay areas as important feeding grounds.

The national legislation relevant to sensitive marine species is the Law № 89-IIIQ On ratification of the Framework Convention for the Protection of the Marine Environment of the Caspian Sea, 4 April 2006.

Areas that have been identified as supporting the highest diversity of endemic mollusks are considered restrictions and require further survey and assessment to inform MSP, site selection and ESIA.

These are shown in Figure 11.4.

FIGURE 11.4 ENDEMIC MOLLUSK AREAS



D. Birds and bats

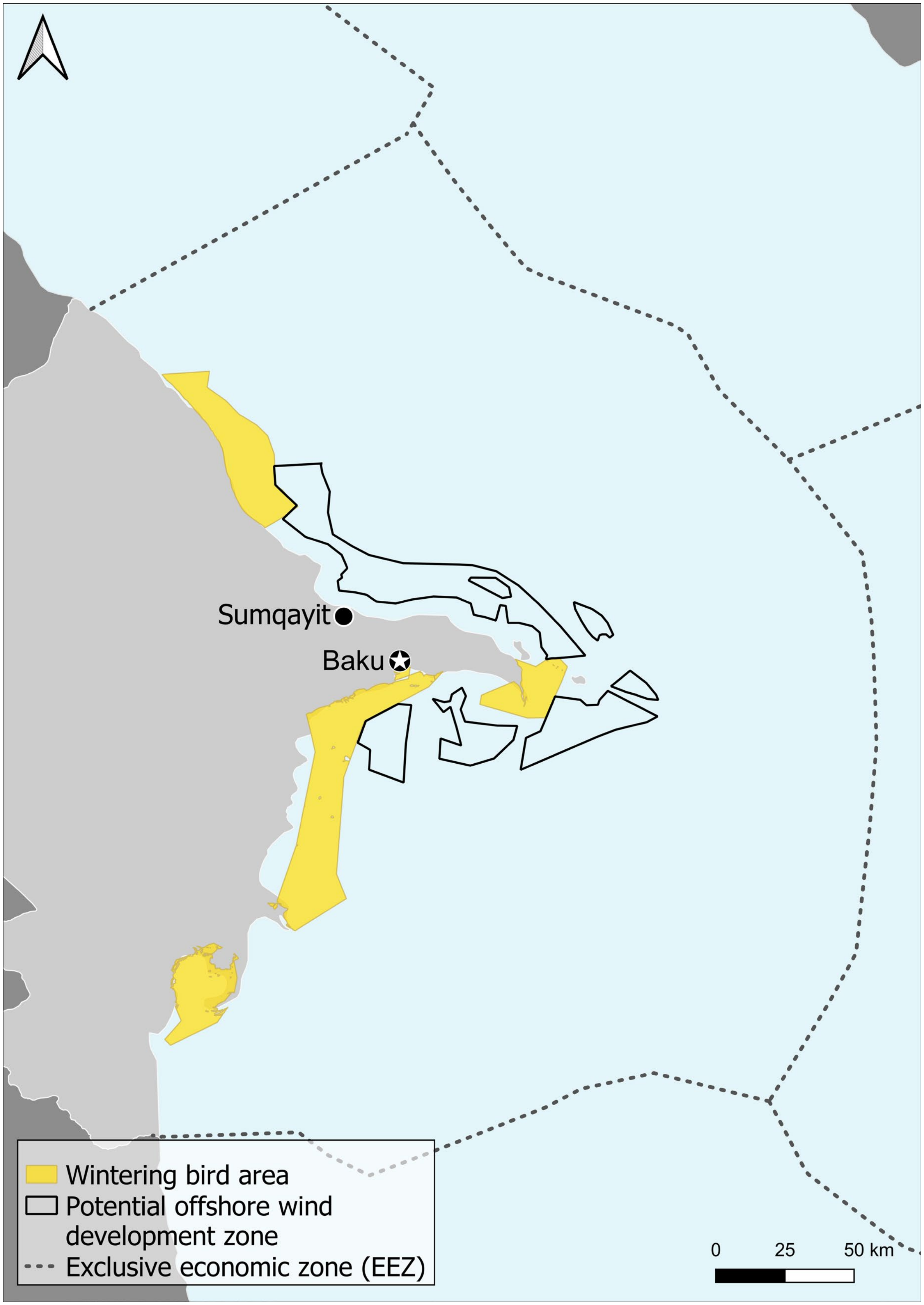
Many bird species use Azerbaijan as a stopping point or destination during seasonal migration. BirdLife international data records a total of 349 species of birds in Azerbaijan, of which 297 are migratory. Whilst the majority of these species are well represented, Azerbaijan does play host to a number of vulnerable, endangered, and critically endangered species such as the white-headed duck (*Oxyura leucocephala*), Siberian crane (*Leucogeranus leucogeranus*), and sociable lapwing (*Vanellus gregarious*).

While there are known to be caves in parts of Azerbaijan that support large colonies of up to several thousand bats, including endangered species of international significance, no information has been available regarding the locations of these key sites, migratory behavior, and the flight paths of the bats.

The national legislation relevant to migratory birds and bats is the Law of the Republic of Azerbaijan № 675-IQ "On Fauna".

There are four marine areas that have been identified as being important for congregatory water birds in the Azerbaijan EEZ that are considered restrictions. These are shown in Figure 11.5.

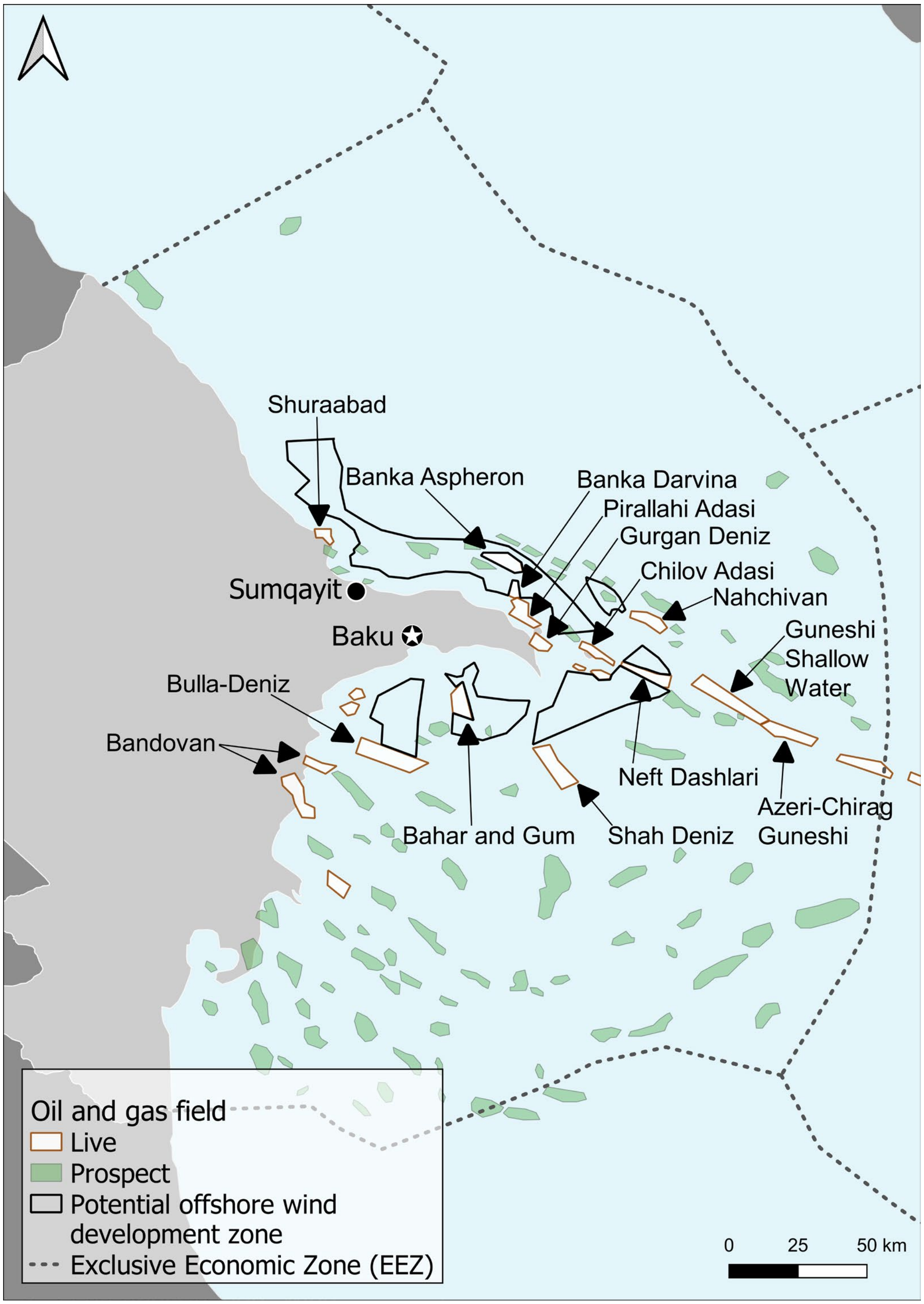
FIGURE 11.5 WINTERING BIRD AREAS



E. Oil and gas operations

Oil and gas fields are located in the east of Azerbaijan in both the nearshore and offshore areas and are connected by pipelines and supply routes to the mainland. Figure 11.6 shows the location of oil and gas fields in Azerbaijan.

FIGURE 11.6 OIL AND GAS FIELDS IN AZERBAIJAN



F. Energy and communication infrastructure

The existing energy and communication infrastructure in the Caspian Sea falls under the responsibility and management of the Ministry of Transport, Communications and High Technologies, and State Oil Company of the Azerbaijan Republic (SOCAR).

Options for Azerbaijan include exact identification of existing and proposed routes of subsea cable infrastructure and ensuring that consultation on their location and potential impacts is carried out early in the site identification and permitting process outlined in Section 13, while keeping the information confidential if there are concerns of potential cable theft (for metal resale, sabotage).

G. Commercial fishing grounds and artisanal fisheries

MENR manages fisheries and is responsible for enforcing fishing rules and addressing illegal fishing. The fisheries sector plays an important role within the national economy as a supplier of food, fodder (fish flour and oil, fish fodder for livestock, aga, various biologically active substances), and technical products.

Artisanal fishing uses low capital, conventional or low-technology fishing methods, and relatively small fishing boats for individual or local consumption.

Commercial fishing consists of medium to large-scale fishing activities for commercial profit.

All types of artisanal and commercial fishing practices from traditional techniques, pole and line fishing, gillnets, trawling, to purse seine fishing are likely to be constrained by the presence of OSW infrastructure sites.

The installation of foundations and cables can also temporarily increase suspended sediments in the water with negative impacts to both artisanal and commercial fisheries.

The part of the Caspian Sea under Azerbaijan authority remains productive and supports two main types of fishing techniques, using seine nets to catch kilka, and using trawl nets to catch other species. Devechi Port and Qizilagac Gulf in particular are of great importance for many commercial fish species.

Fishing is the basis for the economic development of many coastal areas of the country and includes a wide range of activities, from assessing the resources to trading of fish and fisheries products in the domestic and export markets. The fisheries sector encompasses more than 60 enterprises of different forms of ownership and these companies are important in terms of generating employment for the population, particularly in many coastal areas where fishing is the main source of livelihood for people.

The installation of foundations and cables can also temporarily increase suspended sediments in the water with negative impacts to both artisanal and commercial fisheries.

Options for Azerbaijan include site selection and consultation with fishers to avoid interference with the most important commercial fishing grounds and their biologically linked habitats (spawning, nursery areas), use of compensation schemes, and agreeing multi-use areas (for example, allow transit, use of certain gear).

Changes to fishing practices, stocks, and the physical environment (including climate change-driven changes such as temperature changes) can lead to the location of important fishing grounds changing over time, such that important commercial fishing grounds are not static and information regarding the location and importance of fishing areas needs to be continually reviewed.

The national legislation relevant to commercial fishing grounds is the Law № 243 On approval of the "Rules for fishing of fish and other aquatic bioresources", 27 June 2014.

H. Landscape and seascape

The character and features of a specific landscape or seascape may have a physical or aesthetic social value, which can be impacted by the presence of a wind farm. Azerbaijan has several designated sites located along its coast. The visual impact of a wind farm can be positive or negative for observers. Visual intrusion clearly is more important for nearshore developments.

In other jurisdictions, landscape and seascapes are often protected by legislation, and developers must follow official guidance on how the assessment of impacts from OSW farms should be carried out, often involving wide consultation and photomontage representations.

Options for Azerbaijan include mapping of protected landscapes, consultation with local communities, clarification of requirements and restrictions for placing of OSW farms within protected landscapes, and drafting of guidance and regulations for developers to consider landscape and seascape aspects within the environmental and social impact assessment (ESIA) process, including the preference of local communities for wind farm siting.

The national legislation relevant to landscape and seascape is the Law № 166-IVQ 24 June 2011 on ratification of the European Landscape Convention.

I. Historical and cultural heritage

While it is understood that all of Azerbaijan's designated sites of historical and cultural value are located inland and would not be directly affected by OSW developments, it is likely that there are other features which, while not designated, represent historic and cultural heritage. For example, Azerbaijan is known to have a number of shipwrecks. Other examples include sunken aircrafts, which could have cultural and social significance, or vessels and planes which may have been sunk deliberately for diving and tourism purposes.

International experience shows a high degree of protection for underwater archaeology and historical settings (for example, coastal forts), and developers avoiding proximity to these sites. This could include the area of the Boyuk Zira Lighthouse on the historical site of Nargin Island. Pre-installation, developers consult archaeological records and make use of the geophysical surveys carried out to assess the seabed suitability for turbines and to identify potential wreck sites, which could require a site-specific aquatic survey, for example more detailed geophysical surveys or dives.

Options for Azerbaijan include early identification of wrecks and important underwater heritage sites to map them and avoid conflict with offshore developments, and early engagement with stakeholders to understand potential presence of local cultural practices or areas of importance. Opportunities for mitigation, replacement of lost or damaged heritage are limited — once sites are lost, they cannot recover (unlike some ecological areas).

The national legislation relevant to historical and cultural heritage is the Law of the Republic of Azerbaijan About culture № 506-IVQ, 21 December 2012. The State Service for Protection, Development and Restoration of Cultural Heritage under MCT is responsible for managing the historical and cultural heritage, but no permit is required from this Ministry for energy development.

J. Tourism activities

International experience suggests that OSW developers avoid areas with important tourism activities as they are often site-specific and provide numerous jobs (adding economic and social value). The coastal tourism hot spots in Azerbaijan include Baku, Nargin Island, Absheron National Park, and Astara. The development of OSW is likely to have different effects on tourism at each site, as these sites attract visitors for different reasons, such as city tourism, cultural heritage, nature observation, and coastal resorts respectively.

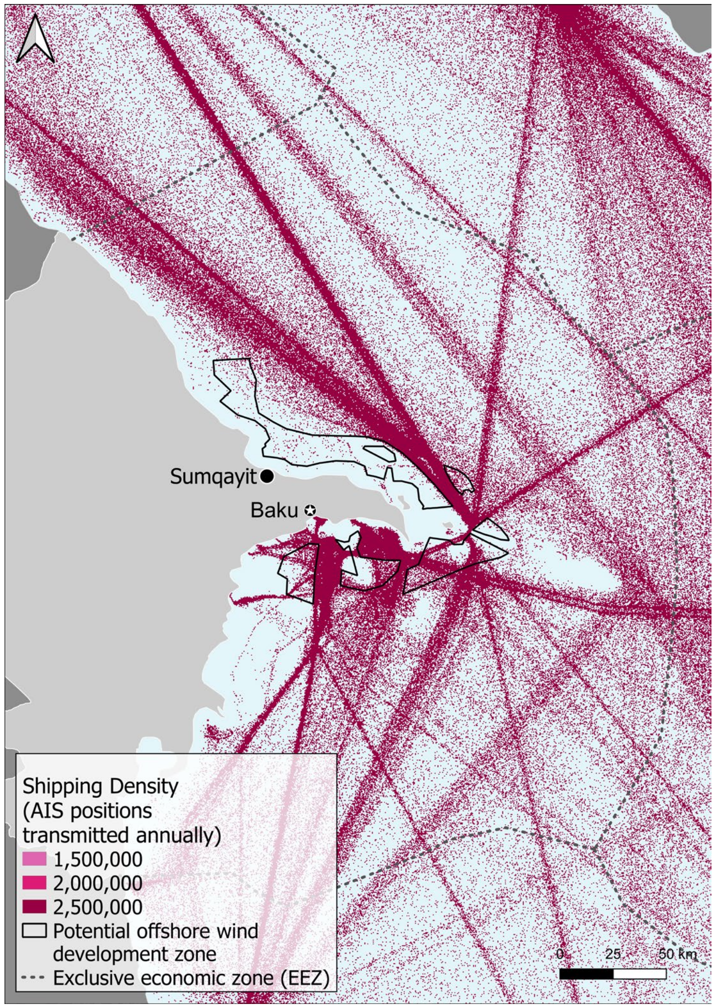
Options for Azerbaijan include the siting of sites away from tourism hot spots of Nargin Island, Absheron National Park, and Astara. Consultation with the public to develop the siting of OSW farms as a tourism attraction may also be possible.

The national legislation relevant to tourism activities is the Law of the Republic of Azerbaijan About Tourism № 674-IQ, 4 June 1999.

K. Ships and navigation routes

OSW development near ports and shipping routes creates risk of collision. exclusion zones and minimum safety zones are required during construction and operational stages. The State Maritime Agency of Azerbaijan is responsible for shipping and maritime transport. See Section 17 for more information on ports to support OSW. Figure 11.7 shows the shipping densities in Azerbaijan.

FIGURE 11.7 AREAS OF HIGH SHIPPING DENSITIES



Shipping routes are important to consider when siting OSW projects. Larger vessels, in particular, cannot pass through an OSW farm and would need to chart a course around projects. Smaller vessels may be able to transit through a wind farm but there is a risk of collision with the offshore structures. A navigational risk assessment needs to be carried out when planning a project and, in general, major shipping routes should be avoided.

High density shipping routes are considered restrictions and have been excluded. Ports are not considered as exclusions, but a 10km from shore exclusion zone has been added to address visual impact.

International experience varies, with some countries declaring wind farm exclusion zones (for example Belgium and Germany) while others are open to transit (for example the UK and Denmark). Where possible, all countries will try to place developments away from major shipping routes and declare minimum safety zones (which may differ between the construction and operation phases) because of the risk of accidents and potential human casualties and environmental damage.[xiii]

The national legislation relevant to ships and navigation routes is the Law of the Republic of Azerbaijan — Merchant Shipping Code № 146-IIQ, 22 June 2001.

xiii Distance from turbines to shipping routes varies from less than 0.5nm (intolerable) to more than 3.5nm (broadly acceptable).

L. Military exercise areas

Military activities, such as vessel maneuvering exercises, firing practice, low-fly training, and testing of ammunition and other technologies are in most cases not compatible with OSW farms and pose a hard constraint.

Consulting with the military early is key to managing this consideration. This is likely to lead to a mix of exclusions and restrictions, though sensitivities may mean that such information is not released to project developers and barriers to development are only found during the permitting process.

In other jurisdictions the military has established exclusion zones, site-specific restrictions, and no-restriction zones for OSW development. Some temporal activities like the export cable installation or survey work are often allowed after consultation with the military. No consent is specifically required during the permitting process but based on international experience it would be highly unusual if the military was not consulted or did not have a strong influence over the location of OSW developments. Particularly at the start of OSW development industry, the military may be very cautious about the siting of OSW farms close to important military areas such as radar facilities and air traffic control where turbines can cause interference.

Options for Azerbaijan include early liaison with the military to determine exclusion zones and development restrictions and avoid spatial conflict with OSW development. A more localized assessment could lead to mitigation measures regarding layout design or location of wind farms which could allow some military activities to continue unimpeded (patrolling, transport, training).

M. Aviation

OSW turbines pose a risk to the aviation sector, by way of physical obstruction, radar interference, and potential negative effects on the performance of communication and navigation systems.[16] In this context, areas around air traffic control centers (radars), airports, aerodromes, and air traffic zones can pose soft or hard constraints for developers.

Numerous aviation related sites exist in Azerbaijan, a number of which are sited near the coast. These could be constraints for OSW development.

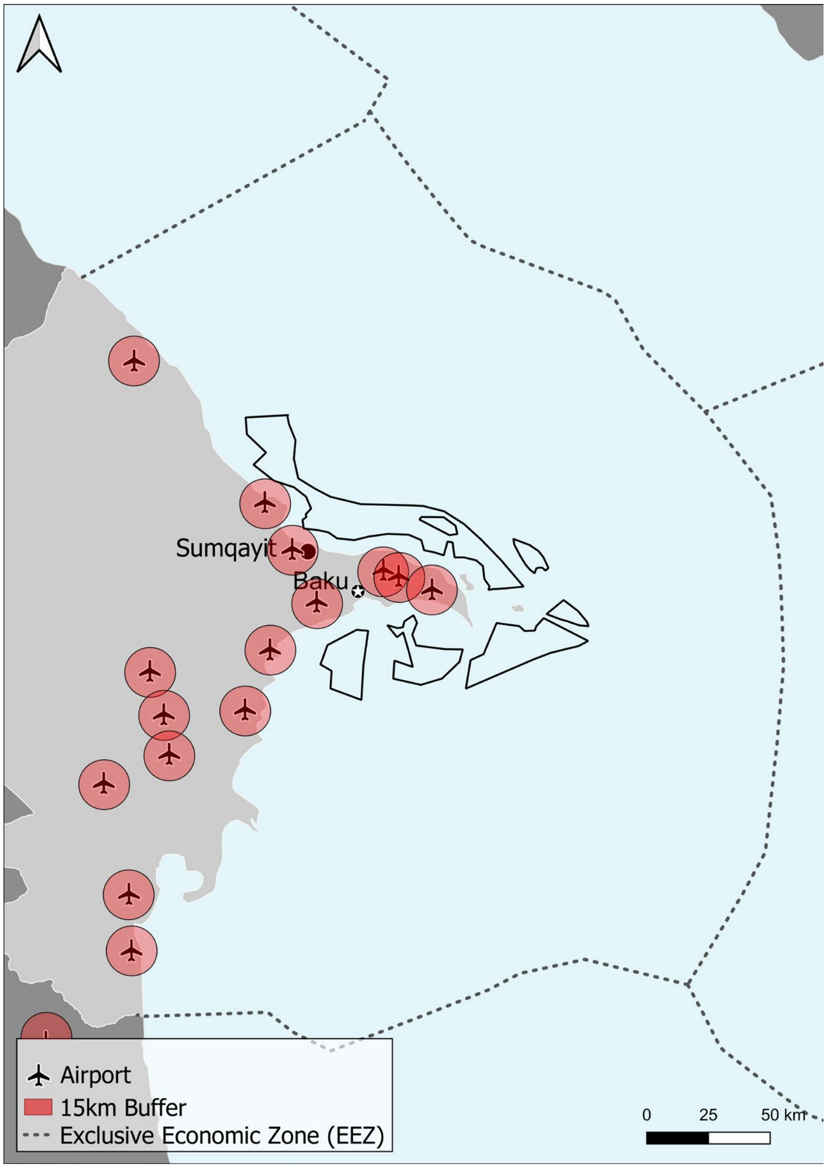
The State Civil Aviation Agency regulates civil aviation, and it is responsible for developing plans, programs, regulations, and standards, and provide flight management and aviation safety. It also manages several airports and aviation support infrastructure. It is a legal requirement to consult them.

The national legislation relevant to aviation is the Law of the Republic of Azerbaijan About Aviation № 944-IIQ, 24 June 2005.

At this preliminary stage, aviation considerations have been considered, but not modelled as restrictions or exclusions.

Figure 11.8 shows the airports in Azerbaijan.

FIGURE 11.8 AIRPORTS IN AZERBAIJAN, WITH 15KM BUFFER



Comparison with WBG ESIA requirements

Azerbaijan basis

There are two main laws relating to national ESIA requirements:

- The Law on the Protection of the Environment of June 8th, 1999 establishes the main environmental protection principles and the rights and obligations of the state, public associations, and citizens regarding environmental protection.
- The Law on Environmental Impact Assessment of June 12, 2018 sets out the legal basis for the environmental impact assessment mechanism to prevent or reduce negative impacts on environment and public health.

The Law on Environmental Impact Assessment provides the following principles for ESIAs:

- An integrated environmental, social, and economic assessment of the impact of the proposed activity on the environment and human health
- Ensuring the integrity, transparency, and reliability of information about the environmental safety of the proposed activity
- The preservation of ecological balance and biodiversity
- Not to exceed the impacts of the proposed activity on the environment to acceptable standards
- Forecasting of possible environmental consequences and assessment of the level of environmental risks
- Ensuring transparency in the EIA
- Informing the public and considering public opinion.

Under the EU-Azerbaijan Partnership and Cooperation Agreement (PCA) and the European Neighbourhood Policy (ENP), Azerbaijan has a commitment to support legislative reform in the environmental sector, including aligning Azerbaijan's environmental legislation and standards with those of the EU.

MENR worked with the European Union and United Nations Economic Commission for Europe (UNECE) to develop a national environmental assessment system in line with the Convention on the Environmental Impact Assessment in the Transboundary Context (ESPOO), which led to the Law on Environmental Impact Assessment being submitted to Parliament.

World Bank Group basis

The World Bank Group (WBG) ESIA process is driven by the ten ESS for projects seeking bank investment financing, as listed in Section 11.2. Specific guidance for wind energy projects is provided in the Environmental, Health, and Safety Guidelines (EHSG) for Wind Energy, published by WBG.[17]

WBG requires stringent implementation of all ESS to ensure that projects are environmentally and socially sound and sustainable, and to address potential risks and impacts.

Comparison

The relevant laws in Azerbaijan are based on local standards while the WBG ESS and EHSG follows Good International Industry Practice, with prevention measures and best practices specific for wind energy projects.

In a high-level consideration of WBG and Azerbaijan requirements, there is a commonality with respect to the environmental components to be assessed such as socio-economic impacts, visual impacts, biodiversity, land use restrictions, ecologically sensitive areas, public health, noise, air, and water quality.

The Azerbaijani law on environmental impact assessment does not address specific requirements for the scoping, surveying, or assessment of environmental and social impacts from wind energy projects.

Other relevant differences include WBG specifically referring to aviation impacts, construction noise, assessment of cumulative impacts, and operational phase biodiversity monitoring for OSW energy projects.

In terms of social aspects, there is a significant difference between the two requirements. WBG requirements refer specifically to economic development, poverty reduction, gender inclusion, and vulnerable groups.

11.4 DISCUSSION

The environmental and social considerations for the development of OSW are different to those for developing onshore wind in terms of receptors which include fisherfolk, shipping, and other sea users, but the concept and process of ESIA is similar. Similarly, MENR will have some familiarity from onshore wind but will likely need upskilling in the technical capacity and knowledge to assess specific OSW offshore aspects. The historically large offshore oil and gas industry in Azerbaijan means that offshore developments and their potential environmental and social impacts are familiar to the Government and its agencies.

A potential constraint slowing development of OSW could be lack of environmental and social data relating to the marine environment, including the location of shipwrecks or species migration routes. Lack of data can make it difficult for Government and OSW developers to consider all the environmental and social elements and engage with relevant stakeholders.

Transparency in the ESIA engagement process, the acquisition and publication of environmental data, accompanied by the building of technical capacity in the relevant government institutions where this is necessary, such as within the MENR, are critical to the successful development of OSW in Azerbaijan.

The identified potential OSW development sites are outside the identified exclusions and restrictions zone, however robust baseline surveys and ESIA completed to GIIP are still required, as well as relevant mitigation. The main concerns related to the sites are noise impacts from piling the monopile foundations, and migratory water birds. While the sites avoid the main wintering areas and coastal migration routes, it is likely that the areas have not been surveyed to date. Cable routes to shore from the sites may also have to go through either wintering bird areas or KBAs.

There are likely to be some gaps between local standards and practices related to ESIA compared to WBG requirements and GIIP. An absence of clear Government guidance and standards for ESIA aligned with GIIP and lender requirements, risks leading to:

- Adverse environmental and social impacts
- Delays to financing projects
- 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:

- MENR addresses any shortfalls in Azerbaijan ESIA requirements compared to those of International Finance Corporation (IFC), GIIP, and other lender standards.
- Ministry of Energy (MOE), in consultation with MENR and MCT, undertakes site screening and investigations of the potential OSW development zones to determine possible environmental and social constraints and hence level of suitability for further development of OSW as part of a wider OSW marine spatial planning activity, especially considering cumulative assessment. Stakeholder engagement is critical to understand perceptions and concerns and explore mitigation measures.
- MOE leads in helping government departments and other key stakeholders to grow capacity and knowledge needed to process a growing volume of OSW projects.

12 LEASING AND PERMITTING

12.1 PURPOSE

Balanced, transparent, and efficient processes for granting project leases and permits are required for Azerbaijan to deliver the volume of offshore wind (OSW) discussed in the two scenarios in Section 2.

In this work package, we examine how leasing and permitting of OSW is currently managed in Azerbaijan. We identify gaps that need to be addressed to ensure the processes are suitable for the expected increase in the volume of projects seeking permits and provide recommendations for improvement to underpin the development of a sustainable OSW industry in Azerbaijan. In Section 13 we cover the next stage for OSW projects, securing a revenue for energy produced.

12.2 METHOD

We have mapped out the current regulatory processes that apply when an OSW developer wishes to secure exclusive rights to explore, develop, and utilize OSW resources in area and all necessary permits, licenses, and clearances to allow construction and operation. We have done this based on our knowledge of the leasing and permitting processes in Azerbaijan. In Section 13 we discuss how the existing legislative framework can be used and adapted to allow OSW projects to secure a lease, permits, and power purchase agreement (PPA).

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

12.3 RESULTS

Key Legislation

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

- *Legislation of the Republic of Azerbaijan on the Use of Renewable Energy Sources in Electricity Generation.* Order of the President of the Azerbaijan Republic of October 21, 2004 № 462 "About approval of the state program on use alternative and renewable energy resources in the Azerbaijan Republic".
- *Constitution of the Republic of Azerbaijan Urban planning and construction code.* Urban Planning and Construction Council of the Republic of Azerbaijan.

- *The Law on Energy Resources Utilization*. Law of the Azerbaijan Republic of May 30, 1996 № 94-IG: About use of energy resources".
- *The Law on Renewable Energy*. Law of the Azerbaijan Republic of July 14, 2021 No 339-VIQ: About the use of renewable energy sources in the production of electricity".
- *The Law on Power Industry*. Law of the Azerbaijan Republic of April 3, 1998 № 459-IG: About power industry.
- *Law on Heat and Electric Power Plants*. Law of the Azerbaijan Republic of 28 December 1999 № 784-IQ: About power and heating stations.
- *Law on Efficient use of energy resources and energy efficiency*. Law of the Azerbaijan Republic of July 9, 2021 № 359-VIQD: About rational use of energy resources and energy efficiency.
- International agreements to which the Republic of Azerbaijan is a party.

The focus of most of these laws is predominantly on the oil and gas and conventional power industries, but they also apply to renewable energy, including onshore wind, solar, and OSW.

Resources

The Ministry of Energy (MOE) is responsible for overseeing energy policy and regulation, including renewable energy. It is responsible for the licensing of power generation, transmission, distribution, and sale, and for increasing energy efficiency and renewable energy use.

In addition to the MOE, there are several other agencies and state-owned companies that play a role in the production and management of electricity.

- Azerenerji is responsible for the generation and transmission of most of the electricity in the country, except a few small hydropower stations and wind farms operated by a few private companies.
- Azerbaijan Renewable Energy Agency (AREA) is an agency under the MOE responsible for the implementation of state policy and regulation regarding renewable energy resources.
- The Azerbaijan Energy Regulatory Agency (AERA) is a public legal entity established under the MOE. It regulates the utility sectors, including electricity, natural gas, and district heating.
- The State Oil Company of Azerbaijan Republic (SOCAR) is a wholly state-owned national oil and gas company, which has also installed onshore wind and solar PV in the Tagiyev oil and gas field and is considering the supply of renewable energy to its offshore facilities from floating OSW.

This list is not exhaustive, and several other Ministries are involved in the approvals process for OSW development, as described below.

Leasing: site identification and exclusivity

The law on the Use of Renewable Energy Sources in Electricity Generation requires the creation of an atlas of potential renewable energy projects. The MOE is responsible for the identification of locations where there is potential for renewable energy generation, including OSW. Information relating to each area must include:

- The project boundaries and a map;
- Renewable energy potential;
- Possibility of connecting to the grid; and
- Land ownership/lease rights and the agreement of those with ownership/use/lease rights for electricity generation.

Once locations have been identified, developers are identified for the sites by an auction process managed by MOE or by direct agreement with MOE, and a PPA is agreed with Azerenerji for the sale of the electricity. The process for the procurement of electricity is further discussed in Section 13.

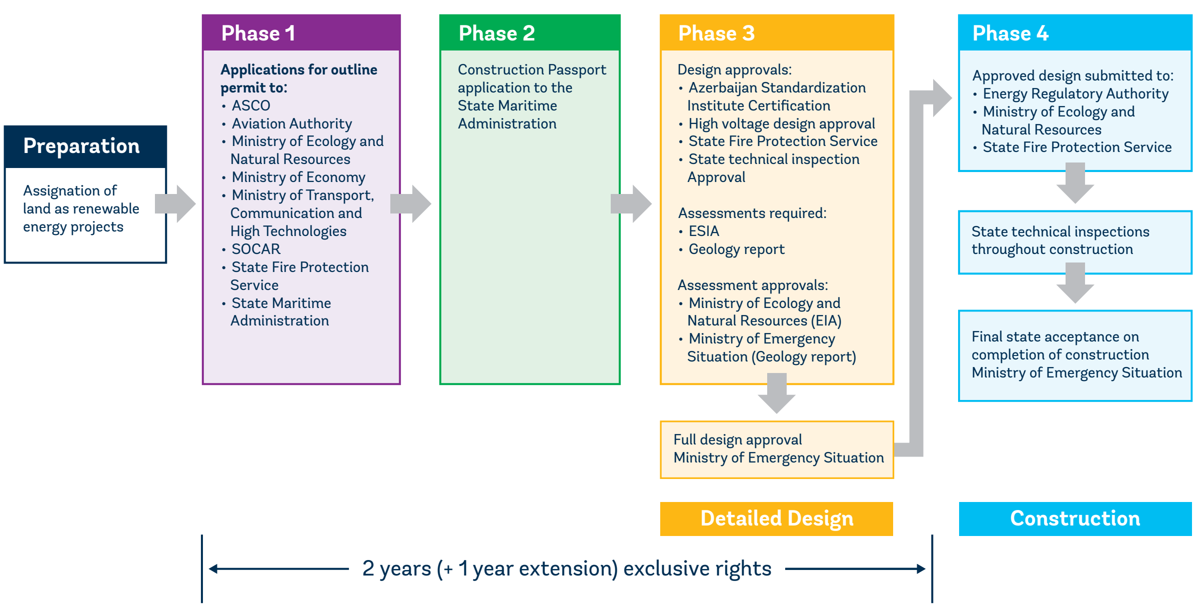
Permitting process

There is a four-phase process to secure the necessary permits to construct and operate a wind farm. This process is the same irrespective of the scale of the development proposed.

From the date of assignation of a location as a renewable energy project, two years are available to gain all the necessary approvals, during which no other developments are permitted on the site. This may be extended by up to one year if necessary.

Figure 12.1 shows the four phases of permitting.

FIGURE 12.1 THE PROCESS OF OBTAINING THE PERMITS TO CONSTRUCT AND OPERATE A WIND FARM IN AZERBAIJAN



Phase 1: 4 – 5 months

Applications are made to the following bodies to obtain their consent for the development:

- Aviation Authority
- Azerbaijan Caspian Shipping Company (ASCO)
- Ministry of Ecology and Natural Resources (MENR)
- Ministry of Economy
- Ministry of Transport, Communication and High Technologies
- SOCAR
- State Fire Protection Service
- State Maritime Administration (SMO).

Phase 2: 3 – 4 months

Once all consents have been received from the organizations listed in Phase 1, information must be submitted to the State Maritime Administration for a Construction Passport. The information needed for the application package includes:

- Cover letter
- Ownership documents
- Sketches and layout information
- The consents obtained during Phase 1.

Phase 3: Design – duration depends on the complexity of the project

This is the developer's detailed design phase. The following assessments and approvals need to be carried out and obtained in this phase:

- Environmental and Social Impact Assessment (ESIA) — submitted to MENR for approval
- Geology report — the developer must employ a licensed company to undertake geotechnical surveys to submit to the Ministry of Emergency Situations (MES) for approval
- Design approval from the State Fire Protection Service (for fire design elements)
- High voltage design approval
- State technical inspection approval
- Azerbaijan Standardization Institute Certification.

All of the above (except the Azerbaijan Standardization Institute Certification) must also be submitted to the MES for design approval.

Phase 4: Construction – duration depends on the complexity of the project

This phase occurs once all the approvals have been gained and is outside the 2+1 years approval timeframe.

The approved design must be submitted to the following Ministries and bodies:

- Energy Regulatory Authority
- State Fire Protection Service
- MENR.

State technical inspections is required of the construction, for example by the State Agency for Control over Construction Safety and the State Fire Protection Service.

Following construction, the final State Acceptance for the development must be obtained from the MES.

12.4 DISCUSSION

In the Government led process outlined in Section 13 we propose that a lease and preliminary permits are provided along with a PPA to developers successful in the procurement competition.

This means that MOE and other Government Ministries and agencies are responsible for Phases 1 and 2 in Figure 12.1, prior to competition. Following the competition and award, the developer is responsible for Phases 3 and 4.

The development of OSW in Azerbaijan is in its early stages, so there will be gaps in the understanding and familiarity with issues related specifically to OSW in the Ministries and other bodies responsible for granting leases and permits. If left unaddressed this gap in experience in dealing with OSW development and in considering specific technical and commercial matters will cause issues as the number and scale of developments ramp up. Further work will be required by Government to address these gaps, with the support of agencies and bodies with experience in other OSW markets.

As the current frameworks are not specific to OSW, it is likely that current standards for environmental and social impact assessments do not meet Good International Industry Practice for OSW development. Increased environmental and social risks and significant project delays can arise when GIIP/lender standards are not followed. Examples of differences are discussed in Section 11.

Currently, there is an expectation of a two to three-year process covering Phases 1 to 3. This is much shorter than seen as required in established OSW markets when engineering and environmental survey work, detailed design and assessment, engaging with all relevant stakeholders, securing a grid connection, gaining the required permissions to begin construction and gaining PPA often take up to 10 years. For example, in the UK, two years of monitoring data for birds is required by regulators to inform the ESIA for an OSW project.

It is suggested that from the point of award, a period of up to eight years is reasonable for developers to carry out remaining activities if initial work delivered by MOE is of a good standard and no new permitting issues arise.

12.5 RECOMMENDATIONS

Based on this analysis, it is recommended that:

- MOE considers streamlining the permitting process and improving coordination between different Ministries and other stakeholders from whom permissions are required whilst at the same time ensuring that permitting requirements including ESIA meet GIIP to help de-risk projects and facilitate access to international finance.
- MOE extends the period of designation for a renewable energy project from a maximum of three years to eight years to allow necessary OSW survey, design, and development processes to be completed.

Note that recommendations regarding improvements to the standards of environmental and social impact assessment and improving the capacity and capability of relevant departments and stakeholders have been provided in Section 11.

13 PROCUREMENT OF ENERGY

13.1 PURPOSE

Robust, transparent, and efficient processes for procurement of large volumes of energy are critical to deliver offshore wind (OSW) at the scale explored, especially in the high growth scenario.

In this work package, we examine how procurement of onshore renewables is currently managed in Azerbaijan and propose a solution for OSW. A key consideration here is developing a process that is sufficiently attractive to potential developers whilst also maintaining competitive tension that drives cost reduction and gets best value for Azerbaijan.

13.2 METHOD

Through engagement and literature review, we have summarized the existing processes, which are primarily designed for relatively small onshore wind and solar projects.

OSW projects are typically designed to operate for at least 25 years, with potential for most projects to be extended to 30 years or more with good management practices, these timescales increasing over time as technology matures. To recoup their investments, developers, lenders, and investors desire long-term visibility and certainty of the revenues a project will generate. Similar to other renewable energy projects, revenue certainty can be provided by long-term offtake agreements (power purchase agreements (PPAs)) and government mechanisms to provide revenue support.[xiv]

Through engagement with relevant stakeholders and a headline options analysis, we have proposed a solution for OSW that Government can consider as an option, based on consideration of:

- Continuity with existing arrangements, where possible, to minimize barriers to implementation
- Future proofing, so that any system does not need to be changed significantly in a few years, which risks delaying the industry and reducing confidence
- Ensuring projects awarded contracts are constructed promptly and competently
- Consumer value for money
- Robustness, transparency, and fairness
- Bankability for project developers

xiv Offtake agreements can take several forms, including Power Purchase Agreements (PPA), Feed-In Tariffs (FIT), Contracts for Difference (CFD), and bilateral agreements with corporate entities.

13.3 RESULTS

Renewable energy law

A new law governing renewable energy entitled *On the Use of Renewable Energy Sources in the Production of Electricity*, № 339-VIQ, dated 31 May 2021 was signed by the President of Azerbaijan in July 2021. A parallel Presidential Decree was issued on the implementation of the law. The renewable energy law (REL) sets out the broad framework of how renewable energy will be procured in Azerbaijan, including the assignation of land and the selection of investors.

Assignation of land

The Ministry of Energy (MOE) is responsible for identifying potential renewable energy projects, including areas of land and water (including offshore) with technical potential. The proposed areas will be subject to approval as renewable energy projects by the Cabinet of Ministers.

Once a location has been designated as a renewable energy project, no other form of development will be permitted at that location. The designation as a renewable energy project will last for a period of two years, within which time a construction permit (CP) must be secured. A maximum extension of one year may be granted.

Selection of investors and awards

The law allows for both competitive auctions and direct negotiations to be used to select investors for designated renewable energy projects. MOE is responsible for running competitive auctions, where investors will be selected on the lowest bid electricity price for a designated site. Successful bidders will be awarded a fixed tariff. The period of duration for the tariff is not defined.

Selection of investors by direct negotiation requires Presidential consent and can be used for pilot projects, projects of strategic national interest and importance to Azerbaijan, or where an auction process has been unsuccessful.

Awards from an auction or from negotiated procurement will include an investment agreement, a PPA and a grid connection agreement. Awarded power producers will enter into a land rights agreement for the designated renewable energy project. Renewable energy certificates will be issued to the power producer to enable traceability and power trading. Producers that enter into a grid connection agreement with the power utility will be granted priority in power distribution and transmission. Producers will be free from grid balancing responsibilities although the utility will retain the right to curtail generation in an emergency.

Existing renewable energy projects and recent competition

The existing renewable energy projects in Azerbaijan, including hydro schemes and small onshore wind and solar projects, have been developed by state utilities. The power purchase mechanisms were arranged within the utility, prior to the existence of the REL.

In early 2020, also prior to the implementation of the REL, two commercial PPAs were awarded to independent power producers for larger scale onshore wind and solar projects. These represent the first foreign investments in larger scale wind and solar projects in Azerbaijan. Interested parties were invited to present their credentials, track record and ability to finance the identified projects. Masdar and ACWA Power were selected from a short-list of interested parties and the PPA terms and conditions were agreed following a period of negotiation.

ACWA Power was awarded a 20 year PPA for a 240MW onshore wind project and Masdar of UAE was awarded a PPA for a 230MW solar energy project. The counter-party for both PPAs was Azerenerji. Both projects will be developed on a build, own, and operate (BOO) model. The awarded tariffs have not been made public.

13.4 DISCUSSION

Proposed process for offshore wind

The proposed process is designed to fit within the REL and the description is based on the high growth scenario. It is presented here as an option for Government to consider. Government should consider retaining the support of specialist transaction advisers to conduct further detailed study and design a procurement framework that meets the needs of Government, stakeholders, developers, and investors.

The same process would be followed for the low growth scenario, but with a single award of the full 1.5GW of capacity to one developer.

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. Including the merits of one-competition and two-competition models according to specific market circumstances.[2]

Combining the learning from this document with a headline options analysis, it is concluded that Government should consider adopting a variant of the one-competition system involving a competitive process between developers of projects soon before reaching final investment decision (FID).

A one-competition process is best suited to the nature of the market in Azerbaijan, where the size of the opportunity is limited compared to other markets, the Government is motivated to drive a decisive energy strategy and is used to playing a hands-on role.

Adoption of a one-competition process, where projects are planned and de-risked by Government upfront, is more likely to strike the balance between attracting developer interest and creating the competitive tension required to drive cost reduction in Azerbaijan.

Multiple competition processes are more viable and often preferred in more accessible markets with higher levels of potential offshore wind capacity and greater electricity demand, where a larger pipeline of diverse projects is required and the market is best placed to progress the most suitable projects at any given time.

Government should consider using pre-qualification and competitive bidding to select a limited number of developers under the high growth scenario. If there are too many developers then the market share would be too small to attract interest, and too few would inhibit competitive tension and cost reduction drivers.

Pre-qualification of developers should be used to secure the participation of organizations with proven experience and capability in developing and building offshore projects in other markets and working in the Caspian Sea environment. It is unlikely that state-owned entities or local independent power producers will therefore be able to pre-qualify on their own, although the opportunity exists for them to form consortia with more experienced OSW players from outside of Azerbaijan.

Government should consider the following process:

- MOE identifies and designates prospective project locations as renewable energy projects in line with REL using a proportionate marine spatial planning (MSP) process and following Good International Industry Practice, including relating to stakeholder engagement.
- MOE commissions, covering the first 5.18GW of capacity:
    - A preliminary front end engineering and design (pre-FEED) study
    - A robust environmental and social impact assessment, again following GIIP and including consideration of cumulative impact of multiple projects
    - A grid connection options assessment and power systems study.
- MOE undertakes preliminary survey work (including wind resource and preliminary geophysical) and project permitting to minimize remaining project developer risk.
- MOE collates a detailed dossier of all relevant documentation, then invites expressions of interest and undertakes prequalification for development of the full pipeline of 7.2GW of capacity (which could be extended further in time):
    - In two initial lots at a first auction, each of about 2.5GW (potentially both having a pathfinder project plus two large projects), with each developer only allowed to bid for one lot.
    - With at least a further 2GW to be contracted through a second auction, about 3 years later, after the first pathfinder project is installed, open only to the successful bidders from the two initial lots.
    - Pre-qualification will be assessed on general experience, capability, and financial capacity statements.
    - Qualified bidders then provide prices for one or both lots. Government has the option to request separate bid prices for each constituent project within a lot, in the interests of understanding LCOE reduction over time, with the overarching single effective bid price being calculated by way of an agreed formula. In established offshore wind markets, the duration of a power purchase contract offered through a competitive auction is often for less than the lifetime of the project. For example, in the UK, the Contracts for Difference (CfD)[18] mechanism provides price certainty for a period of 15 years. This is done to align the period in which CfD payments will apply to the typical debt term of a project finance arrangement. Under these arrangements, where the contract term is less than the project lifetime, the price paid for the electricity will typically be higher than the LCOE for the project, recognizing the uncertainty of electricity price after this.
    - Bidders will also provide detailed project specific capability, delivery, and financial capacity statements, and commitments to supply chain and innovation.
    - Minimum pass/fail hurdles will be imposed on capability, delivery, financial capacity, supply chain, and innovation; with the winners being assessed and selected on bid price alone. No tariff

cap or price guidance will be set for the initial auction, but a cap for the second auction can be imposed to ensure the levelized cost of energy (LOCE) is driven down. Bid prices can be expected to decrease over time.
- In addition to submitting bids for electricity production, developers will be given the option to submit proposals for hydrogen production, using output from the OSW projects and elsewhere.

- MOE negotiates and finalizes arrangements with the selected developers and Azerenerji offers a PPA (and optional hydrogen purchase agreement) based on standardized terms that meet the needs of developers and lending institutions, including curtailment arrangements, as well as meeting the needs of Azerenerji in terms of risk sharing.

The precise details of the procurement process should be drafted by MOE with the support of a specialist transaction advisor and agreed with industry, to ensure that all key considerations are met, all advantages and disadvantages are considered, and equitable compromises found, where needed.

An overview of the proposed process is shown in Figure 5.2. A key element in designing the process will be striking the balance between maintaining competitive tension between bidders whilst also providing enough market certainty that developers are willing to invest and engage. Consideration should be given to whether the successful bidders are encouraged to develop their projects in parallel or offset in time from each other.

Many of the principles of the existing REL can be used, but due to the investment and infrastructure needed to deliver OSW, and the long-term benefits available, it is not feasible for OSW to enter auctions against small volumes of onshore wind and solar.

13.5 RECOMMENDATIONS

Based on this analysis, it is recommended that:

- MOE accelerates the identification and designation of OSW projects, taking advice on good practice and lessons learned from Governments that have implemented Government-led OSW procurement processes.
- MOE undertakes up front project surveys and pre-FEED work required to establish a project pipeline that will be subject to competitive bids.
- MOE establishes a single competition solution solely for OSW, combining leasing, grid connection, and PPA.
- MOE sets out a clear timetable for work to deliver this solution, including dates of private-sector competitions, and keeps all stakeholders well informed of timing and locations of activities, coordinating across Government and private sector to deliver.

14 RISK AND BANKABILITY

14.1 PURPOSE

The purpose of this work package is to define project and market elements which impact the bankability of offshore wind (OSW) projects in Azerbaijan. 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 primarily considered 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. Risks to the Government are covered in the SWOT analyses in Sections 3 and 4. Broader financial market risks are addressed in Section 18.

14.2 METHOD

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

We therefore reviewed key aspects of the emerging renewable energy market in Azerbaijan and considered current trends, such as the implementation of the 2021 renewable energy law and identified the risks that projects developed under it may experience. We engaged with independent power producers that have negotiated power purchase agreements (PPAs) in Azerbaijan and also 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 or skills level of local labor force for OSW.

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 these risks. 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.

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, we have suggested changes.

Each of the risks identified has been assigned a risk magnitude based on the following scale:

(R) Red	Significant financial risk to investors that is likely to stop investment happening, requiring mitigation from the Government.
(A) Amber	Moderate financial risk to investors that will have significant cost or contractual implications and may need mitigation from the Government.
(G) Green	Low-level financial risk not likely to stop investment, the Government may consider mitigation.

14.3 RESULTS

The main financial risks for OSW in Azerbaijan are summarized in Table 14.1 and then discussed, alongside possible mitigations for the Government to consider.

TABLE 14.1 INVESTMENT RISKS

Risk	Description	Project phase	Risk magnitude RAG	Suggested Government mitigation / measures
1. Auction risks	Design and survey data generated by the Government is inadequate or in error, leading to delays and/or cost increases.	Project development	R	Ensure that data is collected to good industry practice standard. Extend the period of designation for a renewable energy location from a maximum of 3 years to a minimum of 6 years to allow developers to complete remaining survey, design, and development processes.
2. Development risks	Developer faces delays in obtaining final permits for projects due to inadequate pre-permitting work.	Project development	R	Undertaking proportionate marine spatial planning and thorough pre-development work following Good International Industry Practice, including consultation with all relevant Ministries and consultees, to substantially de-risk projects prior to offering to developers.
3. Environmental and social risks	Potential environmental and social risks leading to permitting challenges, non-alignment and construction delays.	Project development / Construction	R	Need to take account of stakeholder views, follow GIIP, and understand the environmental and social impacts during development, construction, and operational phases of projects.

Risk	Description	Project phase	Risk magnitude RAG	Suggested Government mitigation / measures
4. Grid connection risks	A mismatch between the timing for Azerenerji to construct and deliver the required grid infrastructure and the OSW developer's project timetable could lead to delay in grid connection being available.	Construction	R	Implement compensation guarantees in favor of developers for delayed grid connection availability.
5. Curtailment risks	Limitations in interconnection and grid management could result in the curtailment of wind power and impact project revenues.	Operation	R	Curtailment compensation (beyond a certain threshold). More coordinated national planning for renewable generation capacity and grid capacity to enhance certainty of offtake. Prioritization of upgrades to system capability to manage high volumes of variable renewables.
6. Counterparty risks	Creditworthiness of Azerenerji as the sole off-taker could cause investment risks as they do not have a long track record as high volume off-take from independently owned power plants.	Operation	A	Explore arrangements for Government to backstop Azerenerji's off-taker obligations for multiple GW-scale projects. Government should confirm its ongoing guarantee of Azerenerji as the PPA off-taker.
7. Policy / regulatory risks	The procurement process could encourage developers to propose unsustainable tariffs.	Development	A	Establishing a floor on pricing or requirement that bidders submit evidence of lender endorsement of proposed price may help alleviate this risk.
8. Contractual risks	Lack of a local and widely employed standardized PPA that is financeable for OSW could lead to challenges in securing project finance.	Operation	A	Develop a standard form PPA that recognizes the financing requirement of OSW.
9. Exchange rate risks	Adverse movements in Manat (AZN) relative to hard currencies including USD could lead to reduced foreign investor appetite.	Operation	A	For foreign investors, long-term exposure to adverse movements in local currency can be managed by including tariff indexation for foreign exchange rate variations into standard form PPAs.
10. Country risks	Local conditions stemming from Azerbaijan's political, economic, and legal framework could impact the stability of earnings.	Project lifecycle	A	Enforceability of contracts, both with government and suppliers, is key. Ongoing guarantee of Azerenerji's liquidity can help manage this risk.

14.4 DISCUSSION

The Azerbaijan electricity market is not deregulated and the majority of active participants are state owned entities. This situation is starting to evolve and with the onshore wind and solar projects being planned by ACWA Power and Masdar respectively the influence of independent power producers relying on international finance will increase.

The law on the use of renewable energy that came into legislation in 2021 puts in place a system that relies on the Government to be proactive in identifying and designating renewable energy project locations that will then be offered to the market either through auction or negotiated PPAs.

Based on this market structure, key risks, challenges, and considerations for bankability of OSW developments in Azerbaijan are as follows:

1. **Auction risks**. Developers will expect good quality survey data and site information in order to inform their bids. If the data available fails to meet industry standards then they will have to price in any outstanding risks into their bids, or they may choose not to bid. Government should take advice on best practice and lessons learned from countries that have implemented Government-led OSW processes. Designated sites will have a maximum of two years (extendable to three years by exception) to conduct the necessary OSW surveys, design, and development work. This period should be extended to a minimum of six years to reduce developer risk.
2. **Development risks**. Given the nascent nature of the local OSW industry, limited local experience and capability may lead to delays in financial close, equipment procurement, physical construction, and securing permits to begin commercial operation. Building on initial Government work, the RE developer will need to obtain final permits and certifications from multiple agencies throughout the development and construction phases. The need to secure various permits at a late stage may result in cost risks (capital costs increases) and uncertainty in the timing of construction completion, and commencement of revenue generation. The potential timing delays expose the developer to the risk of unfunded costs during development and challenges fulfilling debt service obligations in line with the anticipated schedule.
3. **Environmental and social risk**s. The gap between domestic and international environmental and social impact assessment requirements could lead to delays in financing. Environmental mitigation measures recommended any lenders, such as curtailment in some environmental conditions to reduce bird strike risk, can potentially result in impacts on the energy yield, which translates to profitability of an OSW project.
4. **Grid connection risks**. A mismatch between the timing required by Azerenerji to construct and deliver grid infrastructure and the OSW developer's project timetable could lead to delay in grid connection being available. Such events can impact cash flow and ability to meet debt service obligations. Provision of financial guarantees from Government to the developer regarding the timing of grid capacity being available will improve investor confidence and certainty.

5. **Curtailment risks**. Limitations in grid management may result in the curtailment of wind power and impact project revenues. In Azerbaijan there is a lack of experience of balancing high volumes of variable renewable energy on the system, and data, communications and switching systems have not been design with widespread plant dispatch in mind. Azerbaijan suffered a significant system wide black-out event as recently as 2018 due to a fire at a thermal plant that precipitated a cascade of faults through the system. However, the Azerbaijan electricity system has high-volumes of rapidly dispatchable gas and hydro power and a high generation headroom compared to peak load, as well as having multiple inter-connectors with neighboring countries, so is technically well suited to managing large volumes of variable renewables, subject to upgrades to data, communication and switching systems being prioritized for investment.
6. **Counterparty risks**. Lending institutions require high levels of credit assurance in relation to PPA off-takers in order to guarantee revenue streams and debt repayment. Independent developers report that the risk allocations of the current PPA arrangements in Azerbaijan are bankable. Azerenerji is the sole off-taker for PPA in Azerbaijan. As a state-owned entity is credit-worthiness is linked to the credit-worthiness of central Government. Azerenerji's credit rating is BB, with a stable outlook, based on the assumption that the Government of Azerbaijan will continue to guarantee Azerenerji's financial position. The Government should consider clarifying its ongoing support of Azerenerji to provide investor confidence.
7. **Policy or regulatory risks**. Competitive power procurement under the renewable energy law could encourage developers to propose unsustainable tariffs. While procuring RE, including OSW, through auctions is more transparent than a feed in tariff (FIT) scheme, the lack of sufficient precedent projects limits price certainty on equipment and operating costs that would come through a more mature market. This would give rise to a risk of lowball bids by developers, diminishing developer margins and project solvency. Establishing a floor on pricing or a requirement that bidders submit evidence of lender endorsement of proposed price may help alleviate this risk.
8. **Contractual risks**. A lack of a standardized PPA or offtake contract that recognizes the financing requirements of OSW creates challenges in establishing market precedence. This implies that terms and conditions associated with energy offtake are agreed under bilateral negotiations on a project-by-project basis and as a result there is likely to be variance across projects, in turn increasing the level of due diligence needed by investors and lenders prior to making formal investment decisions. Through developing a standard form PPA for adoption across OSW projects, market development can be accelerated by minimizing variation in deal parameters and improving the predictability of terms. Stakeholder engagement with developers and investors will be key when developing the PPA and other contractual arrangements to ensure bankability and ultimately deliver an affordable and sustainable tariff for end users.
9. **Exchange rate risks**. Adverse movements in the Azerbaijan Manat (AZN) relative to hard currencies such as US dollar could lead to reduced foreign investor appetite. This risk is of concern to local developers where a significant element of cost will be hard currency. For OSW, the majority of foreign currency denominated cost is anticipated to be in upfront capital cost, associated with the import of turbines and balance of plant, and ongoing debt repayments. From the operational perspective ongoing operating costs are unlikely to require material foreign currency denominated input. There is opportunity for local developers to minimize foreign exchange risk through entering into hedging arrangements, such as foreign exchange swaps for the operating costs. However, as the financing cost and debt repayment will be in foreign currencies, there would still be a need for foreign currency availability to the project operators through the project lifetime.

There is strong precedent for foreign investment into Azerbaijan across various infrastructure sectors, however foreign investors do face long-term exposure to adverse movements in the Manat, risking eroding their earnings over time when measured in hard currency. Government should consider ensuring measures such as hedging are available to projects, and that risks apparent to international and private investors, such as foreign currency exchange risk, are mitigated. This should be undertaken in consultation with developers and their potential financing partners. Government should consider appointing a specialist to advise on investment risks, appropriate risk allocation, and PPA contract design.

10. **Country risks**. Country risks. Local conditions stemming from Azerbaijan's political, economic, and legal framework could impact the stability of earnings. Azerbaijan does not have an investment grade sovereign credit rating (S&P BB+, Moody's Ba2 with a stable or positive outlook), suggesting overall a lack of strength in the local economy. There is strong precedent of foreign direct investment into Azerbaijan, but it has largely has been limited to the oil and gas sector. Local economic conditions such as high inflation, declining oil production, declining population or availability of suitably skilled labor could impact project returns and debt serviceability. Similarly, the enforceability of contracts, both with Government and suppliers, is key for OSW projects. Establishing either a national offtaker, or centralized coordinating body that can backstop offtaker obligations can help manage this risk.

14.5 RECOMMENDATIONS

Based on this analysis, it is recommended that:

- Azerenerji provides financial guarantees regarding the timely delivery of transmission infrastructure.
- Ministry of Energy (MOE) and Azerenerji ensure clarity on curtailment compensation (beyond a certain threshold) and prioritization of upgrades to system capability to manage high volumes of variable renewables.
- MOE explores arrangements for Government to backstop Azerenerji's off-taker obligations for multiple GW-scale projects.

Note that recommendations regarding the upfront identification and designation of OSW projects and extending the period of designation for a renewable energy project were provided in Sections 12 and 13.

15 HEALTH AND SAFETY

15.1 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 Azerbaijan. The review will show the extent to which current legislation and best practice aligns with OSW requirements. It will also recommend ways of ensuring Azerbaijan can develop an OSW industry that conforms with international H&S needs.

15.2 METHOD

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

15.3 RESULTS

H&S in Azerbaijan is administered by the Ministry of Emergency Situations (MES). Azerbaijan has legislation in place covering labor protection and safety, split down into legislation covering Industrial Sanitation and Occupational Health, Occupational Safety Requirements for Production Equipment, and Fire Safety. In the absence of OSW specific regulations, it is likely that existing oil and gas regulations will be taken as a logical and robust starting point for OSW H&S. Oil and gas activities have different H&S risks associated with them due to the presence of pressurized hydrocarbons, but these regulations have been used as a starting point for OSW H&S standards in other markets.

For Azerbaijan's oil and gas sector, H&S requirements are set out in Production Sharing Agreements (PSAs) signed between the Government and international oil companies. The PSAs call for the adoption of internationally recognized H&S codes and standards. PSAs do not constitute part of the national legal system governing H&S but take precedence over the general legislation in the case of any discrepancies.

The PSA system currently in place in Azerbaijan normally deals with agreements between the State Oil Company of the Azerbaijan Republic (SOCAR) and large international oil and gas companies, which have a robust and well managed safety framework. The type of documentation which would be produced within these PSAs includes:

- Safety management programs (including policies, objectives, safety activities, national and international regulations, and a compliance assessment)
- Risk assessment reports
- Emergency response plans

- Responsibility of organization of individual for safety management (including materials, safety and risk management, emergency response, occupational safety, personnel training, and qualifications)
- Safe design and construction of facilities (including general requirements, hazardous area classification, and firefighting and prevention)
- Safe operation of facilities (including facility operation and maintenance management, communication, transportation of people and cargo, work permits, wind farm vessels, and safety zones) and
- Inspection, investigation, and reporting system (including safety inspection, incident or accident investigation, and reporting systems).

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 applicable to OSW activities globally. Table 15.1 lists the various H&S legislation documents that are commonly used around the world, along with some that are UK-specific. UK-specific guidelines are included in the table to show how some markets also have unique H&S requirements.

The list below is not exhaustive and there are many international standards including EN, ISO, and IEC standards that cover specific areas such as engineering design and processes. The list however captures the main guidance applied to existing OSW projects.

Chapter 3.8 of the World Bank Group's *Key Factors* report also provides additional relevant information.[2]

TABLE 15.1 RELEVANT H&S LEGISLATION AND GUIDANCE DOCUMENTS (UK/WORLDWIDE)

Project Stage / Area	Document	Summary	Applicable to Azerbaijan Projects
Construction	Construction Design and Management (CDM) Regulations	Regulations to cover the management of health, safety, and welfare when carrying out construction projects in the UK.	No (UK specific and there may already be similar in place in Azerbaijan via National Standards for Construction).
Design **Safety / Emergency Response** **Inspection** **Emergency Response**	DNVGL-ST-0145, Offshore Substations (OSSs) for Windfarms	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	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 Turbines	General principles and guidelines for the structural design of wind turbine supports.	Yes (international standard applied globally).

Project Stage / Area	Document	Summary	Applicable to Azerbaijan Projects
Design **Construction**	DNVGL-ST-0437, Loads and Site Conditions for Wind Turbines	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	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	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	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	Various H&S guidelines for OSW farms including Emergency Response guidelines.	UK specific but may be applied internationally.
Safety / Emergency Response Arrangements	Safety of Life at Sea Regulations (SOLAS)	Sets minimum safety standards for life saving appliances and arrangements.	Yes (international standard applied globally).
Helideck Design	ICAO Heliport Manual	Criteria required in assessing the standards for offshore helicopter landing areas.	Yes (international standard applied globally).

In the UK, the CDM regulations apply to most construction projects, while DNVGL-ST guidelines are the main global standards for OSSs and wind turbines.

The G+ is the global OSW H&S body and brings developers and supply chain companies together to work on the areas of incident data reporting, good practice guidelines, safety workshops, and learning from incidents. Their guidance is intended to be used by all to improve global H&S standards within OSW farms. Various G+ and RenewableUK guidelines have been developed specifically for the wind industry (offshore and onshore) and are used in conjunction with the DNV-GL guidelines.

15.4 DISCUSSION

Azerbaijan does not currently have any H&S regulation in place specifically for the OSW industry. PSAs between SOCAR and oil and gas producers encompass H&S requirements and policies. These have the power of law and have a higher legal status than other laws of the Azerbaijan Republic, but their effectiveness relies on oil and gas companies having comprehensive and robust internal safety regimes in place. Experience with the safety elements of these PSAs should eliminate the need to develop entirely new OSW guidelines.

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

15.5 RECOMMENDATIONS

Based on this analysis, it is recommended that:

- MES adapts existing framework of technical codes and regulation, adopting international industry codes where appropriate.
- MES develops H&S regulations specifically designed for application to the OSW industry, which should include reference to the international design and operational standards adopted in established OSW markets.
- MES 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 markets.
- Ministry of Energy (MOE) and MES encourages OSW and oil and gas companies to collaborate on knowledge sharing programs. 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.

16 TRANSMISSION INFRASTRUCTURE

16.1 PURPOSE

In this work package, we summarize the existing transmission network and possible transmission upgrades, as well as changes in grid management that may be required to support development of offshore wind (OSW) under the scenarios presented in Section 2.

We also review the processes that are used to manage system stability and grid connection applications in Azerbaijan.

16.2 METHOD

Our assessment has been based on a review of relevant documentation 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 Azerbaijan.

Further detailed work will be required to address the future expansion of transmission infrastructure and system management in Azerbaijan, considering the needs arising from an expansion of OSW, other forms of variable renewable and non-renewable electricity and wider energy system decarbonization strategies.

Detailed environmental and social impact assessments (ESIA) will need to be undertaken during the future planning and option appraisals for any future transmission network upgrading works but should not fundamentally change the principles presented.

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.

16.3 CURRENT TRANSMISSION NETWORK, INTERCONNECTORS, AND GENERATION SOURCES

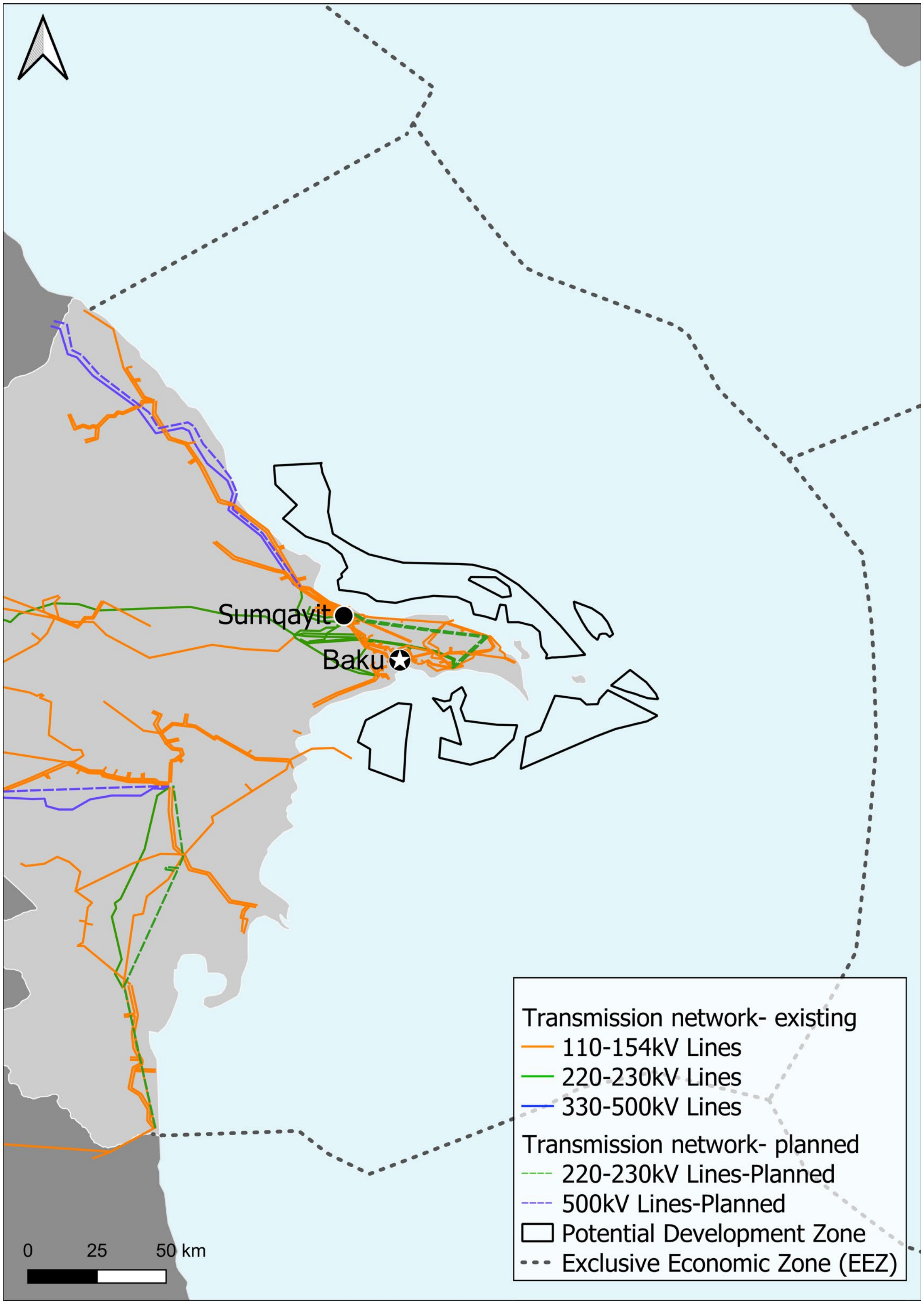
Azerbaijan's high voltage transmission network is owned and operated by Azerenerji. The network total length is about 7,800km, with 93 high voltage substations. A summary of the transmission network is shown below in Table 16.1.

TABLE 16.1 CURRENT TRANSMISSION NETWORK IN AZERBAIJAN

Voltage (kV)	Number of lines	Length (km)	Number of substations
110	189	4,325	70
220	29	1,505	13
230	1	31	-
330	24	1,542	8
500	3	477	2

A map of the transmission network, generation installation, and demand centers is shown in Figure 16.1.

FIGURE 16.1 NATIONAL TRANSMISSION NETWORK



The distribution network in Azerbaijan is operated by Azerishiq. The existing solar and onshore wind projects in Azerbaijan are connected to the distribution grid, but all OSW projects will be connected to the transmission network.

Azerbaijan has significant interconnection with neighboring countries. This should in principle add significant security of supply and resilience to the system.

Azerbaijan's system is synchronized with Russia's Integrated Power System/Unified Power System (IPS/UPS). Cross-border capacity with Russia is via the 330kV (350MW capacity) Yashma-Derbent line.

Russia, Azerbaijan, and Iran are currently negotiating to develop a second 330kV Absheron-Derbent line with Russia, as well as a Russia-Azerbaijan-Iran electricity corridor.

Azerbaijan has two cross-border connections with Georgia; the 500kV (700MW capacity) Samukh-Gardabani line and the 330kV (250MW) Agstafa-Gardabani line. A further 330kV connection on the Agstafa-Gardabani line has been constructed on the Azerbaijani side.

Azerbaijan has three cross-border connections with Turkey in the Nakhchivan Autonomous Republic: the 154kV Igdir-Babek 1 and 2 lines, and the 34.5kV Adaliq-Sadarak line.

Iran will be synchronised with the IPS/UPS once grid compatibility studies have been completed in 2021. Azerbaijan has five cross-border connections with Iran, which are the 330kV Mugan line, the 230kV Imishli and 110kV Astara-Astara lines, and the 132kV Araz-Araz and 132kV Julfa-Julfa lines. Total cross-border capacity with Iran is 600MW. A 220kV Masalli-Astara power transmission line is also being constructed.

In total, export capacity from contiguous Azerbaijan through inter-connectors to neighboring systems totals 1.9GW.

The existing installed generating capacity is 7.56GW including 6.2GW of thermal assets, 1.1GW of hydro, 66MW of wind, 40MW of solar, and 38MW of biomass. As of 2021, the peak demand in Azerbaijan is 4.4GW.

Given this significant headroom and excess generating capacity, Azerbaijan has generally been a net exporter of electricity since 2007. From 2017 onwards, most of the exported electricity has been to Georgia, with annual exported power exceeding an average of 100MW. In recent years, only small volumes of electricity have been exported to Russia and Iran.

The ownership of the generating capacity is as follows:

- Azerenerji: 6,478MW
- Independent generators: 738MW
- Nakhchivan Autonomous Republic: 244MW
- Azerishig: 55MW
- Azalternativeenergy: 17MW.

Further generating capacity is planned, including a new 385 MW modular gas-fired power plant in the Gobu district which is expected to be commissioned in early 2022. A 36MW hydropower plant in the Nakhchivan Autonomous Republic is also under construction, and construction works are yet to start on a private combined-cycle gas turbine of up to 550MW. In 2022, ACWA Power will start construction works on a 240MW wind power plant and Masdar will construct a 230MW solar power plant.

Once these additional generation plants are completed, total generation capacity will be 8.9GW which is more than double the present peak demand of 4.4GW. The majority of the thermal generation is located close to the main load centers formed by the cities of Baku, Sumqayit and Xirdalan, with most of the hydro generation being located in the north west close to the load centers formed by the cities of Ganja and Mingachevir.

16.4 CONSIDERATIONS WITH INCREASED DEPLOYMENT OF VARIABLE RENEWABLE ENERGY

Key generic 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 RE (including OSW) and other power from areas of generation to the load centers.

- **Inclusion of suitable energy storage systems**. The inclusion of suitable and strategically placed energy storage systems in the transmission network, such as utility scale battery storage, will enhance grid robustness and resilience to handle increased variable renewable energy 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 static var compensators (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, inertia 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.

- **Technologies to address grid challenges**. The Renewable Readiness Assessment Report for Azerbaijan report provides specific recommendations for studies to be undertaken to determine the impact of variable RE system power flows on the stability of the existing network.[19] The studies will help identify the need to implement grid upgrading works with the aim to identify and implement technologies to address challenges for the longer-term Azerbaijani transmission network.

16.5 FUTURE NETWORK REQUIREMENTS

Two new high-voltage lines will be constructed to connect the planned onshore wind and solar projects being delivered by ACWA Power and Masdar. Other than these planned lines no information has been made available regarding planned future upgrades to the transmission system. Neither of these projects are in locations relevant to OSW.

A report by an international consulting firm on behalf of Azerbaijan Energy Regulatory Agency (AERA) found that at present there are no bottlenecks on the Azerbaijani grid system and that up to 1500MW of variable renewable energy capacity can be connected without endangering system stability or requiring transmission network upgrades, depending on location. In other words, there is sufficient baseload capability on the network to ensure security of supply and the generation mix lends itself to load control and dispatch, although upgrades will be required to modernize data and communication systems to facilitate plant dispatch. By 2030, it is likely that most of this capacity will have been provided by onshore wind and solar, plus an OSW pathfinder project, meaning that further detailed power systems studies will be required in terms of the specific location and connection points of larger OSW projects to determine transmission network reinforcement requirements and dispatch capability upgrades required. The cost of such upgrades cannot rationally be assessed at this stage.

Connecting new offshore wind farms

At a local transmission-, individual circuit-, or substation-level there may be constraints due to fault levels or local power flows with the connection of significant new OSW capacity. The pathfinder project (210MW) can be connected at 220kV and the larger projects (700MW to 1GW) can be connected at 330kV or 500kV.

Enabling a transformed energy system

The future energy scenarios outlined in Section 8 outline substantial changes to both the supply and demand of energy in Azerbaijan in the coming decades. This transformation has implications for the transmission and distribution systems, over and above connecting a high volume of new renewable energy capacity, including managing the demand profiles of:

- A high penetration of electric vehicles (EVs) (also providing much supply / balancing capability);
- An increased volume of electric heating; and
- High-volume hydrogen production (which can be timed to match supply).

A combined program of system design, infrastructure investment, and improvements to load/demand management capability will be required to enable these changes.

16.6 GRID CONNECTION PROCESS

Given that there are very few independent power projects in Azerbaijan, there has not been a high demand for third party grid connections to date. Under a Government led power procurement system the Government will secure the grid connection and provide this to the successful developer, so there will be no requirement for OSW project developers to apply independently for a grid connection.

As the electricity system transitions to being dominated by variable renewables, it is important that codes enable efficient operation of the system. A unified set of grid codes, including a connection code, system operations code and comprehensive set of standards, is not currently available. The connection code should clarify the requirements for connections with regard to aspects such as voltage control and reactive compensation requirements, harmonics, system inertia requirements through fault ride through, and rate of change of frequency (RoCoF) requirements. A system operations code should set out the rules for generation dispatch, the ancillary services market, mandatory ancillary services requirements from generators connected as well as operational control requirements and interfaces. The codes should take consideration of data sharing between the transmission and distribution network operators and generators across planning and operational timescales including outage planning.

16.7 DISCUSSION

Whilst the transmission system in Azerbaijan is not currently constrained and there is substantial headroom in the available generating capacity compared to periods of peak demand, it is apparent that upgrades will be required to strengthen the transmission and distribution network in Azerbaijan over the next 30 years to accommodate the increase in both the demand and supply of power which will come from a variety of different sources.

Increasing renewable energy penetration and increased decarbonization of heat could have an adverse impact on the operation and stability of the transmission network, and therefore detailed power systems analyses focusing on the reliability and resilience of the system are recommended through power flow simulations to determine the most appropriate grid reinforcement measures to be applied.

The energy market in Azerbaijan is entirely under state control. Reforming towards a more liberalized market could also help facilitate an efficient energy transition and help attract direct foreign investment.

Additional measures that may be required to enable 7GW of OSW and the demand side changes outlined in Section 8 include:

- Strengthening of local transmission and distribution lines in and around the Absheron peninsula to ensure that the potential OSW wind resource can be exported and consumed in the load centers of Baku and Sumqayit. The financing and timing of these transmission network upgrades will be critical as they typically can take ten years or more to plan, design and implement. Investment will be required to build such transmission system upgrades. This can be undertaken using conventional loans from the international market. One commonly used mechanism to facilitate large transmission system upgrades that lessens the investment burden on governments is a build-own-operate-transfer (BOOT) model. Under this model, a private business is mandated by government to finance, construct, build, and operate the transmission infrastructure. The investment is recovered by levying a fee to government. This approach could allow Azerbaijan to undertake an accelerated program of transmission build without public investment.
- Strengthening of interconnector capacity with neighboring countries to facilitate the increased export of electricity. The BOOT model is also well suited to the financing of international interconnectors.
- Strengthening of dispatch capability including load and demand side management, including gaining experience from network operators in markets with high penetration from variable renewables, such as Germany or the UK, where technologies and processes that deliver network balancing are mature.
- Developing the grid infrastructure and load management capabilities required to support both large-scale hydrogen production via electrolysis and the expanded use of electrical heat in residential and industrial applications.
- Developing and adapting infrastructure at distribution system level to enable the required EV charging networks in urban and suburban areas, including vehicle-to-grid capability so that EVs can be used to help balance supply and demand.
- Ensuring that the construction of the required grid infrastructure upgrades and implementation of changes to system management by Azerenerji are aligned with wider Government plans so that grid connections and system improvements are available in time for the construction of the OSW project pipeline.

16.8 RECOMMENDATIONS

Based on this analysis, it is recommended that:

- Ministry of Energy (MOE) publishes 2050 vision for a nationwide electricity transmission network for a decarbonized energy system, including consideration of the impact of market reform and analysis of the offshore development zones, with milestone plans for 2030 and 2040.
- MOE undertakes country-wide power systems studies to understand the potential impacts of OSW and other renewables on the future electricity system, including those directly related to decarbonization of transport and heat, such as hydrogen production close to OSW grid connection points and the opportunity for increased electricity export, considering potential environmental and social impacts of grid upgrades.
- Azerenerji prioritizes the modernization of systems required to perform system wide generation supply and demand balancing and plant dispatch, needed for any efficient future energy system.
- MOE and Azerenerji ensure clarity regarding grid code compliance, and consider compensation arrangements for delays to grid connection or project delivery timelines.

17 PORT INFRASTRUCTURE AND TRANSPORTATION

17.1 PURPOSE

In this work package, we assess Azerbaijan's port infrastructure with regard to offshore wind (OSW).

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 Azerbaijan with the majority of the existing heavy port infrastructure focused on the fabrication of oil and gas structures.

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. There are several locations such as South Bay and smaller facilities in east Baku that could be utilized for operations, maintenance, and service (OMS). We look at the Azerbaijani 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 US$5 million)
- Suitable with moderate upgrades (cost between US$5 million and US$50 million) or
- Suitable only with major upgrades (cost greater than US$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

Azerbaijan has a coastline of just over 700km with a limited number of large-scale ports. The largest commercial port in Azerbaijan is the Port of Baku, which is used mainly for roll-on, roll off (ro-ro) ferries and container freight. Other crucial port-based fabrication sites located south of Baku, such as Baku Shipyard and Bos Shelf, provide the majority of the heavy infrastructure and vessel manufacture for the oil and gas sector. Elsewhere, east of Baku the ports of Zigh and Zira have potential to support various maritime activities. Azerbaijani ports are owned and managed by a mix of state-owned and private enterprises.

Location of potential OSW suppliers

The build out of OSW in Azerbaijan will depend on reliable and accessible port infrastructure to supply the industry.

There are a limited number of potential OSW suppliers located at port-based facilities in Azerbaijan. These are shown in Figure 17.1. The most relevant heavy fabrication facilities are Bos Shelf and Baku Shipyard which are located next to each other, immediately south of Baku.

Bos Shelf was founded in 2001 by State Oil Company of the Azerbaijan Republic (SOCAR) and Star Gulf FZCO. The site is the former Baku Deep Water Jacket Factory that was originally built in 1984. Bos Shelf has a strong track history of providing deep water jackets and piles for oil and gas topsides. It also specializes in the modernization of drill rigs and barges. Bos Shelf manages a neighboring supply base, where BP locates its Caspian Sea operations.

Baku Shipyard is the smaller of the two yards and was established in 2011. It specializes in shipbuilding, repair, conversion, and engineering services to the marine sector. The facility is majority owned by SOCAR, Azerbaijan Investment Company and Keppel.

Zigh Fabrication Site is a smaller facility located on the coastline 13km south east from the center of Baku. Technip formally ran this yard for the fabrication and load out of components for the Shah Deniz Gas Field. The site is now owned by the Oil and Gas Construction Trust operated by SOCAR. The site is currently used for batch production of lattice structures and secondary steel elements for the oil and gas sector. Other notable facilities are the Zira Port Marine Industrial Complex 55km east of Baku and the Port of Baku located at the Alat township 75km south west of Baku. Zira port is owned by ADO-G one of the oldest oil and gas service companies in Azerbaijan. Zira was recently developed by ADO-G and is primarily focused on the manufacture of oilfield equipment manufacturing and fabrication yard for steel structures on total area of 20ha. The port of Baku is publicly owned and provides intermodal logistics, handling mainly freight via ro-ro and general cargo berths.

We anticipate turbine components, such as nacelles and blades, will be shipped from manufacturing sites in Europe through the canal systems or via rail transport where feasible. Due to Azerbaijan's location it is possible that turbine components could be transported in from Asia, where some of the leading western manufacturers have manufacturing facilities, or potentially from China. See Section 17.6 for more detail on the logistical constraints of the canal systems.

17.4 PORT 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.

Manufacturing port requirements

The typical minimum space needed at a turbine tower or blade manufacturing facility is around 20ha, while nacelle manufacturing tends to require less space at between 6 to 10ha. We anticipate blades or nacelles will not be manufactured locally in Azerbaijan and supplied regionally.

Offshore substations (OSSs) tend to be large but are often built as single units or two units at a time and require similar space to a nacelle manufacturing facility. Substations use less serial manufacturing processes, so are more like oil and gas fabrications.

As discussed in Section 9, we anticipate that jackets will be used in the low-grow scenario and monopolies will be used in the high growth scenario. The minimum space required for a jacket foundation manufacturing yard to serve 400MW per year is approximately 20ha. 40ha is needed to deliver up to 1GW annually. A similar amount of space is required for monopiles.

In Table 17.1 we have specified a range of 20 to 40ha of space for a quayside manufacturing port catering for at least one component. Foundations for floating projects can require approximately one third more space compared to fixed bottom projects owing to their size. We therefore expect the larger or specialized ports with dry docks such as Baku Shipyard to be used for manufacture and construction of floating projects, if used in the future.

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 13ha for 400MW build out per year. For sites with greater weather restrictions or for larger-scale projects, up to 30ha is required.

Quay length requirement is between 250 and 300m, which will accommodate up to two mid-sized installation vessels or feeder barges. Launch barges are widely used in the Caspian Sea for the deployment of jackets and presents the most likely option for the installation of these structures in the short term. These vessels have drafts ranging between 8 and 10m and minimal channel depths have been specified based on this. Port channels must be wide enough for vessels with beams ranging between 45 and 60m with overhead clearances of 140m to allow for the vertical shipment of turbine towers.

Quaysides need bearing capacities between 20 and 30 metric tons/m² for load-out to adjacent vessels while storage areas need a capacity of at least 10 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 handing 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 AZERBAIJANI PORT CAPABILITIES

Port criterion	Value	Weighting
Storage space (ha)	13-30 (20-40 for manufacturing port, per facility)	1
Quay length (m)	250-300	1
Quayside bearing capacity (metric tons /m²)	20-30	1
Storage area bearing capacity (metric tons /m²)	10	1
Channel depth (m)	8-10	1
Channel width (m)	45-60	1
Crane capacity — turbine components (metric tons)*	500-1000	0.2
Crane Capacity — foundations (metric tons)*	1400 — 2200	0.2
Overhead Clearance (m)	140	1
SPMT (no.)	2-4	0.2
Mobile Crane (no.)	1	0.2
Crawler Crane (no.)	1-2	0.2
Other facilities	Workshops, skilled workforce, personnel facilities, road, and rail links	1

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

For each criterion presented in Table 17.1, a weighted score of one to five was allocated as shown. We then summed the total score for each port, noting any showstoppers.

TABLE 17.2 SCORING AGAINST PORT CRITERIA

Score	Definition
1	Not suitable and cannot be upgraded
2	Suitable with major upgrades (cost greater than US$50 million)
3	Suitable with moderate upgrades (cost between US$5 million and US$50 million)
4	Suitable with minor upgrades (cost less than US$5 million)
5	No upgrades needed

17.5 RESULTS

We assessed five potential ports. Detailed scores are provided in Table 17.3 and a summary is provided in Table 17.4 in order of score. Note that the score is only an assessment against criteria — it does not consider suitability of location, availability, or commercial considerations. A map of the port locations is provided in Figure 17.1.

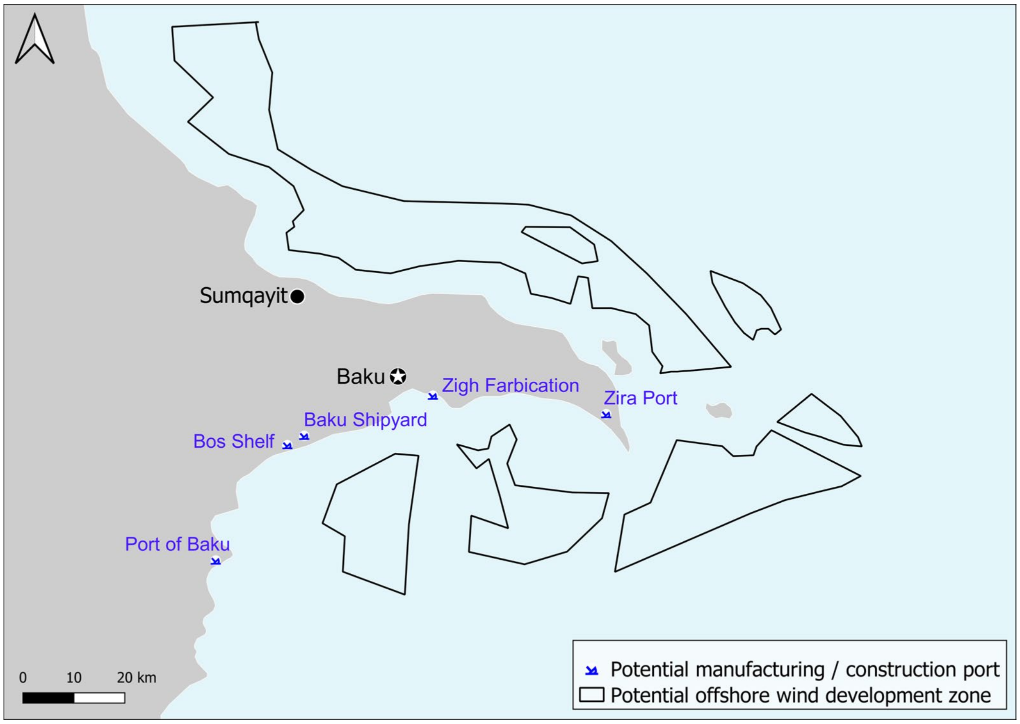
Our assessment shows that Bos Shelf is the only facility large enough to provide manufacturing and construction facilities simultaneously. Recognizing demands from other sectors, the most likely combination is to use Bos Shelf and Baku Shipyard. In the high growth scenario Zira Port could be needed to provide support in turbine marshalling, which will depend on the extent of additional land that could be leveraged at Bos Shelf. It is unlikely that Zigh or Port of Baku will be used for major activities.

At this stage, we have not assessed port availability and interest in OSW. As some ports are established container ports or oil and gas fabrication yards, this could restrict their availability, or if repurposed, could improve the scores presented.

TABLE 17.3 PORT ASSESSMENT DETAILED RESULTS

Criteria	1	2	3	4	5
	Bos Shelf	Baku Shipyard	Zira Port	Zigh	Port of Baku
Space — construction port	3	2	3	2	2
Space — manufacturing port	5	2	2	2	2
Quay length	5	5	5	5	5
Quayside UDL/ bearing capacity	5	5	5	2	2
Storage area UDL/ bearing capacity	5	5	5	2	2
Channel depth	5	5	3	4	3
Channel width	5	5	5	5	4
Crane capacity — turbines	4	4	4	3	3
Crane Capacity — foundations	4	4	3	2	2
Overhead clearance	5	5	5	5	5
SPMT	3	4	3	3	3
Mobile crane	4	5	5	5	5
Crawler crane	5	3	5	5	3
Other facilities	5	4	4	3	4
Construction port rating	42	40	39	31.6	30.2
Suitability for construction	Suitable with minor upgrades	Suitable with minor upgrades	Suitable with moderate upgrades	Suitable with major upgrades	Suitable with major upgrades
Manufacturing port rating	44	40	38	31.6	30.2
Suitability for manufacture	Suitable with minor upgrades	Suitable with minor upgrades	Suitable with moderate upgrades	Suitable with major upgrades	Suitable with major upgrades

FIGURE 17.1 POTENTIAL OFFSHORE WIND MANUFACTURING AND CONSTRUCTION PORTS IN AZERBAIJAN



Ports upgrade summary

We determined that all ports require some level of upgrade to be suitable for construction or manufacturing. A summary of the capabilities and potential upgrades required is included in Table 17.4. Any potential port facility upgrades or expansions would require full ESIA.

TABLE 17.4 SUMMARY OF MANUFACTURING AND CONSTRUCTION PORTS FOR OFFSHORE WIND IN AZERBAIJAN

#	Port	Suitability for construction	Suitability for manufacture	Comment
1	**Bos Shelf**	Suitable with minor upgrades	Suitable with minor upgrades	• Ownership: Public • Location: South west of Baku • Suitable for manufacturing of foundations and construction after minor upgrades are completed • Capable also of fabricating substation topsides • Good port facilities, quay and skidway can handle super large structures • Minor upgrades mainly consist of land reclamation for storage purposes. Facility has access to 200ha of land nearby • The facility is located close to a Key Biodiversity Area and an Important Bird Area therefore impacts of any upgrades or expansion would require careful EISA.

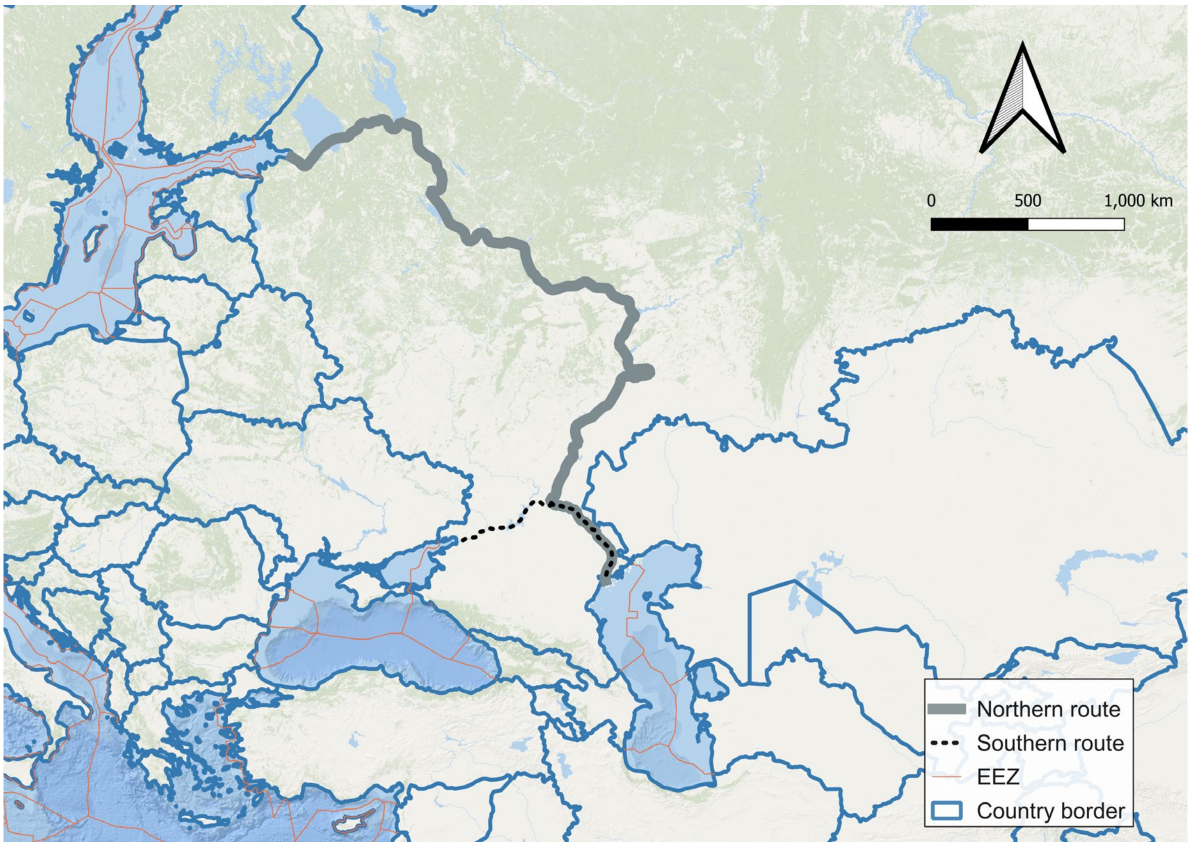
#	Port	Suitability for construction	Suitability for manufacture	Comment
2	**Baku Shipyard**	Suitable with minor upgrades	Suitable with minor upgrades	• Ownership: Public • Location: South west of Baku • Suitable for foundation manufacture or marshalling of turbines with minor upgrades • Good port facilities, quay, and drydocks • Could be used simultaneously with Bos Shelf to facilitate both foundation manufacture and turbine marshalling with minor upgrades • In isolation, moderate upgrades required to facilitate both foundation manufacture and turbine marshalling, consisting of land reclamation or infilling in the harbor area.
3	**Zira Port**	Suitable with moderate upgrades	Suitable with moderate upgrades	• Ownership: Private • Location: 55km east of Baku • Suitable for foundation manufacture or marshalling of turbines after moderate upgrades are completed • Good quay and storage area bearing capacity • Port is underutilized • Moderate upgrades required to provide more landside space and to establish supporting infrastructure.
4	**Zigh**	Suitable with major upgrades	Suitable with major upgrades	• Ownership: Public • Location: 13km south east of Baku • Suitable for foundation manufacture or marshalling of turbines after major upgr ades are completed • SOCAR site with some active batch fabrication • Major upgrades required to provide more landside space, increase quayside bearing capacity, and deepening of the channel.
5	**Port Baku**	Suitable with major upgrades	Suitable with major upgrades	• Ownership: Public • Location: Alat township, 75km south of Baku • Potential for turbine marshalling after major upgrades; low potential for foundation manufacture due to existing use • Modern port used mainly for freight and ro-ro ferries • Unlikely to be available for OSW due to existing freight activities • Requires extension or repurposing before use for OSW • Major upgrades required to bearing capacity and landside space • Located within Alat Bay — Baku archipelago KBA.

17.6 TRANSPORTATION CONSTRAINTS

Many OSW components are very large, meaning that some components (foundations and substations) and installation vessels must be manufactured locally. Other components can be transported but have been designed for transport on the open sea, and not through constrained canals.

The Caspian Sea is connected to the Baltic and the Black seas via two routes, referred to as the Northern and Southern routes, as shown in Figure 17.2. The entry point for the Northern route is at St. Petersburg in the Gulf of Finland. The Southern route begins at Rostov on Don in the Azov Sea.

FIGURE 17.2 NORTHERN AND SOUTHERN ROUTES TO THE CASPIAN SEA



These two routes are available for marine transportation of project cargo into the Caspian Sea. Both routes are subject to closure during winter months due to ice formation on the waterways. The Northern route is approximately 4000km in length from St. Petersburg to Baku and is open from the end of April to the second week in November each year. The Southern route is approximately 1500km in length and is open from mid-April to end of November. Consideration must be given to transit times for barges and vessels to enter and return from Caspian Sea. Transit time via the Northern route from St. Petersburg to Baku is approximately two weeks. Transit time via the Southern route from Rostov on Don to Baku is approximately one week.

The technical constraints for each route are included in Appendix C.

Volga Max vessels are the largest ships suitable for transit through the canal systems. These vessels have a beam of approximately 17m and an overall length of 140m. They are specified as bulk carriers but have been used previously to transport turbine blades for onshore wind projects and other oversized cargo.[20]

It is unlikely that wind turbine blades and nacelles will be manufactured in the Caspian region due to high set-up cost for the size of market, so it is most likely that these components will require shipping through the canal system.

Wind turbine blades

Blades for the pathfinder project are likely to be about 110m long. This will increase to 119-133m for 18MW turbines and up to 143m for 20MW turbines.

Even the smallest of these blades, transported flat on deck, will result in an overhang of approximately 4m towards the bow of a Volga-Max vessel. It is likely that transport can be facilitated in this way through the northern route where lock lengths are less constrained, subject to detailed analysis. It is expected that a maximum of three blades per vessel could be transported in this configuration, but longer blades are likely to need another solution.

Very large blades for some models of onshore wind turbines are now designed to be transported in two sections, then joined on or near site, in order to address road transport logistics. Similar solutions could be used for blades that are too large to transport in one piece on Volga Max vessels. Such blades need internal reinforcement around the joints. For Azerbaijan, it would be preferable to locate joints as close as possible towards the blade tip, depending on the length limitation for transport. This method is yet to be applied for OSW projects (where logistics constraints are not as common as in onshore wind), but it is deemed feasible with only a small impact on manufacturing complexity and cost, at least for some wind turbine suppliers. Two-piece blades could then be transported through both the Northern and Southern routes. Blade logistics could reduce competition for wind turbine supply, but we anticipate sufficient interest in the market in the high growth scenario, at least, to ensure there remains a competitive market.

Wind turbine nacelles

The expected height of a fully intact 18MW nacelle on transport frame is up to about 16m. Transportation of nacelles of this size would require partial disassembly due to height restrictions on the canal systems. The removal of nacelle covers, and other sub-assemblies is one potential method to alleviate height restrictions. It is anticipated that a Volga-Max vessel could transport one or two partially disassembled nacelles and would be most feasible on the northern route, providing that the height of individual sections are no greater than approximately 11m. Otherwise, emerging modular nacelle designs with sub-assemblies held within two to three shipping containers could be adopted, which are specifically designed to overcome logistical constraints imposed by bridges and other obstacles.[21] A containerized, modular approach would likely introduce better transport efficiencies than the partial disassembly approach and should be feasible on both the Northern and Southern routes, but may only be available for some wind turbine models. Nacelle transport (and even installation) in modules has been used many times to address onshore logistics challenges.

Wind turbine towers

The diameter of towers could pose a restriction for transport, but early assessment suggests that even the cost of transport is likely to drive local manufacture, with flat steel plate being imported through the canal system to capable fabrication facilities in Azerbaijan.

Further detailed transportation studies will be required in due course to de-risk the logistics challenges posed by the access restrictions.

17.7 DISCUSSION

Due to the limited amount of available and suitable ports, the best immediate option for OSW manufacturing and construction activities are at Bos Shelf, although the site is situated within an important bird area and any development would need to be carefully planned and implemented to ensure that it did not impact the internationally important bird populations supported. The neighboring Baku Shipyard could be used simultaneously to support manufacture or construction activities at Bos Shelf if it continues in oil and gas fabrication. Baku shipyard could provide foundation manufacture or turbine marshalling in isolation, although the latter would not make efficient use of the available infrastructure which is best suited to large scale fabrication or repair. Zira has potential as it is generally underutilized and moderate upgrades could help establish a dedicated port for either foundation manufacture or turbine marshalling. It is unlikely that Zigh or Port of Baku will be used for major activities. It will be important Government add the project developers to coordinate with the port operators to ensure that the port upgrades outlined below are available in time to deliver the OSW pipeline, including the design, financing, and construction of key infrastructure improvements.

Low growth scenario

Our low scenario for annual installed capacity indicates that the equivalent of one major foundation manufacturing facility and one turbine marshalling port will be required between 2028 and 2032, ideally at Bos Shelf or Baku Shipyard. Bos Shelf has the capacity to provide both foundation manufacture and turbine marshalling with minor upgrades, providing there is limited continued demand from the oil and gas sector. Baku Shipyard could provide support to either activity in periods of heightened demand from other sectors. There is also the opportunity for one of these facilities to also provide tower manufacture and OSS manufacture and assembly.

High growth scenario

In the high growth scenario, the demand for foundation manufacture and construction ports will increase between 2028 and 2036, requiring between one or two ports every year across both activities. Based on our assessment, Bos Shelf and Baku Shipyard have strengths in fabrication and will likely see both these facilities used for foundation manufacture in the high scenario. These sites will only be able to accommodate OSW growth if they are open to provide most of their existing port space to OSW projects. Oil and gas production reduced over the last decade in Azerbaijan but significant activities remain, which could require compromise. Bos Shelf does have access to 200ha of land nearby which could provide additional storage space for marshalling of turbines or to relocate existing operations to free up land near the quayside. The requirement of a separate port to facilitate preassembly and marshalling of turbines would depend on the extent and availability of new areas at Bos Shelf. The most promising option for a secondary location to support the preassembly and marshalling of turbine components is at Zira. This port will require moderate upgrades, but its apparent low utilization could present an opportunity for a facility of this kind.

17.8 RECOMMENDATIONS

Based on this analysis, it is recommended that:

- Ministry of Energy (MOE) works with ports of Baku Shipyard, Bos Shelf, and Zira to determine their interest and availability to deliver manufacturing and construction services to the OSW industry and explore routes to necessary upgrades, considering potential environmental and social impacts of such expansion.

18 FINANCE

18.1 PURPOSE

The cost of finance has a significant impact on power purchase agreement (PPA) prices. This work package presents a high-level assessment of the potential role of broader public policy (including concessionary and climate finance) in the offshore wind (OSW) rollout in Azerbaijan. 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.

For context, development and construction of the wind farms under the high growth scenario will require approximately US$20 billion of capital to be deployed, about 80% (US$16 billion) of which is likely to be in the form of non-recourse debt secured against the assets. It is expected that the long-term funds required for the OSW projects would be provided primarily in foreign currencies.

18.2 METHOD

We have identified relevant financial instruments that could play an enabling role in the development of the Azerbaijani offshore wind industry. We consulted with independent renewable energy project developers and legal firms to understand their perspective on the availability of project finance in Azerbaijan.

18.3 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
- Green equity instruments.

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). Most infrastructure developments are financed directly by the Azerbaijani Government or through traditional secured and unsecured loan arrangements, rather than through the project finance structures commonly used in offshore wind.

Local banks

Azerbaijan does not have a track record of large-scale debt financed renewable energy projects. The existing onshore wind and solar projects In Azerbaijan are modest in size and have been financed with a combination of balance sheet equity from Azerbaijani entities and some debt raised from local state-owned banks.

It is likely that Azerbaijani banks will not be able to provide a significant percentage of the debt required for large offshore wind projects cost effectively and that most of the financing will come from international banks and financial institutions.

International banks

International financial institutions (IFIs) such as the Asian Development Bank (ADB), European Bank for Reconstruction and Development (EBRD), German Investment Corporation (DEG), and International Finance Corporation (IFC) are active lenders in Azerbaijan and have financed projects in the oil and gas, transportation, chemical, and food sectors in recent years. These IFIs have not yet participated in any large scale renewable energy projects in Azerbaijan, although it is considered likely that international lenders will participate in the onshore wind and solar projects that are being developed by ACWA Power and Masdar respectively and due to be constructed in 2023.

In 2019 Azerbaijan attracted foreign direct investments (FDI) of US$1.5 billion and between 2003 and 2017 attracted a total of US$32.7 billion, 50% of which was directed towards coal, oil, and gas sectors.[22] This demonstrates that there is the appetite from foreign investors for supporting large scale energy infrastructure projects in Azerbaijan.

The UK is the largest source of FDI in Azerbaijan, providing 26% of FDI between 2009 and 2017. The UK's interest in Azerbaijan has centered on the country's energy industry, focusing on oil and gas, to date.[23]

Multilateral development banks (MDBs) invested a further 14%, followed by Turkey (13%), Malaysia (9%), Switzerland (8%), the Russian Federation (6%), Iran (6%), Japan (5%), and the United States of America (5%).

Tax and policy incentives

There are several tax and policy incentives already in place for renewable energy projects in Azerbaijan, including OSW, by reducing the tax burden on projects. Current incentives offered to organizations investing in renewable energy include the following:[24]

- Exemption from customs duties
- Exemption value-added tax for technical equipment and facilities for a period of seven years
- Exemption from paying property tax, land tax, and half their income tax.

These incentives directly lead to cost reductions for developers, reducing the amount they need to recuperate through revenue.

Given the substantial overlap between the energy consumers paying tariffs and taxpayers, these policies are less likely to be effective where the concern is the overall level of affordability to Azerbaijan as a country. They may have advantages where particular distributional outcomes are more difficult to achieve with the tariff regime than with the tax regime.

Government reducing project developer risk by acting as a backstop on offtaker (PPA counterparty) obligations is also an option to reduce the cost of project finance.

Multilateral lending

The ability of private sector developers to secure finance from multilateral lending agencies (MLAs) such as the IFC, ADB, and European Investment Bank (EIB) can create several benefits in terms of the overall availability of finance and its cost.

Participation (in equity or, more typically, debt) from multilateral lenders has several benefits. 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 acts as a signal which often increases interest among private institutions
- Their environmental and social impact assessment (ESIA) standards such as IFC PS6 ensure that best practice in ESIS is applied, making it easier for other investors to participate;[44]
- 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.

Multilateral lenders may 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[xv]) which have been used previously in Azerbaijan.

xv MLAs may also subordinate their debt to other lenders or offer loan loss reserve funds, reducing the risk of default for other sources of finance.

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

Credit enhancement mechanisms

Credit enhancement mechanisms are tools used to improve the credit risk profile of a business (that is improve its creditworthiness), which should lead to reductions in financing costs.

These credit enhancement mechanisms can be deployed by national entities, or as part of participation in a project by a multilateral lender. We note that some of the credit enhancement mechanisms (such as political risk guarantees) may overlap with some of our suggestions of risk mitigation solutions discussed in Section 14.

The sub-sections below provide examples of credit enhancement mechanisms that may be considered.

Partial risk guarantees

A credit guarantee may be created to absorb part or all of the debt service default risk of a project, regardless of the reason for default. This will reduce the cost of financing for a developer, which should then reduce the tariff required by the developer to pay its financing costs.

Other credit enhancement mechanisms

There are a number of other credit enhancement mechanisms which help to mitigate risks for investors, such as currency swap risks associated with cross-border transactions or the performance risk that efficiency solutions will not achieve a certain level of energy savings.

While there are a range of credit enhancement mechanisms available, the most effective mechanisms will address the largest risks which have not been addressed in the structure of the PPA arrangement. This risk reduction will allow developers to access cheaper financing which should reduce the required feed in tariff (FIT) and lessen the tariff burden on consumers.

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 (UNFCC) and MDBs.

The UNFCC 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). Azerbaijan is a non-Annex 1 country due to its heavy economic reliance on fossil fuel production and related commerce.

The UNFCC Paris Agreement progressed plans for an annual US$100 billion climate finance fund to be made available to non-Annex 1 countries, funded by financial commitments from Annex 1 countries. This goal was reemphasized at COP26 in November 2021 as part of the Glasgow Climate Pact.[26]

The main climate finance mechanisms are the Green Climate Fund (GCF), the Global Environment Facility (GEF) and the Climate Investment Fund (CIF).

The GCF is the centerpiece of efforts to raise climate finance under the UNFCC. It supports projects, programs, and policies in developing economies. As a non-Annex 1 country Azerbaijan is eligible to receive GCF funding.[27] The designated authority in Azerbaijan for the implementation of GCF funding is the Ministry of Ecology and Natural Resources.

The GEF provides funding to assist developing countries in meeting the objectives of international environmental conventions. Regarding renewable energy, GEF funds can be deployed to address policy, regulatory, and technical barriers to the adoption of renewable energy technology, to build capacity and to finance investments in renewable energy, including pathfinder projects.[28] Azerbaijan is eligible to receive assistance from the GEF.

CIF is administered by the World Bank in partnership with the African Development Bank (AfDB), Asian Development Bank (ADB), European Bank for Reconstruction and Development (EBRD), and the Inter-American Development Bank (IDB). Azerbaijan is eligible for support from the CIF, although to date no projects have been supported.

CIF operates through various financing windows including the Clean Technology Fund (CTF) and the Special Climate Change Fund (SCF). These various funding programs provide financing to low and middle income countries. Renewable energy programs under the CIF include:

- Scaling up technologies that enable renewable energy, like storage solutions, grid management and green fuels;
- Enhancing infrastructure to be renewable energy ready through smart grids and grid interconnections;
- Supporting renewable energy innovation, for example by empowering consumers to contribute actively to demand-side management; and
- Enhancing system and market design and operation, through regulatory change and procedural innovation.

The GCF, GEF, and CIF can be used to enable access to additional private finance.

Azerbaijan's eligibility to these sources of climate finance offers an opportunity to progress and accelerate the OSW program in Azerbaijan including the funding of site preparation activities, development of the pathfinder project, decarbonization of the energy system, and strengthening of transmission infrastructure.

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
- 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.

Green bonds have so far not been used to support renewable energy in Azerbaijan.

To support the offshore sector, Azerbaijan could consider adopting an international definition of a 'green' project so that it could label infrastructure projects that meet the criteria, such as offshore wind projects, with the 'green' label. This would help to facilitate increased access to international capital markets for the private developers of these projects, helping to accelerate the development of the offshore wind industry by reducing the costs of finance.

This could reduce the cost of finance for offshore projects, and so reduce the level of charges to energy consumers through their tariffs.

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 three forms of green equity instruments:

- Public-private partnership (PPP), involving a long-term contract between a public entity and a private party that is used to deliver infrastructure or services
- Joint venture (JV), involving an agreement between two or more businesses that pool their capital, skills, and resources for a specific project
- Private equity, equity issued by a developer or business to fund specific projects.

Of these equity instruments, the most relevant policy option from the Government's perspective will be the PPP. Azerbaijan has a history of using PPPs in the oil and gas sector.

18.4 DISCUSSION

To support the development of offshore wind, Azerbaijani energy customers will have to support the difference between its costs and the cost of electricity produced by other means.

There are actions which Azerbaijan can take to reduce the cost of finance for OSW projects that will also reduce the LCOE. Some national policies (for example reducing duties) can transfer the cost from customers to taxpayers and could be considered. A higher priority should be the encouragement of participation in projects by multilateral lenders, the deployment (by national or multilateral lenders) of credit enhancement mechanisms, the deployment of climate finance and the adoption of green standards. This can reduce the cost of financing offshore wind by encouraging greater competition in finance, or by achieving a more efficient allocation of financing risks (for example credit default).

A significant reduction in the cost of offshore wind finance will lead to a material reduction on the overall cost of offshore wind, and hence in the end to lower cost for Azerbaijani electricity customers.

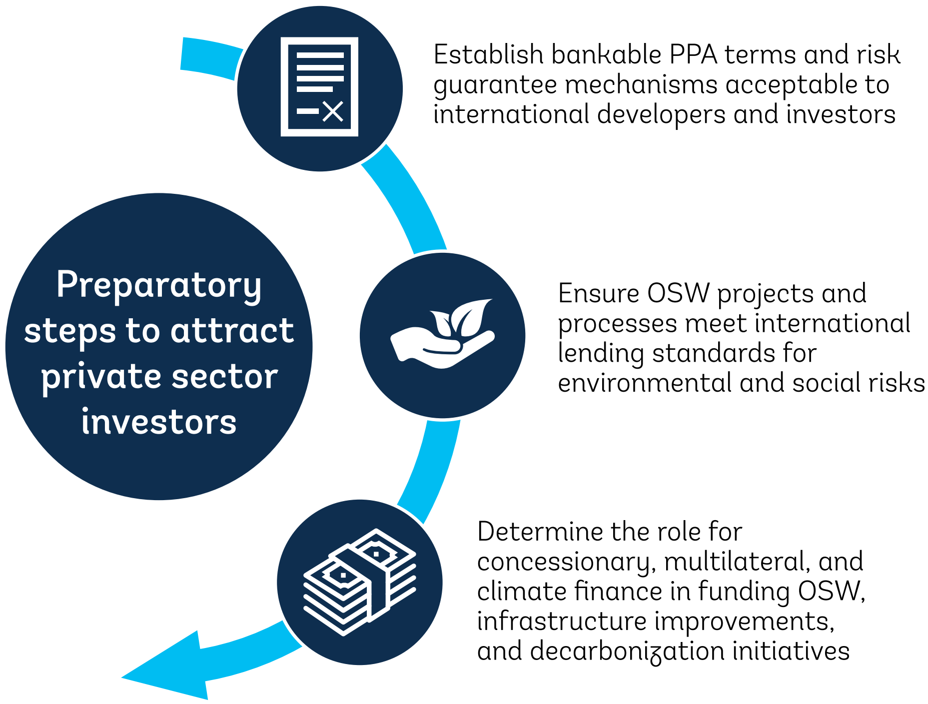
It will be important for Government, investors and developers to identify risk mitigation measures and mechanisms to address financing risks that will impact international and private sector investors in Azerbaijan, including foreign exchange risks.

Consideration will also need to be given to how Azerbaijan will access long-term finance to realize the wider decarbonization of its energy system. This will require Government and financial institutions to work together to find solutions, including the deployment of multilateral, concessional, and climate finance in the form of grants and loans.

To attract international finance OSW projects and supporting processes will be required to meet the environmental and social governance standards such as World Bank's Environmental and Social Framework (ESF)[14] and the Equator Principles[29], which are widely applied in project financing.

Figure 18.1 outlines the preparatory steps that Government should consider taking to structure viable commercial OSW projects in Azerbaijan that can attract international and private sector investment.

FIGURE 18.1 PREPARATORY STEPS TO ATTRACT PRIVATE INVESTORS



18.5 RECOMMENDATIONS

Based on this analysis, it is recommended that:

- Ministry of Energy (MOE) and Azerenerji structure OSW PPA terms to be attractive to multilateral international lending and consider risk guarantee mechanisms that reduce investor risk and the cost of finance and deliver an acceptable sharing of risk between the developer and Azerenerji.
- MOE, Ministry of Economy, and Ministry of Ecology and Natural Resources adopts international standards for environmental and social governance such that projects can attract international finance and Government considers the deployment of concessional, multilateral, and climate finance towards offshore wind and decarbonization in Azerbaijan.

19 SPATIAL MAPPING

19.1 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 Azerbaijan, and to derive OSW development zones.

The maps presented are intended to inform readers of the potential considerations and site characteristics in areas potentially suitable for OSW development.

Only a preliminary analysis is carried out. Additional datasets and further analysis will need to be considered in developing a marine spatial plan or developing an OSW project.

19.2 METHOD

In the sections below, we present:

- Technical potential for OSW in the Azerbaijan based on a simplified assessment
- Environmental, social, and technical considerations
- Environmental and social restrictions and exclusions, based on these considerations
- Levelized cost of energy (LCOE) and
- Potential OSW development zones, based on all of the above.

The following subsections describe the methods used to derive the results in each of these areas.

Technical potential

The analysis was originally described and published in the *Going Global: Expanding Offshore Wind to Emerging Markets* report which estimated Azerbaijan's 'technical potential' to be 35GW for fixed foundation and 122GW for floating foundation OSW technologies.[30] See this document for full methodology.

Technical potential is defined as the maximum possible installed capacity as determined by wind speed and water depth. Mean wind speeds (at 100m height) exceeding 7m/s are considered viable for OSW, and water depths of up to 50m and up to 1000m are considered viable for fixed and floating foundations respectively. The datasets used in this analysis are listed under technical considerations in Table 19.1.

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.

Environmental, social, & technical constraints

The environmental, social, and technical constraints mapping provides additional context about the known locations of environmentally sensitive areas, important land, and costal infrastructure. Most datasets identified are global datasets which include data covering Azerbaijan. Table 19.1 provides a list of the spatial datasets and sources that were included in this constraints mapping activity.

TABLE 19.1 SPATIAL DATA LAYERS INCLUDED IN THE CONSTRAINT MAPPING

Data layer	Notes	Data Source	Reference
Environmental restrictions			
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/
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	https://www.ibat-alliance.org/
Ecologically or Biologically Significant Marine Areas	Internationally agreed marine areas of importance	CDB	http://www.cbd.int/
Marine National Parks	A Marine National Park is defined as an area which includes the sea as well as the adjacent coastal belt	Protected Planet	www.protectedplanet.net
State Nature Sanctuaries	State Nature Sanctuaries allow human activity. A Sanctuary conveys the lowest form of protection when compared to other protection statuses	Protected Planet	www.protectedplanet.net
Marine invertebrates	Distribution of endemic mollusks	The Biodiversity Consultancy report, Appendix D	https://doi.pangaea.de/10.1594/PANGAEA.908169
Waterbird wintering areas	Important natural habitat	The Biodiversity Consultancy report, Appendix D	www.unece.org
Social considerations			
Airports	Regions around airports may need to be avoided to reduce radar impacts	Openflights 2020	https://openflights.org/data.html

Data layer	Notes	Data Source	Reference
Ports	Locations and size of ports		
UNESCO World Heritage Sites (WHS)	Cultural and/or natural heritage sites with outstanding universal value to humanity — no sites identified within the Azerbaijan analysis area	UNESCO	http://ihp-wins.unesco.org/layers/worldheritagesites:geonode:worldheritagesites
Exclusive Economic Zones (EEZ)	Internationally recognized marine boundaries	Marine Eco Regions	https://www.marineregions.org/
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 500m x 500m grid at the Equator) The AIS positions may have been transmitted by both moving and stationary ships within each grid cell, therefore the density is analogous to the general intensity of shipping activity	World Bank	https://datacatalog.worldbank.org/search/dataset/0037580/Global-Shipping-Traffic-Density
Undersea cables	Dataset includes approximate route, official submarine cable system name, cable system length, landing points, and owners	Submarine Cable Map	https://www.submarinecablemap.com/
Offshore oil and gas fields and pipelines	Manually digitized from published map	On The World Map	https://ontheworldmap.com/zerbaijan/map-of-oil-and-gas-in-azerbaijan.html
Military zones	This report did not consider military zones. Further work will be required by Government and Ministry of Defense to establish military considerations as part of future studies.	n/a	n/a
Technical considerations			
Mean wind speed	Used to determine annual energy production (AEP) and LCOE	The Global Wind Atlas v3.0, released in 2019 (Danish Technical University (DTU) and the World Bank Group (WBG))	https://globalwindatlas.info/
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)	https://www.gebco.net/data_and_products/gridded_bathymetry_data/
Seismic activity	Used for information	PREVIEW Global Data Risk Platform	https://preview.grid.unep.ch/

No reliable data sets were obtained for the following social and technical constraints:

- Wrecks and historic offshore sites
- Military and danger areas
- Offshore disposal sites
- Aggregate and material extraction areas
- Marine aquaculture
- Commercial fisheries
- Important tourism and recreation areas
- Historical, religious, and culturally significant sites.

Future spatial analysis as part of a country-scale marine spatial planning exercise will need to consult stakeholders, identify relevant existing data, and gather data on prioritized biodiversity aspects to better understand Azerbaijan's onshore, coastal, and offshore ecosystems.[xvi] It is likely that data gaps in relation to the biodiversity baseline will require additional field surveys to be completed according to Good International Industry Practice to inform spatial planning, site selection, and project-level environmental and social impact assessment.

Environmental and social restrictions and exclusions

For the purposes of defining potential OSW development zones, the range of environmental and social considerations are reduced to four layers:

- Environmental restrictions
- Environmental exclusions
- Social restrictions
- Social exclusions.

The method for reducing to environmental restriction and exclusion layers is presented in Appendix D.

xvi These aspects are likely to include birds, marine mammals, fish, benthic communities, bats, and onshore receptors.

Levelized cost of energy

Certain characteristics of a site will have a large influence on the cost of energy that would result if a project were constructed at that location. 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 an assumed set of reference project characteristics, as shown in Table 19.2, and functions of typical project costs from BVG Associates as inputs into a technoeconomic model which was used to estimate the spatial distribution of the relative LCOE for a reference project in Azerbaijan's waters.

TABLE 19.2 ASSUMED CHARACTERISTICS OF THE REFERENCE WIND FARM PROJECT USED IN THE MODELLING (HIGH GROWTH SCENARIO)

Property	Value
Growth scenario	High
Year of FID (Final investment decision)	2031
Turbine rating (MW)	18
Turbine rotor diameter (m)	230
Turbine hub height (m)	170
Project size (MW)	990
Lifetime (years)	30
Weighted average cost of capital (WACC)	5%
Foundation type	Jacket
Transmission type	HVAC
Operations, Maintenance, and Service (OMS) strategy	Crew transfer vessel (CTV) *

** Use of CTVs was assumed for costing purposes. In practice, CTVs by themselves are not likely to be optimal for some areas (particularly north of the peninsula) due to distances (and hence travel times) from the OMS ports. This is discussed further in Section 21.6.*

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

For the cost analysis we assumed the distance to grid connection to be equal to the shortest distance to shore plus 20km.

We calculated travel distance from the construction and operation ports listed in Section 17.

Potential offshore wind development zones

In order to support the long-term development of OSW in Azerbaijan in the high growth scenario, a strategic approach to OSW and transmission network development will be needed. In support of this, we have derived six potential OSW development zones showing best potential for OSW.

When defining these zones, we considered the following environmental, social, and technical considerations:

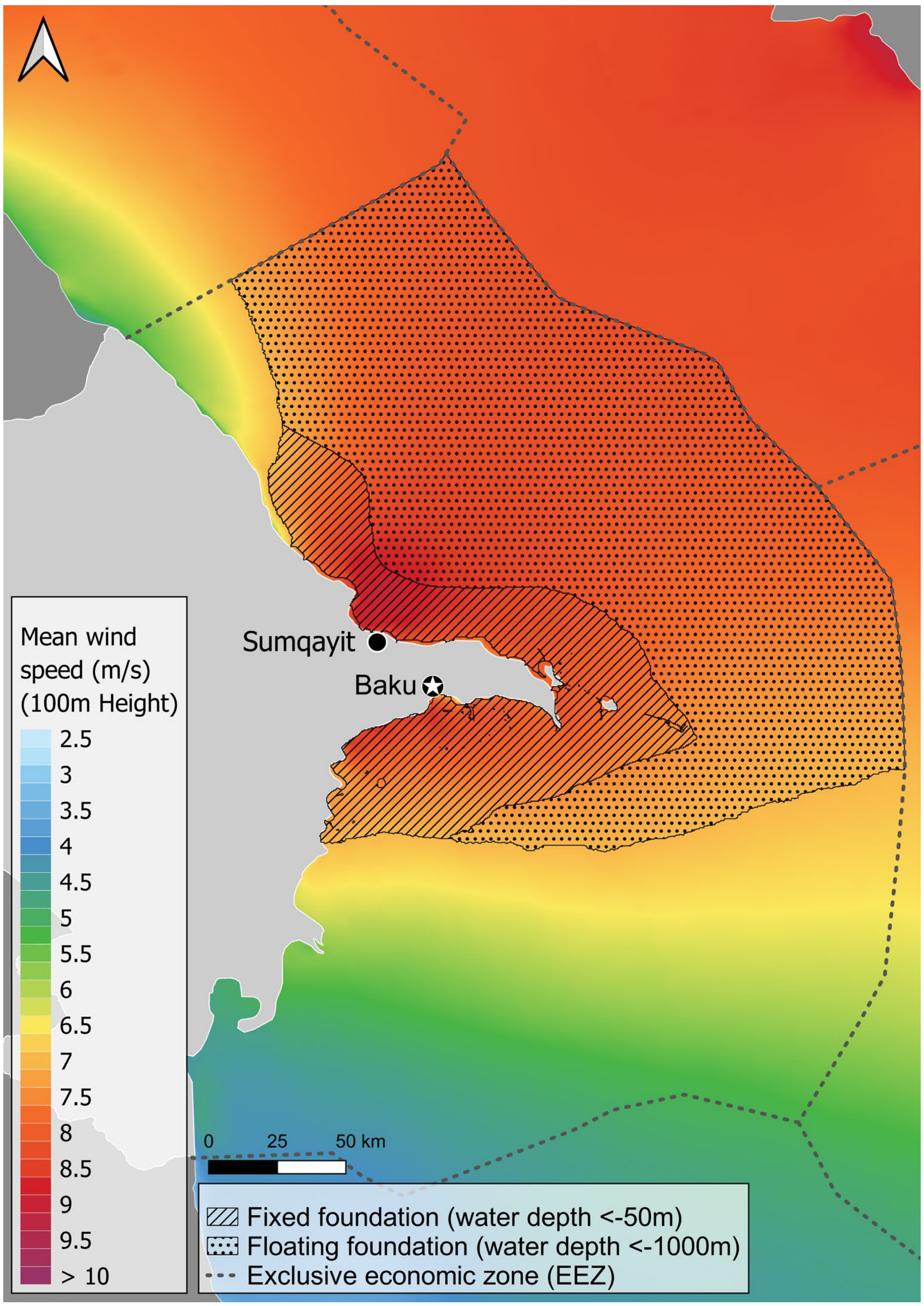
- Exclusions and restrictions based on biodiversity and social considerations
- High shipping density (>10,000,000 hourly AIS position transmittals, 2015 to 2020 inclusive)
- Subsea cable and pipeline routes (with a 1km buffer)
- Minimum distance from shore (chosen to be 10km to address visual impact)
- Maximum water depth (50 m).

19.3 RESULTS

Technical potential

The technical potential determined from previous analysis by Energy Sector Management Assistance Program (ESMAP) and WBG is shown in Figure 19.1.

FIGURE 19.1 TECHNICAL POTENTIAL FOR OFFSHORE WIND (ESMAP)

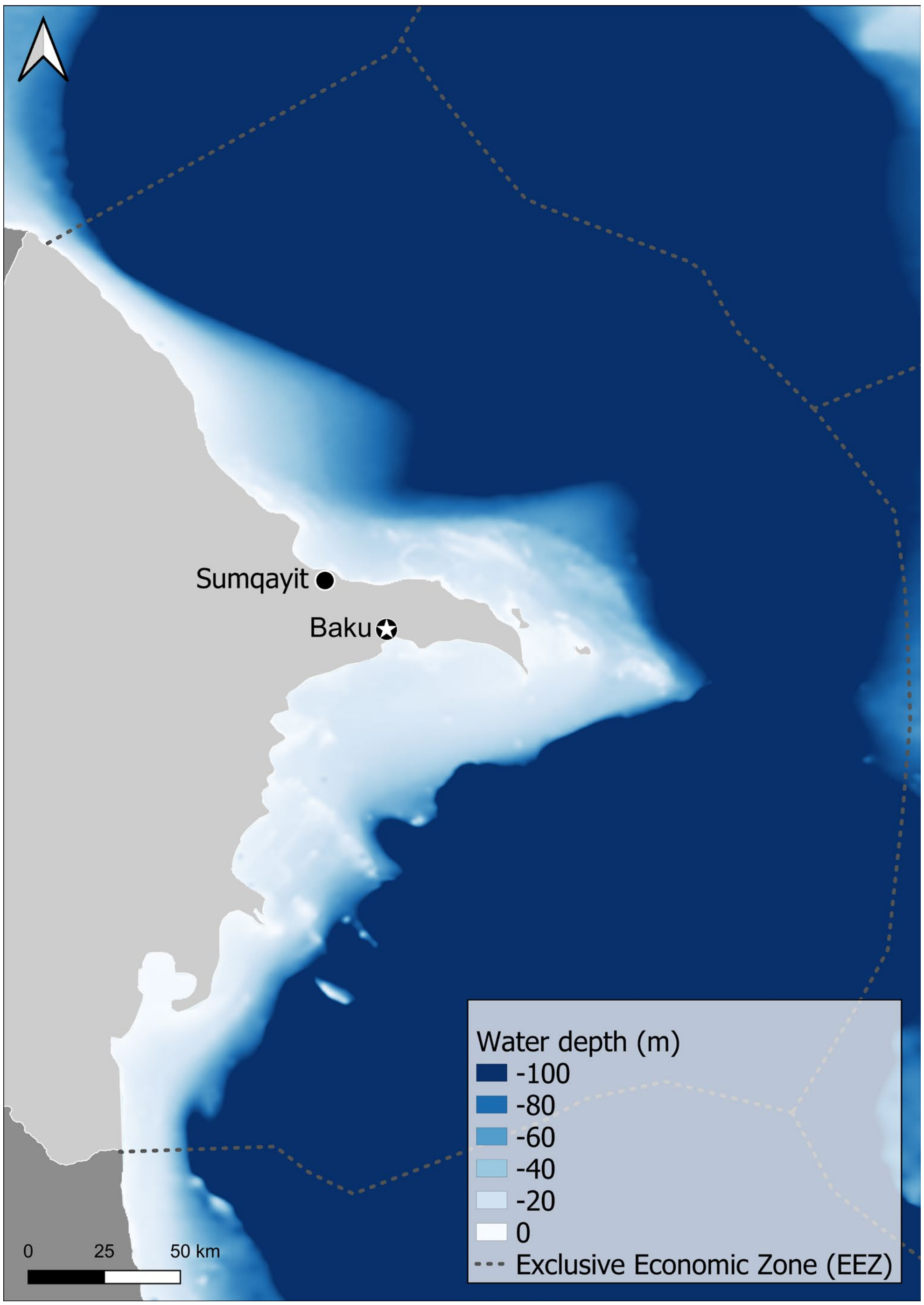


Environmental, social, and technical considerations

Water depth

Figure 19.2 shows water depth in Azerbaijan. There are many areas of shallow water, coupled with good wind resource (see Figure 19.2), pointing to the adequacy of fixed foundation projects.

FIGURE 19.2 WATER DEPTH



Shipping densities

Shipping routes are important to consider when siting OSW projects. Larger vessels, in particular, cannot pass through an OSW farm and need to chart a course a safe distance away from projects. Smaller vessels may be able to transit through a wind farm but there is a risk of collision with the offshore structures. A navigational risk assessment needs to be carried out, including consultation with Azerbaijan's maritime authorities and shipping.

Areas of relatively high shipping density are shown in Figure 19.5.

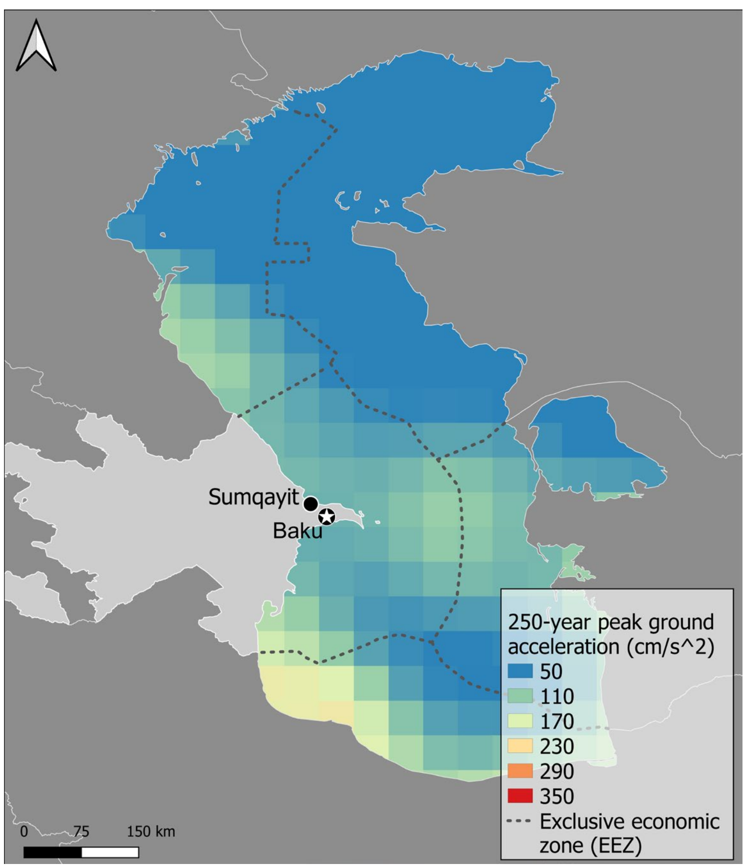
Extreme wind speeds

The Caspian Sea does not suffer from intense cyclonic weather patterns so extreme wind speeds are not considered a significant factor for OSW in Azerbaijan.

Seismic activity

The key challenge of seismic activity relates to the integrity of the foundation and tower. Monopiles are seen as the most susceptible to seismic risks, followed by jackets, then floating foundations. Both ground accelerations and resulting waves are important to consider. In Azerbaijan, the key challenge would seem to be for fixed projects though the overall risk is low. See Figure 19.3, using data from the PREVIEW Global Data Risk Platform.[31]

FIGURE 19.3 SEISMIC ACTIVITY



Environmental and social restrictions and exclusions

Environmental restrictions and exclusions

Environmental considerations are shown in Figure 19.4. They are split into exclusions (areas where offshore wind farms cannot be deployed due to the high sensitivity of the designation) and restrictions (areas where offshore wind farms may be deployed under caution).

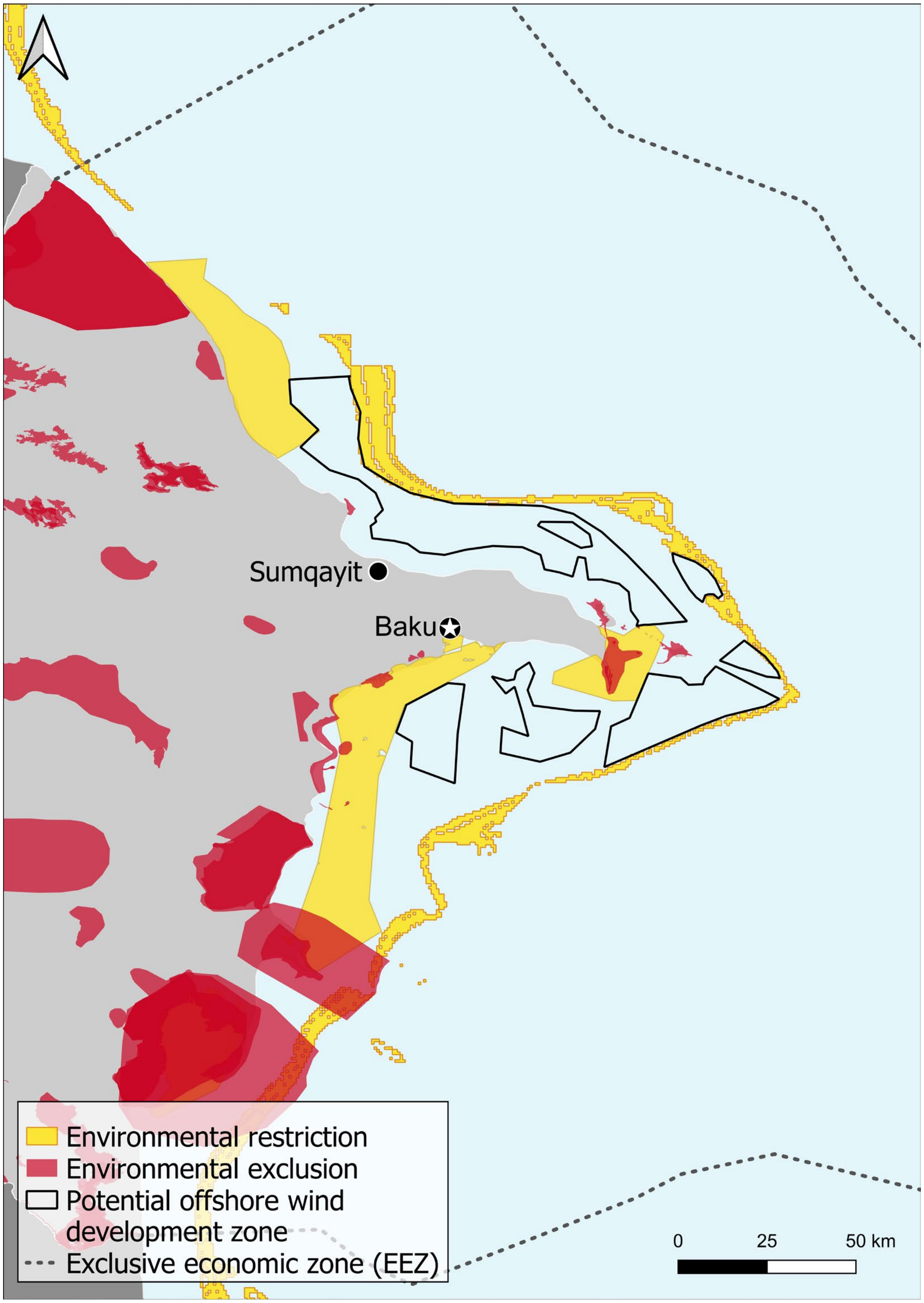
Excluded areas include:

- Ecologically or Biologically Significant Areas (EBSAs)
- Key Biodiversity Areas (KBAs)
- Ramsar sites
- Marine Natural Parks and
- State Nature Sanctuaries.

Restricted areas include:

- Endemic mollusk beds
- Wintering birds areas

FIGURE 19.4 ENVIRONMENTAL RESTRICTIONS AND EXCLUSIONS

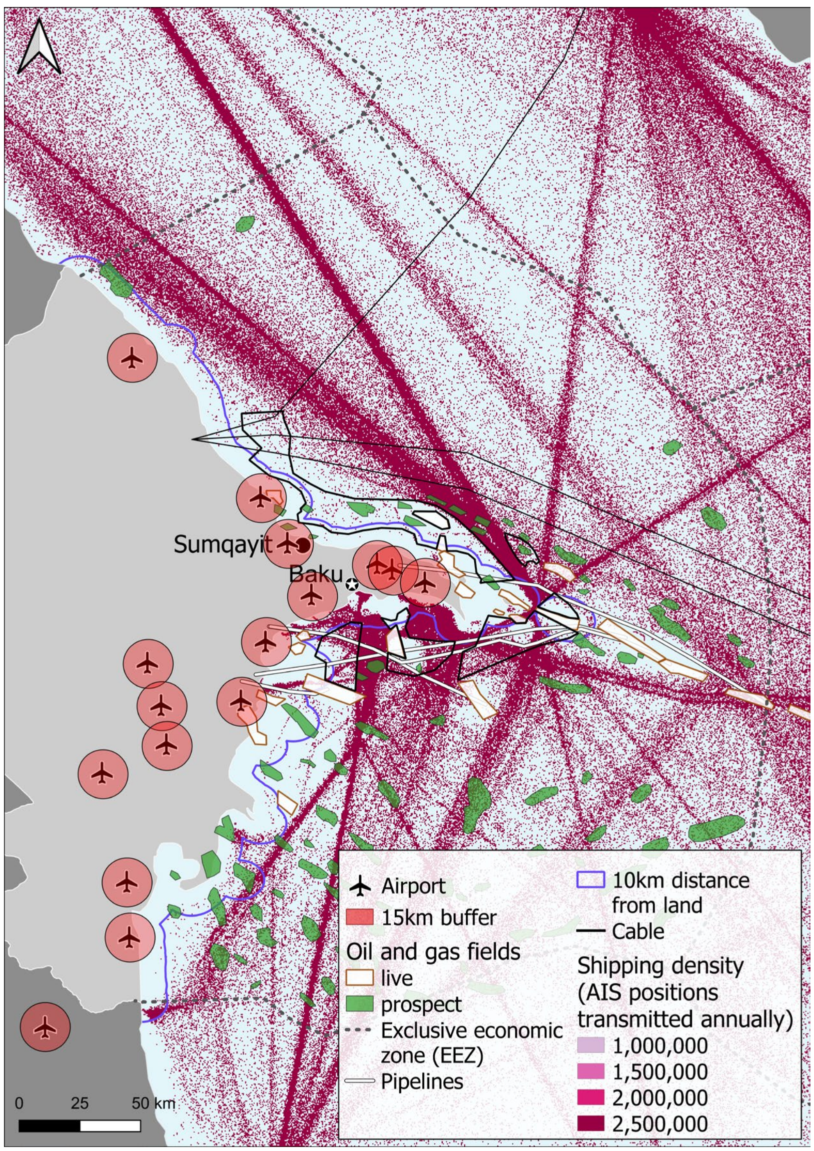


Social restrictions and exclusions

Figure 19.5 shows the social restrictions and exclusions. These include:

- Airports, with a buffer area
- Port areas
- Undersea cables
- High shipping densities
- Oil and gas fields and pipelines and
- Considerations for visual amenity, using distance from shore as a proxy.

FIGURE 19.5 SOCIAL RESTRICTIONS AND EXCLUSIONS

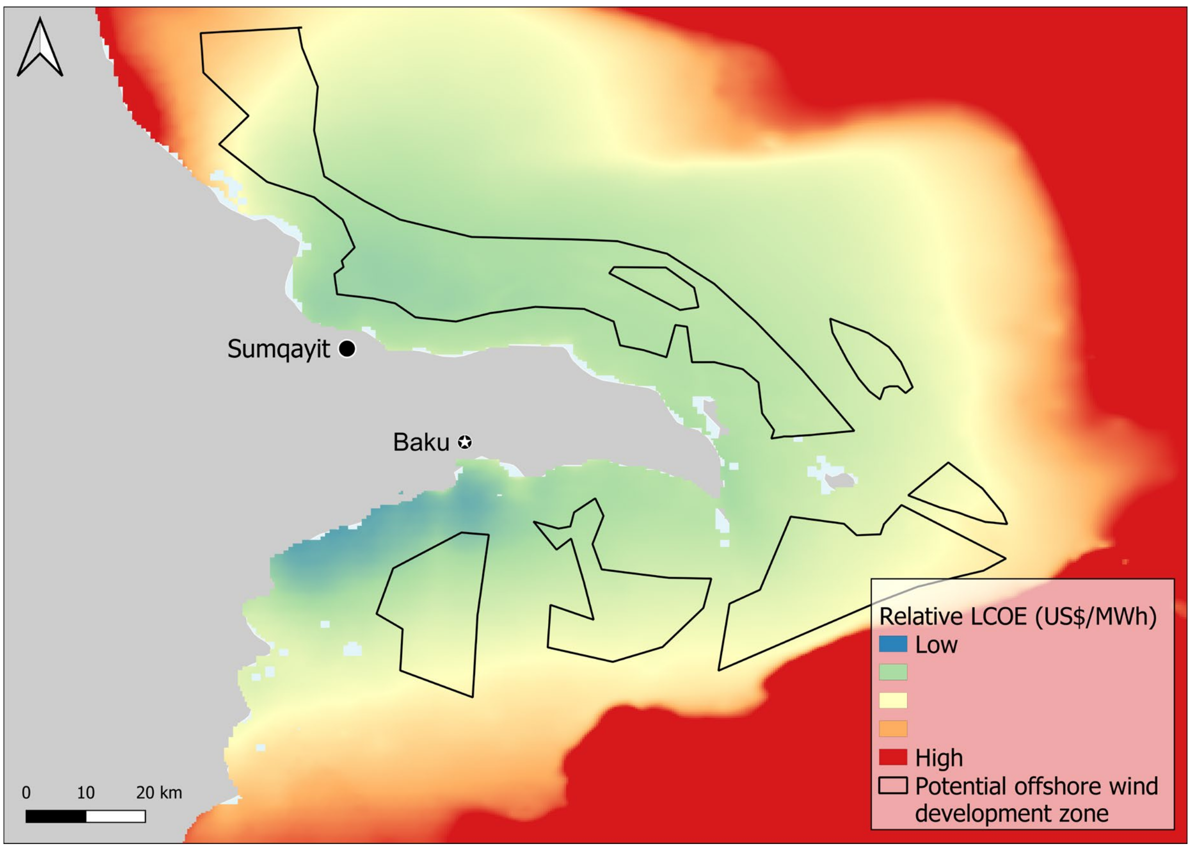


Levelized cost of energy

The cost of energy from OSW is an important factor in determining the viability of projects and different sites. The wind speed is the most critical factor as this determines the energy production. Figure 19.6 shows the relative LCOE distribution in 2031 in the high growth scenario.

The distribution of LCOE follows trends that are present in the technical potential mapping. Areas with high wind speeds, shallower waters, and closer to shore and ports have lower LCOE. In particular, this applies to the areas off the Absheron peninsula close to Baku.

FIGURE 19.6 RELATIVE LCOE FOR A REFERENCE PROJECT IN AZERBAIJAN IN 2031 IN HIGH GROWTH SCENARIO



Potential offshore wind development zones

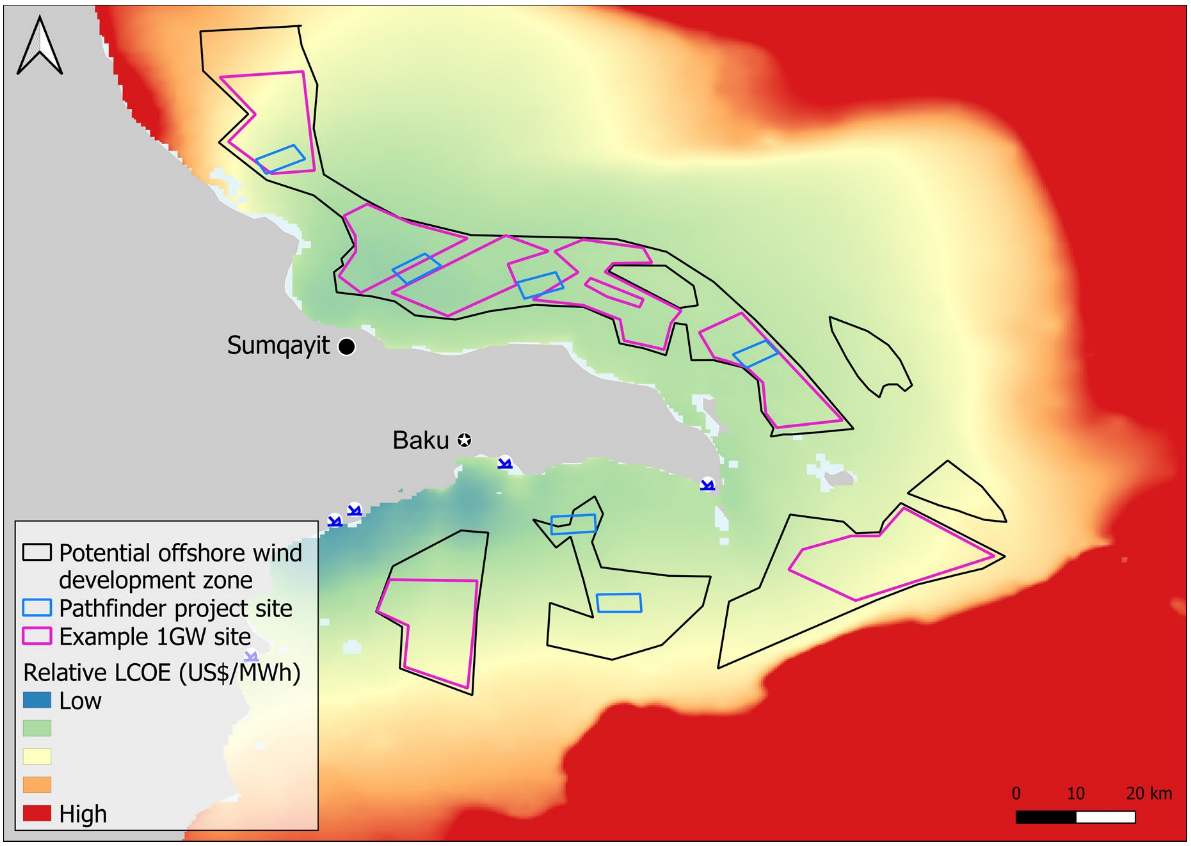
Considering the environmental and social exclusions discussed above, we identified six potential OSW development zones. These are shown in Figure 19.7. In addition, we show the proposed location of the 210MW pathfinder project site (blue; see Section 21) and how 7GW of capacity can fit in these areas, shown as 1GW example sites.

The example sites are for illustration only, with the aim to show how much area of seabed will be required to reach the 7.2GW high growth scenario target. It shows that the northern side of the peninsula will likely be heavily populated with OSW projects (four to five GW, with little break between), though there is scope for expanding into some unused OSW development zones in order to spread the developments more evenly.

The example 1GW sites to the north of the Absheron peninsula are all around 200km^2 providing a capacity of around 1GW assuming a density of 5MW/km^2. Example site 5 is larger at 235km^2. This allows for greater spacing due to sub-optimal shape (it does not align well with the prevailing wind direction). The prevailing wind direction on the north side of the peninsula is NNW, and on the south side it is northerly.

Example sites 6 and 7 are larger still at 270km^2 and 335km^2 respectively to make allowance for the heavily trafficked sea lanes that go through them.

FIGURE 19.7 PROPOSED OSW DEVELOPMENT ZONES AND EXAMPLE SITES WITH CAPACITY 7GW



19.4 DISCUSSION

These maps show that large areas of Azerbaijan's territorial waters are likely to be well suited to OSW development. Some areas, particularly to the north of the Absheron peninsula, have relatively strong high wind speeds and are close to the onshore transmission grid as well as load centers.

The definition of these zones has accommodated a limited number of considerations. There are other sources of information which will need to be included for a more accurate assessment of the potential capacity. These include:

- Commercial interests, such as fishing areas

- Environmental considerations, detailed information on priority biodiversity values such as threatened species
- Social considerations, such as visual impact and tourism activities
- Technical aspects, such as seabed geology and metocean conditions and
- Enabling infrastructure, such as grid capacity and port facilities (initial assessments of both are included in this report).

The majority of considerations are "soft", meaning they are not exclusive by default, but some allowance will typically need to be made to accommodate them. Wind farms can be built in or near shipping lanes and fishing areas, but stakeholder engagement is key to making that a successful collaboration.

There may be particular cumulative impact considerations regarding the OSW wind development zone on the north side of the Absheron peninsula, both regarding visual and environmental impacts.

In Section 8 we discuss the potential for further floating OSW projects coming online between 2040 and 2050. Initial analysis shows that there is significant space that is many times more than sufficient for this additional capacity in Azerbaijan's waters, using areas further offshore than the potential OSW development zones to the north of the Absheron peninsula. Sites located in these areas have deeper water and marginally lower wind resource than the potential OSW development zones identified in this report.

19.5 RECOMMENDATIONS

Based on this analysis, it is recommended that:

- Ministry of Energy (MOE) undertakes a proportionate marine spatial planning (MSP) process to inform project identification.
- MOE initiates or coordinates measurement and data gathering campaigns on key technical aspects of the potential OSW development zones including:
  - Wind resource measurement
  - Metocean campaigns also considering significant wave heights and currents
  - Geological surveys of the seabed and substrates
  - Ecological surveys to address any identified gaps in current knowledge of the zones and
  - Social perceptions and effect on local industries such as fishing, aquaculture, and tourism.

Note that recommendations regarding the requirement for marine spatial planning and the identification and designation of OSW projects are provided in Sections 11 and 14 respectively.

20 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 Azerbaijan.

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 and
- Identifying priority biodiversity values, 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 (MSP) and environmental and social impact assessment (ESIA), and a non-exhaustive list of key stakeholders has been identified and is provided in Table 20.1 under five headings:

- *Government.* Government departments, regulators, and institutions at national and regional level
- *Project developers.* OSW project developers known to be active in Azerbaijan
- *Supply chain.* Supply chain businesses known to be active in OSW in Azerbaijan, or those with potential to provide services
- *Non-governmental organizations (NGOs).* National and international NGOs with an interest in OSW in Azerbaijan, including those involved in international development
- *Academic institutions.*

By nature, this list is dynamic and as interest in the market continues to increase, it will be outdated soon after publication.

TABLE 20.1 KEY STAKEHOLDERS

Name	Role
Government	
Azerbaijan Energy Regulatory Agency	Government department responsible for the regulation of relations between producers, shippers, distributors, suppliers, and consumers in the field of electricity and thermal energy, as well as gas supply in the Republic of Azerbaijan.
Azerbaijan Renewable Energy Agency	Government department responsible for the arrangement, regulation, and efficient use of renewable energy sources in the Republic of Azerbaijan.
Ministry of Ecology and Natural Resources	Government department responsible for regulations to do with ecology, environmental protection, and use of natural resources of Azerbaijan.
Ministry of Ecology and Natural Resources — Division for Management of Water Reserves	Government agency.
Ministry of Ecology and Natural Resources — Division for Ecological Awareness and Public Relations	Government agency.
Ministry of Ecology and Natural Resources — National Hydrometeorology Department	Government department responsible for hydrometeorological services such as weather forecasting, studying geophysical processes, and studying climate change.
Ministry of Defense	Government agency responsible for national defense.
Ministry of Economy	Government department responsible for economic policy, promoting economic growth, entrepreneurship, industry, consumer rights, state assets, and taxes.
Ministry of Emergency Situations	Government department responsible for protecting the public from natural and man-made disasters such as fire, flooding, or pollutants.
Ministry of Energy	Government department responsible for implementing state policy and regulations in the fuel and energy sectors.
Natural History Museum	Largest museum in Azerbaijan, located in Baku.
State Maritime Agency	Government department responsible for managing maritime activities in Azerbaijan, including drafting of maritime legislation, regulation of shipping, search and rescue, and control over navigational aids.
Sumqayit Center for Environmental Rehabilitation (ECOPARK)	Government and UN funded agency that aims to increase and strengthen environmental awareness among the general public through various activities, publications, conferences, workshops, and training.
Swiss National Science Foundation & Swiss Agency for Development and Cooperation — Sustainable Caucasus Project	Swiss Government agency project to support regional scientific networking in the Caucasus.

Name	Role
Project developers	
ACWA	Renewable energy developer from Saudi Arabia, developing onshore wind project in Azerbaijan.
BP	British multinational oil and gas company. Signed a memorandum of understanding (MoU) with the Ministry of Energy to investigate opportunities for developing the country's renewable energy sources.
Copenhagen Infrastructure Partners	International offshore wind developer, headquartered in Denmark.
Equinor	Equinor is Norwegian state-owned multinational energy company, which has oil and gas interests in the Caspian Sea.
Masdar	United Arab Amirates Government owned renewable energy company, developing solar energy projects in Azerbaijan.
State Oil Company of the Azerbaijan Republic (SOCAR)	Fully state-owned national oil and gas company. Has shown interest in floating wind as a means to power offshore oil platforms.
TotalEnergies	French multinational integrated oil and gas company with assets in the Caspian Sea.
Supply chain	
ADO-G	Supply chain business (Tower, onshore infrastructure and array and export cable installation).
ASCO	Supply chain business (Turbine and foundation installation).
Azerbaijan Caspian Shipping Company	Joint stock company with offshore and transportation fleets. Has experience in oil and gas platform construction.
Azfen	Construction and engineering firm that provides services to oil companies in the Caspian region. Offshore substation (OSS) supply and balance of plant and maintenance services.
Baku International Sea Trade Port	Sea port located in the Bay of Baku.
Baku Shipyard	Integrated shipyard providing shipbuilding, ship repair, conversion, and engineering services for the marine and offshore industry around the Caspian Sea. Foundation supply and OSS supply.
Bos Shelf	Supply chain business (Foundation supply and OSS supply).
Caspian Geomatics	Supply chain business (Development and project management).
Caspian Marine Services	Supply chain business (Wind farm operation).
Encotec	Engineering consultants.
Enermech	Global services company specializing in critical asset support.
Fugro	Supply chain business (Development and project management).
GeoGlobe	Supply chain business (Development and project management).
Glensol	Supply chain business (Turbine maintenance and service and balance of plant maintenance and service).

Name	Role
Jan de Nul	International construction and maintenance of maritime infrastructure firm.
Kent	Supply chain business (Development and project management).
Nobel Oil	Oil and natural gas producer primarily working in the Republic of Azerbaijan, UK, US, and Romania.
OGCT (SOCAR's Construction Entity)	Company responsible for the maintenance and construction of deep-water and shallow-water offshore facilities and onshore facilities for SOCAR.
Rapid Solutions	Supply chain business (Balance of plant and maintenance services).
Shah Deniz Consortium	Supply chain business (Turbine and foundation installation).
SOCAR's Baku Deepwater Jacket Factory	Responsible for fabricating deep-water jackets for the development of oil and gas fields.
Sumqayit Technology Park	Supply chain business (Tower, array, and export cable supply).
TechnipFMC	Project management, engineering, and construction for the energy industries. Developing a floating OSW project in Azerbaijan to supply offshore oil and gas platforms, in partnership with SOCAR.
Wood	Supply chain business (Development and project management and balance of plant maintenance and service).
Worley	Supply chain business (Development and project management).
Zigh Port	Sea port to the east of Baku.
Zira Port	Sea port to the east of Baku.
Non-governmental organizations	
Azerbaijan Ornithological Society (AOS)	National affiliate of BirdLife International.
Azerenerji	An Azerbaijan-state owned joint stock company. The largest electricity producer in the country. Also owns the largest distribution network. Responsible for power purchase agreements (PPAs) and transmission agreements with OSW operators.
AzerIshiq	The electrical grid operator for Baku. Gives permission to connect to the network.
Caspian Centre for Energy and Environment	Institution associated with the ADA University that provides academic research, teaching, and training in topics relating to energy and the environment.
Danish Energy Agency (DEA)	The Danish Energy Agency is responsible for energy policy and regulation in Denmark and efforts to reduce carbon emissions, including the delivery of international renewable energy programs.
European Bank for Reconstruction and Development	International financial institution (IFI) that is committed to fostering the transition towards open market-oriented economies and promoting private and entrepreneurial initiative.
International Dialogue for Environmental Action (IDEA)	International campaign launched in Baku to encourage environmental awareness.
GIZ	German government agency that provides services in the field of international development cooperation and international education work.

Name	Role
GRID-Arendal	Non-profit environmental communications center collaborating with the UN.
GWEC	Global Wind Energy Council, international trade body for the wind energy industry.
International Finance Corporation	International financial institution that provides funding to capital projects in developing economies.
Ornithological Society of the Middle East (OSME) The Caucasus and Central Asia	British-based ornithological and birdwatching club for people interested in the birds of the Middle East, the Caucasus, and Central Asia.
REC Caucasus	Non-profit that aims to assist in solving environmental problems as well as development of the civic society in the countries of the South Caucasus.
UK Department for International Trade	UK Government department responsible for striking and extending trade agreements between the United Kingdom and foreign countries, as well as for encouraging foreign investment and export trade.
UNDP Azerbaijan	Azerbaijani arm of the United Nations Development Programme.
World Bank Group	International development bank that provides funding and technical assistance in developing countries.
WWF-Caucasus	International NGO that works in the field of wilderness preservation and the reduction of human impact on the environment.
Academic institutions	
Azerbaijan National Academy of Sciences Institute of Botany — Society of Azerbaijani Botanists	Research center studying flora of Azerbaijan Republic.
Azerbaijan National Academy of Sciences Institute of Geography — Centre of the Caspian Sea Problems	Studies the hydrological, morphological, geological, and geo-morphological as well as socio-economic aspects in the Caspian Sea basin.
Azerbaijan National Academy of Sciences Institute of Geology and Geophysics	Research institute studying geology and geophysics.
Azerbaijan National Academy of Sciences Institute of Zoology	Research institute studying zoology.
Azerbaijan National Academy of Sciences (ANAS) National Museum of History of Azerbaijan	Largest museum in Azerbaijan, located in Baku.
Azerbaijan Technical University	Public university that specializes in engineering.
Azerbaijan University	Private university located in Baku.
Baku State University	Public university located in Baku.
Goodman Ecology & Evolution Lab — Leeds University	Lab associated with Leeds University that conducts research at the interface of population and evolutionary genetics, disease ecology, and conservation biology.

21 PATHFINDER PROJECT

21.1 PURPOSE

In this section, we summarize the identification, outline design, and programme development for a fixed-bottom offshore wind (OSW) pathfinder project and define further studies and surveys that will be required. The purpose of such a site is to help accelerate the industry by enabling delivery of a first, small project that demonstrates OSW in Azerbaijan, starts to develop the local supply chain, and helps prove physical, commercial, and legal processes. The 210 MW demonstration site will be developed as part of the first tranche of capacity to be progressed under the Government led procurement process outlined in Section 13. The design of the pathfinder project is based on the assumptions in the low growth scenario, including the use of jacket foundations. Were the pathfinder project to be based on the assumptions of the high growth scenario the resulting project specific levelized cost of energy (LCOE) would be lower due to the use of monopile foundations and installation methods.

The project capacity of 210MW was selected as it is:

- Large enough to provide impetus to the frameworks required to deliver OSW in Azerbaijan
- Large enough to encourage the first steps of local supply chain development
- Large enough to allow meaningful assessment of social and environmental impacts and
- Small enough that it can be developed and delivered by 2028, in line with the low and high growth scenarios.

21.2 METHOD

To develop an outline design and delivery programme we carried out:

- Site selection, where we identified potential development areas and selected a preferred site
- Site initial design, where we developed preliminary project concepts, including turbine model and site layout
- Balance of plant initial design
- Installation strategy initial design
- Operational strategy initial design and
- Sourcing strategy initial design.

Finally, we developed a timeline for the project and developed an initial cost and LCOE estimate.

21.3 SITE SELECTION

Identification and selection of pathfinder project site

The main principles for selecting a site are:

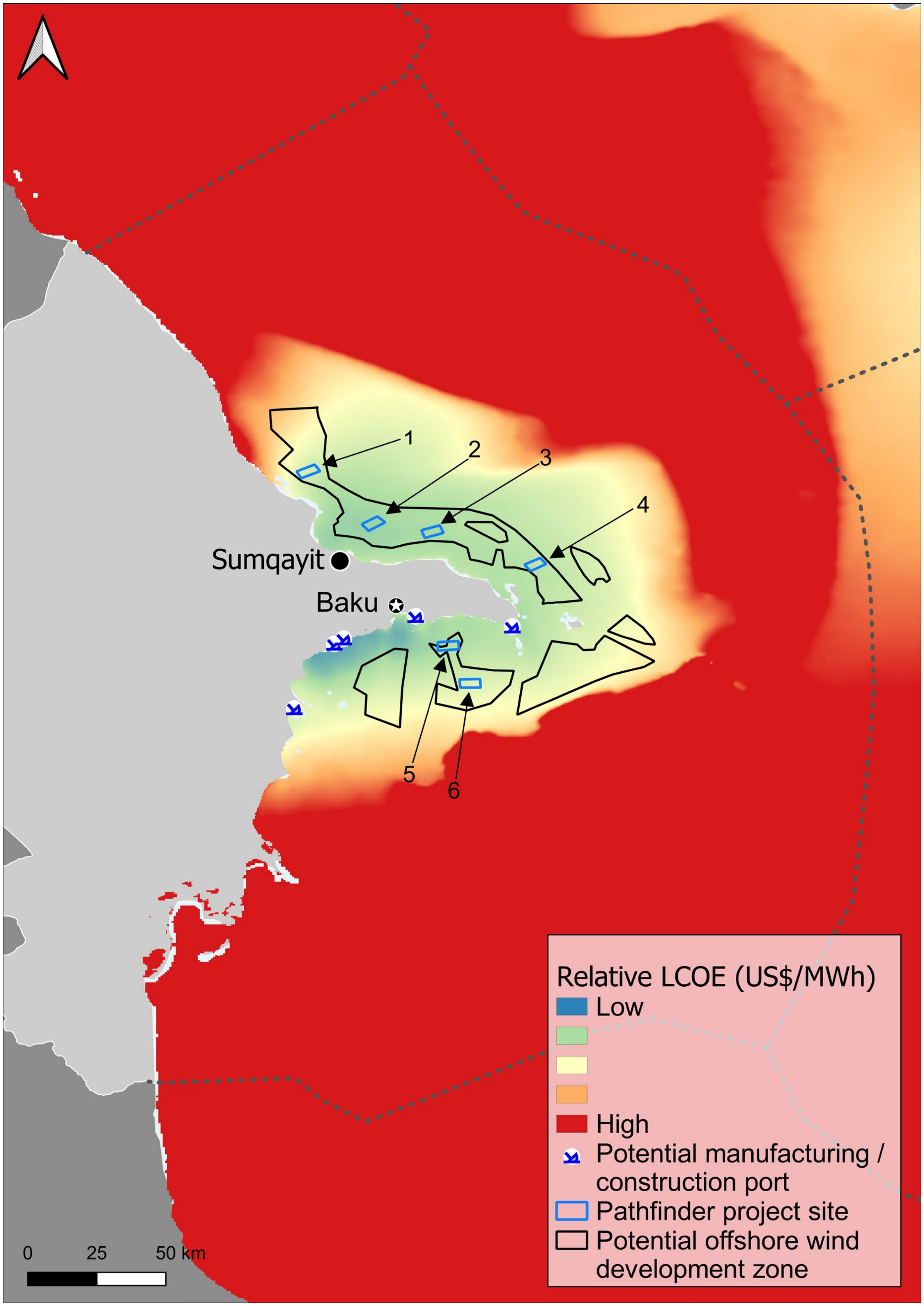
- To achieve the lowest cost of energy
- Ensure the highest likelihood of a successful project and
- Avoid exclusion areas and future large-scale OSW sites.

To identify a suitable location for this site we considered:

- LCOE
- Distance from shore (chosen to be a minimum of 10km to address visual impact)
- Proximity and sensitivity to environmental restrictions and exclusions, including for cable routes and landfall
- Proximity and sensitivity to social and technical restrictions and exclusions and
- Capability of the local transmission network.

We used the spatial datasets and process identified in Section 19 to identify six potentially suitable pathfinder project locations, then applied a quantitative assessment of these six sites to arrive at a final recommendation. The six sites are shown in Figure 21.1.

FIGURE 21.1 POTENTIAL PATHFINDER PROJECT SITES



The winds to the north of the Absheron peninsula are predominately north-north-westerly in direction, and those to the south of the peninsula are predominately northerly, based on data from the Global Wind Atlas.[32] The areas shown are all approximately 40km^2 in area which is sufficient to accommodate a 210MW wind farm. We have aligned the long edge of the rectangular site boundaries perpendicular to the predominant wind direction to minimize wake losses.

Table 21.1 summarizes the attributes of each of the six sites. The values in the columns are color coded, showing red for the least favorable, green for the most favorable, and amber for the remaining.

TABLE 21.1 SUMMARY OF POTENTIAL PATHFINDER PROJECT SITES

ID	Site	Wind speed (m/s) @ 100m	Distance to shore (km)	Water depth (m)	Distance to Construction port (km)	LCOE ranking*
1	**Gilazi**	8.5	15	30	296	Higher
2	**Sumqayit**	8.8	21	26	254	Lower
3	**Bilgah**	8.6	16	26	223	Lower
4	**Pirallahi**	8.1	15	24	172	Mid
5	**Baku 1**	8.2	14	13	70	Mid
6	**Baku 2**	7.9	33	16	49	Higher

** Relative to the other demo sites, considering relative LCOE under the high growth scenario.*

A high-level analysis of sites is provided in the following sections. This analysis draws on the findings of Sections 11, 16, 17, and 19.

1 Gilazi

The Gilazi site has relatively low wind speeds, deep water, and is remote from construction ports, all of which contribute to a mid-to high LCOE.

Some turbines will be close to the 10km limit from shore, presenting an increased chance of negative visual impact.

The site is close to the 15km buffer around Sital Chay airport which may present complications for air traffic considerations.

The site is relatively close to the KBA at Yashma Island and is close to the mollusk and wintering bird areas identified as restrictions.

The site is not significantly impacted by, or near to, other infrastructure such as shipping or oil and gas facilities.

It is likely that 210 MW can be accommodated on the local grid without significant upgrades or curtailment although detailed network studies will be required to confirm this.

2 Sumqayit

Sumqayit is the site with the lowest expected LCOE.

Closest turbines will be 10 to 15 km from shore and visible from Baku, Sumqayit, and tourism beaches.

The site is within 10 km of known prospective oil and gas fields but does not overlap them.

There are no known environmental exclusions or restrictions nearby.

It is likely that 210MW can be accommodated on the local grid without significant upgrades or curtailment although detailed network studies will be required to confirm this.

3 Bilgah

Bilgah is the site with second lowest expected LCOE, being only marginally higher than Sumqayit.

Closest turbines will be 10 to 15km from shore and visible from Baku, Sumqayit, and tourism beaches.

The site is close to several prospective oil and gas fields but does not overlap them.

It is within 10km of the restricted mollusk areas to the north, but construction and operations traffic is not expected to impact this.

It is likely that 210MW can be accommodated on the local grid without significant upgrades or curtailment although detailed network studies will be required to confirm this.

4 Pirallahi

Pirallahi has a relatively high LCOE.

Closest turbines will be around 10km from shore, and visible from Baku, Sumqayit, and tourism beaches.

The site is within 10 km of known prospective oil and gas fields but does not overlap them. There are however significant oil and gas fields located between it and the shore and this may complicate cable routes and permitting for the export system.

The Shadidi Spit KBA is also between the site and potential cable landfall, which increases the environmental sensitivity of the site.

It is likely that 210MW can be accommodated on the local grid without significant upgrades or curtailment although detailed network studies will be required to confirm this.

5 Baku 1

Baku 1 has a medium LCOE.

Closest turbines will be around 10km from shore and will be very visible from Baku. Even though it is beyond the 10km limit, this may not be acceptable for visual impact given the heavily populated area.

The significant oil and gas fields of Gum Island are located between it and the shore (and Bahar and Gum is very close to the south) and this may complicate permitting and negotiation with other key stakeholders. It is possible that there is too much existing interest in this area from the O&G industry to consider this site as a viable location for OSW.

It is close to wintering bird restricted areas. These lie on the shore-side of the site, so cable landfall and site traffic will both likely face close scrutiny on their impacts.

It is likely that 210MW can be accommodated on the local grid without significant upgrades or curtailment although detailed network studies will be required to confirm this.

6 Baku 2

Baku 2 has the highest LCOE.

All turbines will be over 20km from shore. This should be acceptable for visual impact even if they will be seen from Baku.

The site is within 5km of the known Bahar and Gum and gas field but does not overlap it. As with Site 5, there are significant oil and gas fields located between it and the shore and this, together with the same wintering bird areas as mentioned for Site 5, may complicate permitting and negotiation with other key stakeholders. It is possible that there is too much existing interest in this area from the oil and gas industry to consider this site as a viable location for a wind farm.

Access to the site will cross heavily-used shipping lanes.

It is likely that 210MW can be accommodated on the local grid without significant upgrades or curtailment although detailed network studies will be required to confirm this.

Choice of pathfinder project site

Our rating of each site is shown in Table 21.2. Scoring for each category is based on the following scale:

- 1 = low risk / most attractive to
- 5 = high risk / least attractive.

TABLE 21.2 RATING OF POTENTIAL PATHFINDER PROJECT SITES

ID	Site	Engineering	Permitting	Infrastructure	LCOE	Overall (lowest is best)
1	**Gilazi**	3	2	4	5	14
2	**Sumqayit**	3	4	2	1	10
3	**Bilgah**	3	3	2	1	9
4	**Pirallahi**	3	4	3	3	13
5	**Baku 1**	3	5	3	3	14
6	**Baku 2**	3	3	3	5	14

Given the scoring presented in Table 21.2 together with the considerations listed above, Bilgah was identified as the most appropriate site to take forward as a pathfinder project.

21.4 SITE INITIAL DESIGN

Preliminary project concept

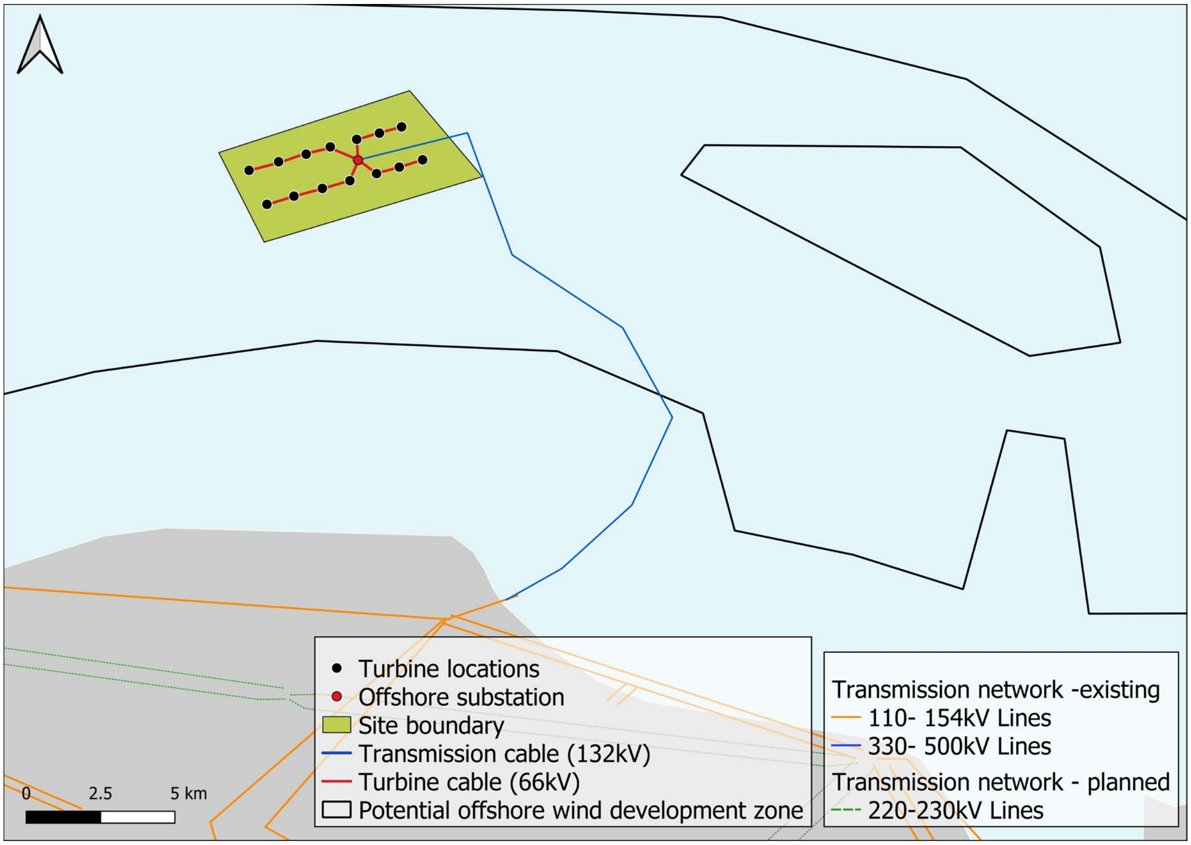
Key parameters of the pathfinder project site are listed in Table 21.3, based on the choice of Bilgah, the purpose and timing of the pathfinder project, and international good practice. Whilst the initial design concept is specific to the Bilgah location, the other five sites have similarities to Bilgah and the design concept is broadly applicable to the other potential pathfinder project locations.

TABLE 21.3 KEY PARAMETERS OF THE PATHFINDER PROJECT SITE

Parameter	Units	Value
Target project capacity	MW	210
Commercial operation date		2028
Financial investment decision		2025
Number of turbines		14
Turbine rating	MW	15
Rotor diameter	m	224
Mean wind speed (100m height)	m/s	8.6
Mean water depth	m	24
Foundation type		Jackets
Offshore export distance	km	31
Onshore cable distance	km	5
Transmission technology		HVAC offshore substation
Distance from construction port	km	210
Distance from O&M port	km	17

Based on the identified location, metocean conditions, wind resource, and good industry practice, we developed the preliminary layout shown in Figure 21.2.

FIGURE 21.2 PRELIMINARY LAYOUT OF PATHFINDER PROJECT SITE



Turbine selection

The wind farm will consist of 14 wind turbines. Each turbine will have a generating capacity of 15MW, in line with anticipated state-of-the-art options available for 2028 installation. For the purpose of evaluating LCOE and other site-specific impacts, we have used a generic design from no specific manufacturer. An approximate guide to the general dimensions of such a 15MW turbine are as follows:

- Rotor diameter: 224m
- Hub height: 150 to 170m
- Nacelle mass: 550 to 700t
- Tower base diameter: 8m
- Tower top diameter: 5m
- Tower mass: 700 to 900t.

There are further issues to consider when finalizing the turbine choice as part of a front end engineering and design (FEED) study, including:

- IEC rating of the site, to be determined by the wind measurement campaign
- Larger turbines, and larger rotor diameters for a given turbine rating, typically offer LCOE benefits
- Transport limitations, especially through the canal system, using transport specifications provided by turbine suppliers and
- Other commercial and technical considerations.

21.5 BALANCE OF PLANT INITIAL DESIGN

Foundation

As the pathfinder project will be built during the very early stages of OSW in Azerbaijan, the most likely foundation option for the pathfinder project is locally manufactured jackets, using oil and gas facilities. 4-leg jackets with leg separation about 17m at the top of the jacket, 25m at the base and a mass of about 1000t would be required. The dimensions and mass of the jacket foundations for the pathfinder project site will be subject to detailed engineering design and will be strongly influenced by the specific geological conditions. The jacket itself can be attached to the seabed via either piles or suction buckets. The choice will depend on the specific seabed conditions found at the site. Geotechnical survey work is required to determine this design choice. Jacket structures for oil and gas infrastructure in the Caspian Sea are typically piled. Figure 21.3 shows a picture of jacket foundations being transported.

FIGURE 21.3 EXAMPLE OF JACKET FOUNDATIONS

Courtesy of Lamprell.

Further information on OSW turbine foundation types is available in Guide to an Offshore Wind Farm.[33]

Array cables

The proposed wind farm consists of 14 turbines, each of 15MW capacity. To prevent overloading of individual cables, it is normal practice to cable several turbines into 'strings', with up to four turbines in each 'string' when considering turbines of this size and the standard array system rating of 66kV.

The proposed layout for this project given the turbine rating is a 66kV system with the cables connecting to an offshore substation (OSS). A 66kV system will comprise four strings of up to four turbines each. A cable conductor size of 400 to 630mm^2 for each of the strings is likely to be suitable. Cable sizing will vary along the strings within these ranges.

The cable construction for the wind farm can be a wet-type design. The conductor can be made from either copper or aluminum. Cable suppliers provide designs based on specifications.

Where OSW farms are located close to shore it is technically feasible to avoid an OSS and instead run the array cables directly to shore. Typically, this solution becomes favorable below 100MW capacity and closer than 10-15km from shore, so is unlikely to be preferable here, but due to different logistics costs in Azerbaijan, this option should be further assessed in due course.

It should be noted that further optimization is required based on power systems studies into the voltage drop and considering distance to connection, amperage, and capacity to determine the exact number of cable arrays.

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 minimizes losses in the export system and is therefore more important the further offshore the wind farm is located. For many OSW farms, an alternating current (AC) connection offers the most reliable and cost-effective option for transmission. This is what we have assumed for the demo site. Only at distances of 60km and above might direct current (DC) solutions be more cost effective.

OSSs are purpose-designed for each project. Typical OSS platforms are multi-deck structures which provide significant redundancy in electrical systems and also offer control rooms and facilities for the wider windfarm although simple facilities are possible to reduce initial costs.

Initial work suggests the OSS will have a topside weight in the range 1,000t to 2,000t. The platform will typically have height of around 30m, a width of 20m, and a length of 20m. Both monopiles and jackets can be used for OSS foundations, depending on the seabed conditions. Further information on offshore substations is available in *Guide to an Offshore Wind Farm*, including example images.[33]

The export cable will be at a higher voltage than the array cables and will typically match the voltage rating at the point of connection to the grid. For the demo site this will be at least 110kV if the nearest substation is used, with 132kV the proposed export cable voltage. A higher voltage (230kV) export cable could be needed if a different point on the network is required, particularly if the length of cable route is significantly increased.

Onshore grid connection

The closest connection point to the selected landfall site is the Mastaga 110kV substation.

While in principle it is feasible to connect 210MW of generation to a 110kV substation, further analysis is required to confirm this solution for the pathfinder project site. The factors that need to be considered and their potential impact on the project are shown in Table 21.4.

TABLE 21.4 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, 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 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.

21.6 INSTALLATION INITIAL DESIGN

Transportation and installation plans are required for the wind turbines, foundations, OSS, and cables. The following initial design solutions are for jacket foundations, with pre-driven piles for wind turbine jackets and post-driven piles for the OSS.

Turbine jacket foundation pile installation

Installing pin pile foundations is an activity already performed in the oil and gas sector in the Caspian Sea, so existing skills, fabrication capabilities, and installation vessels have been assumed.

The following steps are planned:

- Fabricate pile installation template (including levelling restraint systems to install piles to tolerance). Figure 21.4 shows an example of a pile installation template.
- Fabricate pin piles locally at construction yard (requires ~4m diameter tubular rolling capabilities).

- Transport piles to site, assuming suitable platform service vessel (PSV) or multi-purpose offshore construction vessel (MPOCV) or subsea construction vessel (SCV), suitably sea-fastened. Figure 21.5 shows an example of a PSV. An example of a modern SCV is the Khankendi, purpose built by BP for working in the Caspian Sea is shown in Figure 21.6.
- Lower pile template from installation vessel or supporting crane vessel to the seabed and level.
- Lift piles into template and drive to required penetration. Should ground conditions require it (such as in rocky conditions), drilled piles can be used.
- Remove template, relocate to next wind turbine site, and repeat.

FIGURE 21.4 EXAMPLE OF A PILE INSTALLATION TEMPLATE FOR A FOUR-LEGGED JACKET FOUNDATION

Courtesy of Beatrice Offshore Windfarm.

FIGURE 21.5 "TOPAZ" — EXAMPLE OF A PSV IN THE CASPIAN SEA

Courtesy of P&O Maritime Logistics.

FIGURE 21.6 "KHANKENDI" — EXAMPLE OF A SCV IN THE CASPIAN SEA

Courtesy of Ingeteam.

Turbine jacket foundation installation

Turbine jacket foundations will be installed using launch barges native to the Caspian Sea. The size of existing vessels limits the installation to one foundation at a time. The foundation will be transferred onto the barge at the construction yard, floated out to the turbine location at site, then toppled ("launched") into the sea and guided into position.

Figure 21.7 shows an example of a jacket foundation (with suction bucket feet) positioned on a launch barge.

FIGURE 21.7 EXAMPLE OF JACKET FOUNDATION ON LAUNCH BARGE

Courtesy of SPT Offshore.

The jacket is ballasted to facilitate controlled positioning onto pre-driven pin piles.

The existing local oil and gas industry has experience of this type of foundation installation, having used it for the Shah Deniz topside foundations amongst others.[xvii]

The cost of a launch barge is approximately US$40k per day and initial analysis shows the suggested installation method, though novel for OSW, is lower cost than compromise methods that are closer to conventional, but without very large installation vessels that can carry multiple jackets.

xvii https://www.youtube.com/watch?v=woxRwyunUN4

Offshore substation installation

The installation process for the offshore substation will be a "float over" technique. 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.

The existing local oil and gas industry has experience of this type of installation, having used it for the installation of the Shah Deniz Bravo topsides amongst others.[xviii]

Figure 21.8 shows an example of a topside floated over pre-installed foundations, ready to be lowered on to them. This method has not been used routinely in established markets but is chosen here due to the unavailability of a very large crane vessel. Initial costing, however, suggests that in the relatively benign conditions in the Caspian Sea, this is a lower cost solution than if a suitable vessel was available.

FIGURE 21.8 EXAMPLE OF A FLOAT OVER TOPSIDE INSTALLATION

Courtesy of OffshoreTech LLC.

xviii https://www.youtube.com/watch?v=U8FbfHe-FLO

Cable installation

In most other offshore markets, cables are installed using specialist cable lay vessels (CLVs). We believe there are no specialist CLVs in the Caspian Sea, but that some SCVs (BP's Khankendi, for example) have the ability, or can be adapted to lay cables.

Cable installation is completed in the following stages:

1. Deployment of pull-in, termination, and testing equipment on the turbines and OSS
2. Pre-lay inspection for each cable run
3. Between each pair of end points (turbine to turbine, turbine to OSS, or OSS to shore)
    - 1st end pull-in
    - Cable lay
    - 2nd end pull-in
4. Termination and testing
5. As-built survey
6. 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, with post-lay backfill;
    - Simultaneous lay and burial; or
    - Post-lay trenching.
- Or surface lay with post-lay artificial covering, via a combination of:
    - Rock/rubble dump;
    - Concrete mattresses;
    - Metal framing; or
    - Cable protection system (CPS).

Based on initial work, we expect that the seabed conditions at the pathfinder project site will allow for trenching.

Pre- and post-lay trenching is typically completed by tracked remotely operated vehicles (ROVs).

Wind turbine installation

The installation of the turbine is recognized as potentially difficult and significantly more expensive than in established markets due to the lack of large heavy-lift jack-up vessels in the Caspian Sea.

The Caspian Sea does have a small number of jack-up vessels that could be used. The preferred solution is to install a crawler crane on one of these vessels, with components transported to site on feeder vessels. Feeding solutions have been avoided in Europe because of the challenge of lifting sensitive turbine components off a floating vessel. Initial analysis suggests that the more benign weather conditions in the Caspian Sea make this a viable option.

With such a setup, installation will take approximately 25% longer than in established markets due to use of feeder vessel, positioning of rig, and increased mobilization effort. Critical weather conditions are wind speed, especially for blade lifts, and wave height for lifting from feeder vessels.

One foreseeable risk is that the crawler crane safe wind speed lifting limit may be lower than the purpose-built solutions found elsewhere. A potential alternative could be the use of innovative rack & pinion system to lift nacelle and rotor without the use of a high hook-height crane. It is known that solutions of this type are already in development in Europe.

21.7 OPERATIONAL STRATEGY INITIAL DESIGN

The operational strategy defines how the site will be managed over its lifetime, and covers the following items:

- Operations, maintenance, and service (OMS) contracting strategy
- Maintenance strategy (for routine activities)
- Operations base and logistics
- Organizational structure.

OMS contracting strategy

For a project of this size, the owner would normally take a low-risk medium-term warranty and service agreement with the wind turbine supplier for the turbines. Our proposed alternative, based on the pathfinder project site being the first of a number of projects likely using similar technology, and with turbine suppliers having no other OSW capacity close by, and the need to use bespoke 'local' logistics solutions, is to bring much of the planned maintenance and unplanned service activity (in response to fault or impending failure) in-house, upskilling to carry out all but the most specialist activity with minimal input from the wind turbine supplier.

A similar approach to the OMS for the balance of plant, including the foundations, array cables, and export cables. This may also be provided by the turbine supplier, though it is more likely to come from a specialist company.

Crucial to the long-term strategy for OSW in Azerbaijan will be the transference of skills and increase in local industry-specific expertise.

Operations base and logistics

It is most likely that the operations base will be the closest existing small harbor on the north side of the Absheron peninsula, such as the marina on Nardaran beach, or to build a new, optimally located jetty and facilities. The requirements for an operations base are much less than those required for manufacturing and installation and is often the case that local ports can be found with suitable levels of amenity. Aspects to consider for the operations base include:

- Land lease costs;
- Indoor facilities (200-400m^2 required);
- Indoor warehouse facilities (300-800m^2 required);
- Outdoor storage space (800-1500m^2 required); and
- Parking space (500-1000m^2 required).

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 crew transfer vessel (CTV) augmented by occasional use of a helicopter.

There is a trend in more mature markets to use service operations vessels (SOVs). SOVs are typically 10 to 20 times the cost (US$/vessel/day) of CTVs, but they support larger numbers of technicians and can facilitate 24 hour working using shift patterns. Using SOVs also reduces the need for helicopter support. SOVs are likely to be significantly under-utilized in a wind farm of this size and location but are likely to become more attractive as the local installed capacity increases in the future.

Organizational structure

Our recommendation is that focus is concentrated on the back office and asset management functions. These include the following roles:

- General Manager
- Finance Manager
- Accountant
- Legal
- Procurement & Commercial Manager
- Contracts Manager
- Procurement Back Office
- Insurance Manager
- Project Administration
- Safety, Health, and Environment
- Performance Engineer.

Each role would require one full-time equivalent (FTE) person, equaling 12 separate FTE positions to fill in total. For redundancy, and for the purpose of learning and growing the knowledge base in Azerbaijan, all positions should have a backup person assigned. This could be achieved in some instances by using other roles to provide that backup, thus minimizing the need for further staff (for example, the General Manager could provide backup for the Health and Safety role).

The following are roles that need to be filled for site operations:

- Site Manager
- Control Room Operator
- Shift Supervisor
- Admin Support
- Control Room Manager
- Balance of Plant Technicians
- WTG Technicians
- Store Room Operator
- Offshore Engineering Manager
- Subsea Engineer
- Turbine Platform Engineer
- Electrical Engineer
- Electrical & Control System Manager
- Supervisory Control and Data Acquisition (SCADA) System Engineer
- HV Switching Technicians.

21.8 PATHFINDER PROJECT DELIVERY

As outlined in Section 2, the pathfinder project would be the first OSW farm in Azerbaijan and could be operational by 2028.

The timeline and budget estimates presented here are based on a single pathfinder project site being progressed through the Government led procurement process outlined in Section 13. The option exists for Government to carry out early development then grant rights for two pathfinder projects, one each to two separate developers, though as the local supply chain is likely to serve both, this is seen as an unnecessary expense.

This timing is important as Government-led early pathfinder project development runs in parallel with early project development for future projects offered at the same auction.

Five phases are required to deliver the pathfinder project:

A. Site preparation

B. Permitting

C. Site procurement

D. Post-award development

E. Construction.

There are critical path activities within each phase that must be undertaken to deliver the pathfinder project in 2028. We highlight these critical path activities below and discuss the purpose and key aspects of the main studies that need to be undertaken.

The development timeline and costs of all four phases are shown in Section 21.9.

A. Site preparation

This phase will be led by Government, who we suggest appoints a specialist contractor to scope and manage delivery of environmental and technical studies, a preliminary front end engineering and design (FEED) study, a transmission system study, and a preliminary environmental and social impact analysis (ESIA). The aim of this phase of work is to determine the baseline conditions for the project that will inform the subsequent phases.

Activities in this phase include:

- Environmental studies including baseline bird, habitat, and marine mammal surveys and social studies including marine navigation, socio-economics, fishing, archaeology, and visual impact assessment.
  - 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.
  - Good International Industry Practice (GIIP) is to collect two years of data covering consecutive species breeding and migration seasons. This data will be required prior to the designation of the pathfinder project site in 2023, according to the Renewable Energy Law (REL) as outlined in Section 13, and for input into the subsequent preliminary front end engineering and design (pre-FEED) and ESIA studies, so needs to commence as soon as possible.
  - 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.
  - 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 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 are comprised of photomontages from specific viewpoints of what the proposed wind farm will look like. These are used to inform consultation exercises with stakeholders, including permitting authorities and the local community.

- 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. 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. GIIP is to collect 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. After the first two years of data collection, Government has the option to hand over the operation of the wind and metocean studies to the appointed developer, as further data collection before and during wind farm operation is of value.
  - Metocean surveys are used to determine 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), sometimes sea bed-positioned. These will record the full wave data spectrum including velocity, direction, and period. Multiple sensors are used to provide spatial coverage and redundancy.
  - Geological sea bed surveys analyze the sea bed 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, sea bed features, water depth, and soil stratigraphy, as well as identifying hazardous areas on the seafloor and manmade 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.
- Geotechnical site investigations are conducted following the geophysical survey to use the information obtained to target 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). Typically the geotechnical surveys are performed later in project development to add value to the project risk mitigation process.
- 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 sea bed characteristics. Boreholes and CPTs to depths of up to 70m are carried out to investigate the physical characteristics of the sea bed. Surface push CPTs are also used as a rapid method to gather sea bed soil stratigraphy.
- Hydrographic surveys examine the impact of the wind farm development on local sedimentation and coastal processes such as erosion. This is often part of the geophysical survey. Such surveys are also repeated by the project developer as part of the post construction monitoring during the operations phase.

■ A pre-FEED study to address areas of wind farm design in advance of the permitting, site procurement, and post award development phases.

- 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 impact studies.
- 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 further than provided within this roadmap section.
- The FEED study will be continually refined through the development process and then will be deepened in the post-award development phase, as the final design is completed.

■ A transmission system study to address how the wind farm will connect to the transmission system.

- Transmission system studies model power flows within the system and identify existing sub-stations with the capacity to accept power from new generating capacity.
- Power flow constraints and impacts are identified, including power quality issues, and transmission system upgrades are specified to mitigate these.

- A preliminary ESIA which will be used to secure the outline permits prior to the site procurement phase.
    - 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 pathfinder 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 pathfinder 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.
    - The ESIA will be deepened and refined in the post-award development phase to input into the final permit determination.

For the pathfinder project, the above studies will be carried out to the extent required to:

1. Secure outline permits;
2. Provide a high degree of technical certainty to developers in the procurement process; and
3. Enable the projects to be delivered by 2028.

For the rest of the projects in the initial auction, reduced scopes will be deployed in some of the initial studies and surveys, including environmental and social, and geotechnical, on the basis that further time will be available in the post-award phase for the completion of these studies by the developer. Scopes need to cover points 1 and 2, above.

B. Permitting

This phase of work will be carried out by Government, who will utilize the data and findings of the site preparation phase to designate the pathfinder project location as a renewable energy project, according to the Renewable Energy Law and as discussed in Sections 12 and 13.

Government will also secure outline permits and a construction passport that will provide a developer with reasonable assurance that full permits and licenses can be secured, subject to further detailed FEED and ESIA studies, in the post-award development phase.

Activities in this phase of work include securing:

- The designation of the pathfinder project by the end of 2023; and
- Outline permits and construction passport by mid-2024 to feed into the site procurement phase in 2025.

C. Site procurement

This phase of work will be led by Government and will involve prospective project developers, who will be invited to participate in the procurement process for the pathfinder project site and further capacity, as discussed in Section 13.

Activities in this phase of work include:

- Ongoing provision of key findings from the site preparation phase to enable interested project developers to prepare for the procurement process.
- A pre-qualification process, starting in mid-2023 and concluding by early 2024, where Government selects a small number of developers to enter the auction process.
- Compilation by Government of a detailed dossier of relevant documentation that presents the data and findings of the pre-FEED study, preliminary ESIA, outline permits, and construction passport, including all survey and study results for the pathfinder project site and all other sites that are being auctioned. This dossier should be made available by mid-2024 to enable project developers to use information to decide on their bid price.
- Submission of a bid price by prequalified developers to Government, in early 2025.
- Selection by Government of successful bidder or bidders, including finalization of PPA terms and conditions, by mid-2025.

Costs for Government and developers during this phase are not shown in Table 21.5.

D. Post award development

This phase of work will be carried out by each successful developer. The aim of this phase of activity is for the developer to finalize the detailed design of the pathfinder project, to secure all permits and to reach a final investment decision (FID), prior to the commencement of construction activity in 2028.

Activities in this phase of work include:

- Continuation through to 2026 of the environmental and technical surveys that were initiated in the site preparation phase, including detailed site-specific geotechnical surveys. The outputs of these surveys are required to inform the FEED and ESIA processes.
- Completion by the end of 2026 of a detailed FEED study.
- Preparation and submission of the ESIA that builds on the preliminary ESIA and is used to secure final permits by early 2027.
- Commencement of turbine and balance of plant procurement in 2026, with all major procurement activity to be completed by mid-2027.

- Securing FID by mid-2027 (though with some long-lead commitments made earlier).
- Commencement of project construction in early 2028, assuming a single Summer season construction programme for the 14 turbines and balance of plant, and completion of the construction activity by the end of 2028.

21.9 TIMELINE AND COSTS

The duration and approximate annual costs of activities (US$) required to deliver the pathfinder project by 2028 are shown in Table 21.5.

For context, we also show duration and annual costs to undertake the site preparation, permitting, and site procurement phases for the first tranche of capacity auctioned in the high growth scenario, as defined in Section 2. Government costs are assuming site preparation and development activity is carried out simultaneously for the pathfinder project site and the rest of the first tranche of sites, before the developer progresses the pathfinder project site from completion by the end of 2028, with other projects following on later.

Costs incurred by the appointed developer in the site procurement and post-award development phases are provided for the pathfinder project only.

The suggested timeline below is based on the principle of delivering first projects as early as possible. It is the best case scenario and is based on a fast and committed start by Government.

TABLE 21.5 TIMELINE AND COSTS (US$) FOR PATHFINDER PROJECT PLUS GOVERNMENT COSTS FOR EARLY DEVELOPMENT ACTIVITIES AND FOR THE REST OF THE HIGH GROWTH SCENARIO

KEY

Government

Developer

	Activity	2022	2023	2024	2025	2026	2027	2028	Total (US$m)
	A. Site preparation — demonstration project and other projects in first auction								
Government activity	Specialist project management contractor	0.5	0.5	0.5					1.5
	Environmental and social surveys — demonstration project	1	2						3
	Preliminary environmental and social surveys — other projects in first auction	1	1	1					3
	Wind resource survey — demonstration project	0.50	0.50	0.50					1.5
	Wind resource surveys — other projects in first auction	1	1	1					3
	Metocean survey — demonstration project	0.25	0.25	0.25					0.75
	Metocean surveys — other projects in first auction	1	1	1					3
	Geophysical survey — demonstration project		1	1					2.0
	Geophysical surveys — other projects in first auction		0.6	0.6					1.2
	Geotechnical survey — demonstration project		2.5	2.5					5.0
	Geotechnical surveys — other projects in first auction		1	1					2
	Hydrographic survey — demonstration project		0.5	0.5					1
	Hydrographic surveys — other projects in first auction		0.5	0.5					1
	FEED study — demonstration project		2	1.5					3.5
	Pre-FEED study — other projects in first auction		3	3					6
	Transmission system study — demonstration project		0.25						0.25
	Transmission system study — other projects in first auction		0.5						0.5
	ESIA — demonstration project		2	3					5
	Preliminary ESIA — other projects in first auction		2	2					4
	Total	**5.25**	**22.1**	**19.85**					**47.2**
	B. Permitting — demonstration project and other projects in first auction								
	Site designation according to REL		♦						
	Outline permits			♦					
	Construction passport			♦					

Developer activity

Activity	2022	2023	2024	2025	2026	2027	2028	Total (US$m)
C. Site procurement process — first auction								
Pre-qualification			◆					
Supply of project dossier			◆					
Bid submission				◆				
Developer selection				◆				
PPA finalisation				◆				
D. Post award development — demonstration project								
Wind resource survey				0.5	0.5			1
Metocean survey				0.45	0.45			0.9
Finalize FEED study				2				2
Development project management				0.75	1	1	1.3	4.05
ESIA approval					◆			
FID					◆			
Main procurement end					◆			
Total				**3.7**	**1.95**	**1**	**1.3**	**7.95**
E. Construction — demonstration project								
Construction						100	534	634
Works completion							◆	
Final state acceptance							◆	
Total						**100**	**534**	**634**

Government spend — demonstration project and other projects in first auction								
Demonstration project — pre-award	1.75	14	6.25	-22				0
Other projects in first auction	3.5	11.1	10.6	-25.2				0
Total	**5.25**	**25.1**	**16.85**	**-47.2**				**0**

*Successful developers pay government development costs

Developer spend—demonstration project (exc. auction success fees*)								
Post award development				3.7	1.95	1	1.3	7.95
Construction						100	534	634
Total				**3.7**	**1.95**	**101**	**535.3**	**641.95**

Combined Government and developer spend—demonstration project								
Total	**1.75**	**14**	**6.25**	**3.7**	**1.95**	**1**	**1.3**	**30.0**

22 RESEARCH AND DEVELOPMENT NEEDS

22.1 PURPOSE

In this work package we consider the opportunities for local research and development (R&D) to positively impact the development of a competitive offshore wind (OSW) industry in Azerbaijan. The section summarizes the key R&D needs for Azerbaijan considering local considerations and competences. It provides an account of what role academics in Azerbaijan might play in the development of OSW given recent experience developing oil and gas assets. The section then makes recommendations for academic institutions and policymakers interested in strengthening OSW R&D in Azerbaijan.

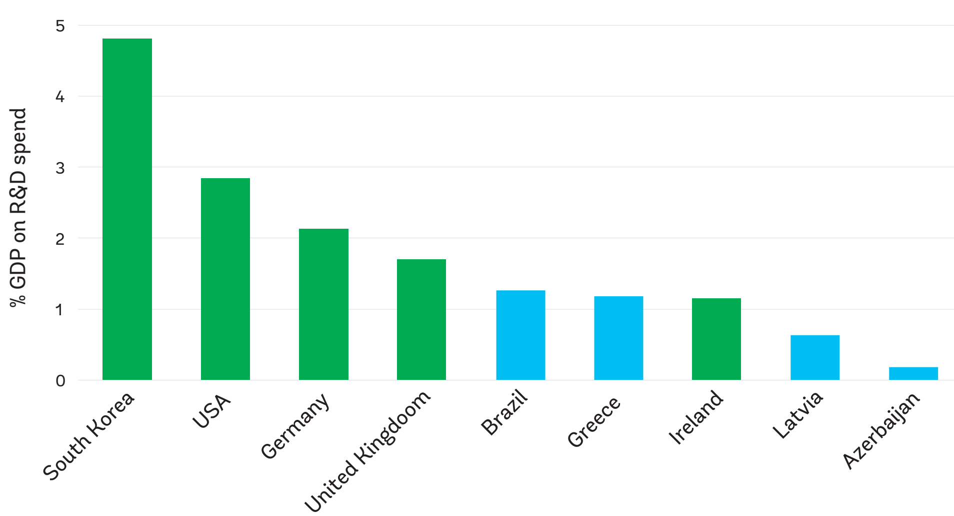
22.2 METHOD

Desk research and stakeholder engagement established the R&D landscape in Azerbaijan and how it compares with other countries that have committed to develop OSW projects. We also assessed the current academic context in Azerbaijan, its relation to industry, and provide examples of how tertiary education institutes can best support R&D in OSW.

22.3 RESULTS

Azerbaijan currently spends less than 0.2% of its GDP on R&D activities across all sectors according to World Bank Data.[34] This is lower than the OECD average of 2.5% and lower than other emerging or established OSW markets, as shown in Figure 22.1.

FIGURE 22.1 GDP % SPENT ON R&D IN AZERBAIJAN COMPARED TO OTHER COUNTRIES, MARKETS WITH INSTALLED OSW CAPACITY ARE SHOWN IN GREEN



Source: BVG Associates.

Almost all R&D in Azerbaijan is publicly funded, with the private sector covering just 5% of total R&D costs. Around 80% of all funding is applied to basic research and there are few competitive grants to fund industry projects.[24]

The role of higher education

Higher education institutions are fundamental for launching successful R&D programs as they generate the base capabilities and skills to drive forward future research and establish a base of knowledge which can be applied by the industry. There are several higher education institutions in Azerbaijan which could support targeted OSW R&D programs. These Include:

- ADA University (Caspian Center for Energy and Environment);
- Azerbaijan National Academy of Sciences (ANAS) Institute of Physics and Institute of Petrochemical Processes;
- Azerbaijan Scientific-Research and Design-Prospecting Power Engineering Institute;
- Azerbaijan State Oil and Industry University;
- Azerbaijan State University of Architecture and Construction;
- Azerbaijan Technical University;
- Azerbaijan University;
- Baku Engineering University;
- Baku Higher Oil School; and
- State Oil Company of Azerbaijan Republic (SOCAR) Oil and Gas Research and Design Institute.

Azerbaijan University, ADA University, and Azerbaijan Technical University all offer post graduate courses in electrical engineering, energy engineering, materials engineering, energy engineering, automation, economics, and computer science. This indicates there is a good level of cross-sectoral expertise to support research programs in OSW.

While this expertise exists, academic institutions need to take a coordinated approach to R&D and engage internationally to ensure they develop relevant research projects and programs that usefully align with government energy policy objectives and industry needs. Academic research is currently coordinated by ANAS. The Ministry of Energy, the Ministry of Transport, Communications and High Technologies, the Azerbaijan State Oil and Industrial University, and SOCAR carry out R&D activities in their own institutes or by funding other organizations.[24]

The State Oil and Industry University already has strong links with the oil and gas industry which may provide a useful framework for future collaboration with the OSW sector, ensuring that research is grounded in industry need.

Experience of UK academic institutions in supporting R&D

In developing its position as a global market leader in OSW, the UK has implemented a program of targeted R&D activity that has been focused on addressing specific industry research needs. In doing so, the UK developed several examples of strong co-ordination between industry and academic institutions.

The UK government has set out a clear direction for R&D via a roadmap which commits to US$29 billion of public funding for R&D annually by 2024/25. The joint industry-government OSW Sector Deal signed in 2019 identified autonomous technologies, advanced analytics, and grid integration as key areas of focus for targeted funding for UK R&D in the short term.[35]

The universities of Strathclyde and Edinburgh in Scotland have established a Doctoral Training Centre (DTC) for wind and marine energy systems with the support of 20 industry partners including OSW developers and wind turbine manufacturers.[36] The DTC was set up partly to address a potential skills gap which threatened to limit the growth of the industry. The DTC allows the academic partners to benefit from strategic industry guidance and gives students the opportunity to carry out industrial placements. An industry advisory board meets frequently to discuss research proposals and ensure they are matched to industry needs.

The University of Strathclyde has also linked its technical expertise to the wind industry via a partnership funded by ScottishPower, SSE, and Wood Group called *The Technology and Innovation Centre Low Carbon Power and Energy Programme* which was set up in 2013.[36] Industry partners have funded 13 projects since its inception and independent assessment shows these have delivered net cumulative benefits of US$264 million against a total budget of US$4.9 million.[37] The Universities of Sheffield, Hull and Durham have meanwhile partnered with UK Research and Innovation, Ørsted and Siemens Gamesa to carry out early stage research into modular generators and convertors, condition monitoring, and novel blade and array cable technology as part of a programme dubbed New Partnership in Offshore Wind.[38]

Universities in the UK, Denmark, and the Netherlands have also established sector-specific second-cycle (Master's Degree) courses for OSW. Developers pay for scholarships to encourage students to enroll in these courses, which ensure a strong supply of talent into the labor market and discourages brain drain into parallel sectors or foreign markets.

Beyond academic institutions

OSW R&D programs in established markets have typically extended far beyond academic institutions. As Figure 22.2 shows, developing new useful products and bringing them to market is a multi-phased process which requires a supportive ecosystem. Academic institutions, RTOs, test sites, large OSW industry companies, SMEs, private venture capital, and well-targeted government grants or tax credits all have roles to play in this ecosystem.

FIGURE 22.2 STAGES A PRODUCT / SERVICE DEVELOPMENT PROCESS

Early stage research	Testing and demonstration	Commercialization
• Adresses fundamental gaps in knowlegde • Largely takes place within academic institutions • Funded by industry and government	• Develops and proves prototypes of new products / services • Takes place at advanced testing facilities and/or demonstration sites • Largely funded by industry, venture capital and government grants/tax credits	• Takes concepts to market • May benefit from support programmes delivered at national and regional levels • Largely funded by industry, venture capital and government grants/tax credits

Increasing technology readiness level →

Research and development needs

R&D can drive OSW deployment by improving technology and industrial processes which makes supply chains more competitive and drives down the levelized cost of OSW energy. It can address market-specific problems to unlock future development for example by helping to design foundations and turbines that are well adapted to local sea states, ground conditions, weather regimes, and environmental sensitivities. It is important to focus R&D activities in the most impactful areas. Governments can play an important role in supporting innovation needs analyses. An example of such an analysis is the *Technology Innovation Needs Assessments* which the UK Government has used to set key innovation needs for publicly funded low-carbon research.[39] Key research themes for Azerbaijan, that complement (rather than repeat) activities happening in other markets, or other sectors in Azerbaijan include:

- Biodiversity research, looking at key receptors discussed in Section 11, and the potential impact of OSW, for example bird migration paths and what has been learnt about OSW impacts in more established markets.
- Environmental research, looking at meteorological climate and technical characteristics of the local wind and wave conditions to help optimize OSW project design and operation, taking advantage of differences in conditions compared to (often harsher conditions in) established markets; also the ongoing impact of water levels in the Caspian Sea dropping and the impact of differences in ground conditions between the Caspian Sea and other markets.
- Technical and engineering research, looking into optimizing local manufacturing and operations based on local capabilities and conditions. This could also stretch to exploring suitable floating foundations concepts for use in the Caspian Sea.
- Energy systems research, considering technical, economic, and social aspects of the energy transition, especially as applied to Azerbaijan, which OSW has the potential to contribute significantly to in displacing higher-carbon technologies from the electricity mix.

Typically, it is helpful to assess potential impacts of R&D on levelized cost of energy (LCOE), else on deliverability of OSW (enabling a larger or faster market).

22.4 DISCUSSION

R&D can play an important role in driving down the cost and increasing the size or pace of the market through addressing barriers to development. Focus should be on market-specific aspects, recognizing that many players are already active in the global OSW technology space, for example in developing next generation wind turbine component technologies. Azerbaijan can benefit for these technologies through the global market, without needing to develop its own.

22.5 RECOMMENDATIONS

Based on this analysis, it is recommended that:

- Ministry of Energy (MOE) produces a roadmap of research priorities for advancing OSW in Azerbaijan, with focus on LCOE reduction and establishes an industry-academic board or national R&D consortium/center to drive activities.
- Academic institutions start developing second-cycle courses and doctoral training programs specific to OSW.

23 GENDER EQUALITY

23.1 PURPOSE

In this work package we present the status of gender equality in Azerbaijan and look at existing legislation and policies that will affect the creation of a diverse offshore wind (OSW) workforce.

We present the case for taking a proactive approach to ensure a gender-equal OSW industry evolves in Azerbaijan. We also look at learnings around workforce diversity from the development of OSW in other countries to highlight ways of eliminating or lowering common barriers to achieving gender equality.

23.2 METHOD

The findings of this section are the result of research to understand the existing position of women and men in the workforce and education system in Azerbaijan. It also lays out the legal and regulatory environment around gender discrimination and diversity targets in the country.

Desk research and stakeholder engagement looked at 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 Azerbaijan's OSW industry.

23.3 RESULTS

It is important for the long-term success of OSW, and its wish to establish as a leading global industry, that it addresses the gender, diversity, and inclusion challenges of our time. Research shows that 32% of renewable energy jobs are held by women compared to 22% in oil and gas.[40] Recent analysis focusing specifically on OSW has however revealed that the global average for women in OSW is 21% with Taiwan topping the diversity charts at just 26%.[41] Poor diversity can be seen as a structural threat to the health of the OSW industry as multiple studies have shown that a diverse workforce is beneficial to the growth, innovation, resilience, and sustainability of all industries. A diverse workforce gives the widest opportunity to attract the best talent to the industry.

The pursuit of gender equality is mandated by existing legislation and soft-law treaties to which Azerbaijan is a signatory. For example, the 2015 Paris Agreement which states that nations should "respect, promote and consider" their obligations towards gender equality and the empowerment of women as they reduce their emissions. Azerbaijan is also committed to the UN's 17 Sustainable Development Goals (SDGs). Gender aspects play an important role in SDG 8 (Decent work and economic growth) and SDG5 (Gender equality). The development of the OSW industry in Azerbaijan will also benefit women as consumers by providing affordable, sustainable energy to the grid which will help meet SGD7 (affordable and clean energy).[42]

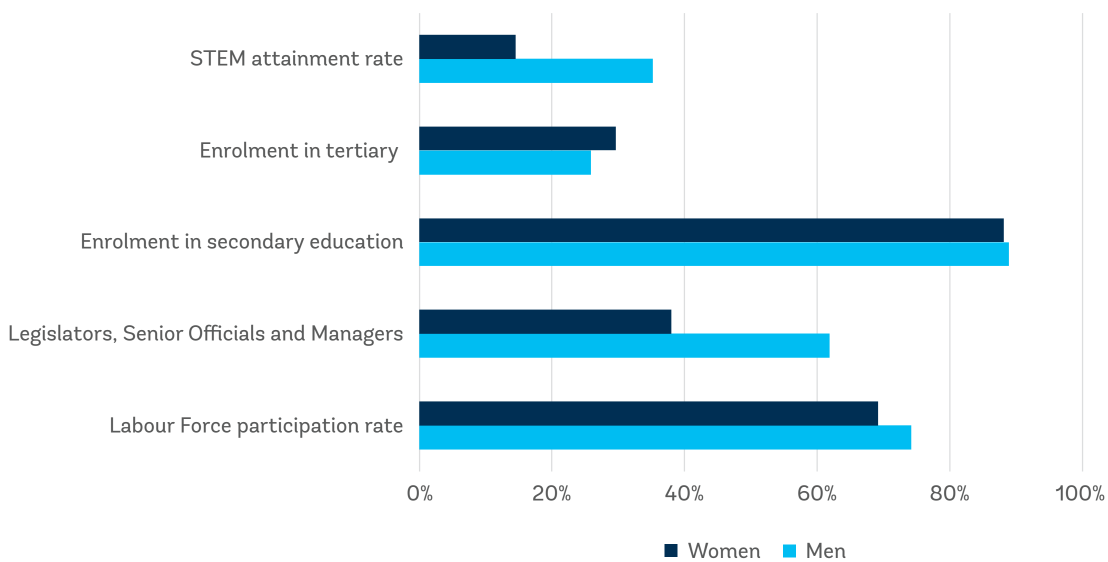
Azerbaijan has passed legislation that protects and promotes women's rights. Most relevant to the development of an OSW industry in the country is the constitution of the Azerbaijan Republic which was adopted in 1995. Article 25 (Right to equality) grants equal status to every person irrespective of factors including race, religion, and gender and Article 35 prohibits workplace discrimination.[43] In 2006, a specific package of gender equality laws was also passed by the Government which were aimed at eliminating all forms of discrimination towards women and creating equal opportunities for participation in all fields of social life.

This legislation states all employers have a responsibility to ensure they have equality of males and females in the workplace. This includes ensuring women have the same opportunities for career development as men and that both sexes secure equal labor pay. Job applicants who are refused for roles have the right to require written information on a person of opposite gender that employers recruit for the role to understand the education and employment background of successful applicants.

In addition to this, Azerbaijan is a signatory to the UN Committee on the Elimination of Discrimination Against Women and works closely with UN Women to promote gender diversity, particularly around educational outcomes for women in the country.

Despite mainstream gender equality legislation, Azerbaijan is ranked only 94 of 153 countries listed in The World Economic Forum's Global Gender Gap index. There are significant gaps still in the number of men and women in work and the types of positions they occupy. While the country has closed gender gaps around education there are still very few women pursuing education in science, technology engineering, and mathematics (STEM) subjects, which are highly relevant to the OSW industry.[45]

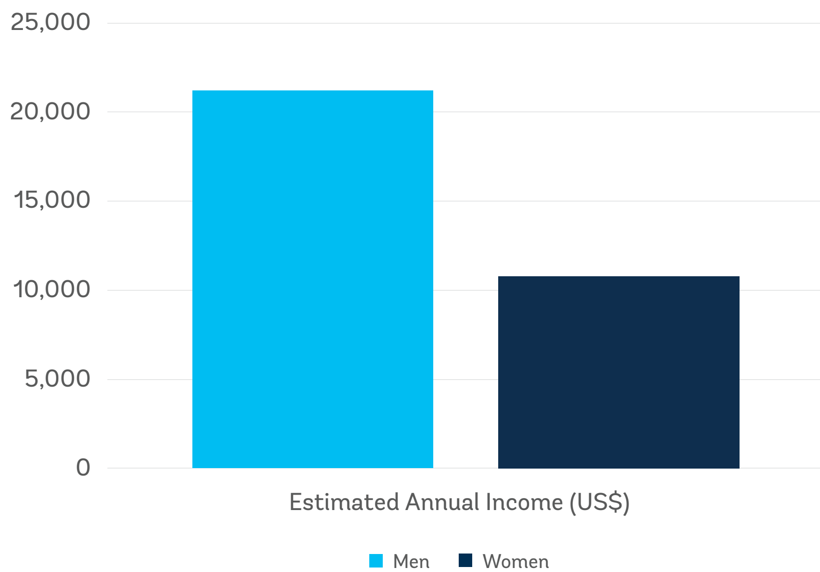
FIGURE 23.1 GENDER GAP ACROSS DIFFERENT AREAS OF SOCIETY IN AZERBAIJAN



Source: BVG Associates.

The report also highlights a significant gender pay gap across the economy with mean earnings for women thought to sit around 50% lower than for men.

FIGURE 23.2 THE GENDER PAY GAP IN AZERBAIJAN



Source: BVG Associates.

Experience from the development of OSW in Northern Europe suggests that strong equality laws alone are not enough to ensure there is not a stark contrast between the number of men and women in the wind energy workforce and the types of roles they occupy.

For example, the Global Wind Energy Council's (GWEC's) 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.[46] Just 8% of senior management positions in wind energy are taken up by women, who more commonly 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 imbalances and how a gender-diverse industry will not emerge by itself so long as only external policies are in place. The UK is a leading nation for OSW development and has passed robust equality legislation. The UK installed its first OSW project in 2000 and by 2018 had 7.5GW of installed OSW capacity and 7,200 people directly employed in the sector. Women, however, made up just 16% of that workforce, despite the UK having passed robust equality legislation. This shows that it is important to put schemes in place as the industry is established to challenge the social or cultural factors that create inequality.

Industry and government have moved to address this gender disparity as part of the UK *Offshore Wind Sector Deal* signed in 2018, which seeks to address a broad range of sector-specific issues.[47] An aspirational target of ensuring women make up at least 40% of the OSW workforce by 2030 has been set. Meeting this target will be challenging, but educational institutions and OSW industry programs are working to eliminate the significant barriers that exist which prevent women from either joining or staying in the OSW. These include:

- Socio-cultural norms which 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 taken another major step to ensure progress towards its 40% target. This has been achieved in part by incorporating gender equality requirements in a scored 'supply chain plan' assessment which developers must pass as a prerequisite for participating in future power purchase auctions.

23.4 DISCUSSION

Anecdotal evidence and feedback during the development of the roadmap suggests OSW presents an opportunity to close the overall gender gap in Azerbaijan, but this will require a concerted effort from industry and government from the outset. Azerbaijan has legislated for equality, but outside of this, work needs to be done to challenge the culture around women pursuing STEM subjects and strive to ensure the OSW industry is an attractive place for women to work. This is an acute challenge for OSW. Women are under-represented in maritime industries due to multiple factors including non-family friendly working conditions and sexual harassment risk.[46] The OSW industry needs to consider how to make offshore jobs more attractive to women to encourage them into the sector and retain them.

23.5 RECOMMENDATIONS

Based on this analysis, it is recommended that:

- Industry and Government work together to encourage women into the sector, including in engineering, design, management, and operations. Opportunities should be well promoted and gender decoders and gender-balanced language used to make recruitment practices unbiased.
- Ministry of Energy (MOE) requires that developers successful in auctions involve their supply chain in gender equality working groups, supported by women's rights organizations in Azerbaijan, and including GWEC, Global Women's Network for Energy Transition, and The Women in Renewable Energy Network.

APPENDIX A: GLOSSARY

Abbreviation	Definition
AEP	Annual energy production
APAC	Asia-Pacific
AZN	Azerbaijan Manat
BOO	Build, own, and operate
BOOT	Build-own-operate-transfer
CAPEX	Capital expenditure
CDM	Construction, design, and management
CfD	Contract for difference
CIA	Cumulative Impact Assessment
CO_2	Carbon dioxide
CP	Construction permit
CPT	Cone penetration testing
COP	Construction and operation plan
CTV	Crew transfer vessel
DEVEX	Development expenditure
EBSA	Ecologically or Biologically Significant Areas
EEZ	Exclusive economic zone
ENP	European Neighbourhood Policy
ESIA	Environmental and social impact assessment
ESPOO	Convention on the Environmental Impact Assessment in the Transboundary Context
ESF	Environmental and Social Framework
ESS	Environmental and social standards
EV	Electric vehicle
FACTS	Flexible alternating current transmission system
FDI	Foreign direct investments
FEED	Front end engineering and design
FID	Final investment decision
FIT	Feed in tariff
FTE	Full-time equivalent
GIIP	Good international industry practice
GIS	Geographical information system
GVA	Gross value added
GW and GWh	Gigawatt and Gigawatt hour
HRA	Habitat regulations assessment
HVAC	High voltage alternating current
HVDC	High voltage direct current

H&S	Health and safety
IFI	International financial institution
INDC	Intended declared contribution
JV	Joint venture
KBA	Key Biodiversity Areas
LCOE	Levelized cost of energy
LPA	Legally protected area
MDB	Multilateral development bank
MLAs	Multilateral lending agencies
MoU	Memorandum of understanding
MSP	Marine spatial plan
MW and MWh	Megawatt and Megawatt hour
NGO	Non-governmental organization
NO_x	Nitrogen oxides
OMS	Operations, maintenance, and service
OPEX	Operational expenditure
OSS	Offshore substation
OSW	Offshore wind
PCA	Partnership and cooperation agreement
PPAs	Power purchase agreements
PPP	Public-private partnership
Pre-FEED	Preliminary front end engineering and design
PSAs	Production Sharing Agreements
PSSAs	Particularly Sensitive Sea Areas
PWPDP	Provincial wind power development plan
RD&D	Research, design, and development
REL	Renewable Energy Law
RoCoF	Rate of change of frequency
ROV	Remotely operated vehicle
R&D	Research and development
SCADA	Supervisory control and data acquisition
SOLAS	Safety of life at sea regulations
SOV	Service operation vessel
SO_2	Sulphur dioxide
SPMT	Self-propelled modular transport
SVC	Static var compensator
TP	Transition Piece
TW and TWh	Terawatt and Terawatt hour
UNFCC	United Nations Framework Convention on Climate Change
US$	United States dollar
UXO	Unexploded ordinance
WACC	Weighted average cost of capital
WCD	Works completion date
WHS	World Heritage Sites

APPENDIX B: ORGANIZATION ABBREVIATIONS

Abbreviation	Definition
ADB	Asian Development Bank
AREA	Azerbaijan Renewable Energy Agency
ANAS	Azerbaijan National Academy of Sciences
AZENCO	Azerbaijan Energy Construction
BOE	Bureau of Energy
BOEM	Bureau of Ocean Energy Management
BVGA	BVG Associates
CES	Crown Estate Scotland
CIF	Climate Investment Fund
COP	Copenhagen Offshore Partners
DEA	Danish Energy Agency
DEG	German Investment Corporation
DoD	US Department of Defense
DoF	Directorate of Fisheries
DOIT	Department of Industry and Trade
DPI	Department of Planning and Investment
DTU	Danish Technical University
EBRD	European Bank for Reconstruction and Development
EIB	European Investment Bank
EPA	Environmental Protection Administration
EPTC	Electrical Power Trading Company
ERAV	Electricity Regulatory Authority of Azerbaijan
EREA	Electricity and Renewable Energy Authority
ESMAP	Energy Sector Management Assistance Program
EVN	Azerbaijan Electricity
GCF	Green Climate Fund
GDE	General Directorate of Energy
GEBCO	The General Bathymetric Chart of the Oceans
GEF	Global Environment Facility
GWO	Global Wind Organization
GWEC	Global Wind Energy Council
HICT	Haiphong International Container Terminal
IFC	International Finance Corporation
IRENA	International Renewable Energy Agency
MARD	Ministry of Agriculture and Rural Development
MCST	Ministry of Culture, Sports and Tourism

MENR	Ministry of Ecology and Natural Resources
MIC	Ministry of Information and Communication
MIGA	Multilateral Investment Guarantee Agency
MMO	Marine Management Organisation
MOC	Ministry of Culture
MOE	Ministry of Energy
MOEA	Ministry of Economic Affairs
MOF	Ministry of Finance
MOIP	Ministry of Industries and Production
MOIT	Ministry of Industry and Trade
MONRE	Ministry of Natural Resources and Environment
MOPI	Ministry of Planning and Investment
MOT	Ministry of Transport
MPI	Ministry of Planning and Investment
MS	Marine Scotland
NLDC	National Load Dispatch Centre
NMFA	National Marine Fisheries Service
NPA	National Property Administration
NPTC	National Power Transmission Corporation
NRW	Natural Resources Wales
OFTO	Offshore transmission owner
PPC	Provincial People's Committee
PVN	PetroAzerbaijan
RPC	Regional Power Corporation
SHPO	State Historic Prevention Office
SOCAR	State Oil Company of the Azerbaijan Republic
TCE	The Crown Estate
USACE	United States Army Corps of Engineers
USCG	United States Coast Guard
USFWS	United States Fish and Wildlife Service
VASI	Azerbaijan Administration of Seas and Islands
VASEP	Azerbaijan Association of Seafood Exporters and Producers
VIET	Azerbaijan Institute for Energy Transition
VIFEP	Azerbaijan Institute of Fisheries Economics and Planning
VISI	Azerbaijan Institute of Seas and Island
WBG	World Bank Group

APPENDIX C: CANAL ROUTE CONSTRAINTS

Constraint	Volga Don (Southern)	Volga Baltic (Northern)
Maximum Draft (m)	3.4	3.6
Designed Air Clearance (from water level) (m)	14.7 *	15.9 **
Actual Passage Air Clearance (taking into consideration water level) (m)	14.7	15
Lock Width (m)	17	17
Maximum Beam of Vessel / Barge (m)	16.5	16.5
Lock Length (m)	141	198
Maximum Length of Vessel (m)	138	150
Maximum Length of Towed Barge (m)	90	90

* Subject to disconnection of power lines. Without disconnection the air clearance is 14.0 meters.

*** Designed passage air clearance near Gorodets is 15.9 meters (down to 14.4 meters near the bridge pillars). According to Navigation Rules the minimum margin of designed air clearance for passing bridges is 0.4 meters.*

APPENDIX D: AZERBAIJAN — PRIORITY BIODIVERSITY VALUES

1 INTRODUCTION

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

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

- WB Environmental and Social Standard 6 (ESS6) Biodiversity Conservation and Sustainable Management of Living Natural Resources (2018), together with the associated Guidance Note ESS6 (2018); and
- IFC Environmental and Social Performance Standard 6 (PS6): Biodiversity Conservation and Sustainable Management of Living Natural Resources (2012), together with the associated Guidance Note 6 (2019).

The objective of this study is to identify priority biodiversity values and areas that support these values that should either be excluded from offshore wind development (i.e., areas of the highest biodiversity sensitivity), or require additional assessment through subsequent Marine Spatial Planning (MSP), site selection, and Environmental and Social Impact Assessment (ESIA) processes. To meet GIIP, wind developments in areas supporting priority biodiversity values would likely be subject to restrictions in the form of greater requirements for baseline studies, as well more intensive mitigation measures to avoid, minimise, and restore adverse environmental impacts. According to IFC PS6 and WB ESS6, projects situated within critical habitat are required to demonstrate that:

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

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

In addition, projects need to achieve net gains of those biodiversity values for which the critical habitat was identified.

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

- Legally protected areas (LPAs) and Internationally recognized areas (IRAs) – see Section 3
- Marine mammals – see Section 4
- Birds – see Section 5
- Fish – see Section 6
- Natural habitats[xix] – see Section 7

2 METHODOLOGY

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

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

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

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

xix For the purposes of this study marine benthic invertebrates are included as integral components of marine natural habitats.

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

3 LEGALLY PROTECTED AREAS AND INTERNATIONALLY RECOGNIZED AREAS

Following the IUCN definition, an LPA is any clearly defined geographical space, recognized, dedicated, and managed, through legal or other effective means, to achieve the long-term conservation of nature with associated ecosystem services and cultural values (Dudley 2008; IFC 2012a). IRAs are exclusively defined in IFC PS6 as UNESCO Natural World Heritage Sites, UNESCO Man and the Biosphere Reserves, Key Biodiversity Areas (KBAs), and wetlands designated under the Convention on Wetlands of International Importance (the Ramsar Convention) (IFC 2012a).

LPAs and IRAs represent high value areas designated for various biodiversity conservation objectives, and some should be excluded from consideration for offshore wind development because of this. For example, development in KBAs (see Section 3.3) should be avoided because these sites represent the most important places in the world for species and their habitats.[xxi] It may also be necessary to avoid other types of designated area, such as Ecologically or Biologically Significant Marine Areas (EBSAs, see Section 3.4), all of which in Azerbaijan overlap with KBAs but have larger areas.

To note, IFC standards prohibit development in UNESCO Natural and Mixed World Heritage Sites, and Alliance for Zero Extinction (AZE) sites (IFC 2012b). There are currently no UNESCO Natural and Mixed World Heritage Sites designated in Azerbaijan.[xxii]

3.1 Nationally Protected Areas

Protected areas are afforded varying levels of legal protection in different national jurisdictions, often underpinned by commitments made under international conventions. The Law of the Republic of Azerbaijan on Specially Protected Natural Territories and Objects determines the legal basis for protected natural areas in Azerbaijan, which comprise 10.3% of the total area of the country. There are a range of LPA types, which are aligned with the IUCN management categories (IUCN n.d.), including the following:

- Strict Nature Reserves
- National Parks
- Marine Protected Areas

xx Range-restricted marine species are defined by IFC PS6 as having an Extent of occurrence less than 100,000 km^2

xxi (Key Biodiversity Areas n.d.)

xxii Hirkan Forests is the only site on the tentative list under the "Natural" category but does not include marine components.

- State Nature Sanctuaries

There are four LPAs that are marine, or have marine components, collectively covering a total of 2,342.65 hectares of marine area (Scientific Net for the Cauca Mountain Reg 2020) (Table 1):

- Marine National Parks
  - Gyzylagach (the only designated Marine National Park)
- National Parks:
  - Absheron National Park
- State Nature Sanctuaries
  - Gil Island
  - Baku and Absheron Peninsula Mud Volcano Group.

A Marine National Park is defined as an area which includes the sea as well as the adjacent coastal belt, which in the case of Gyzylagach also constitutes a Ramsar site with critical wetlands for wintering and breeding waterbird species. National Parks in Azerbaijan are open for eco-tourism, and State Nature Sanctuaries allow human activity. A Sanctuary conveys the lowest form of protection when compared to other protection statuses.

It is unlikely that offshore wind development would be compatible with the conservation objectives of the Gyzylagach Marine National Park or Absheron National Park, therefore both are included in the exclusion zone layer. Although human activity is permitted in Sanctuaries, due to the likely sensitivity of the priority biodiversity values to impacts associated with offshore wind development, Sanctuaries are also included in the exclusion zone layer.

Other types of LPA in Azerbaijan only cover terrestrial (non-marine) areas, and therefore they are not included in the scope of the study. However, two coastal LPAs that have the potential to be impacted by offshore wind development or its associated facilities are included in (Table 1).

TABLE 1: PROTECTED AREAS IN AZERBAIJAN WITH MARINE OR RELEVANT COASTAL COMPONENTS[xxiii,xxiv]

Legally Protected Area	Total declared area (ha)	Marine area (ha)	Percentage of declared area that is marine
Absheron National Park	783	783	100
Baku and Absheron Peninsula Mud Volcano Group State Nature Sanctuary	12,3223	1,160.65	9.42
Khara Zira Mud Volcano	350	350	100
Bandovan Mud Volcano	118	118	100
Qarasu (Los) Island Mud Volcano	58.66	58.66	100

xxiii Data shared by the Ministry of Ecology and Natural Resources – source: Milli Parklar n.d., http://eco.gov.az/az/tebii-servetlerimiz/milli-parklar

xxiv EaPGREEN Partnership for Environment and Growth et al. 2016, https://unece.org/fileadmin/DAM/env/eia/documents/EaP_GREEN/1_Homepage/Azerbaijan/SEA_report_Azerbaijan_Executive_Summary_October_2016.pdf.

Legally Protected Area	Total declared area (ha)	Marine area (ha)	Percentage of declared area that is marine
Agzibir Mud Volcano	473.03	473.03	100
Zanbil Island Mud Volcano	55.79	55.79	100
Gil Island Mud Volcano	93.22	93.22	100
Cigil Island Mud Volcano	11.95	11.95	100
Sangi-Mugan Island Mud Volcano	47,95	47,95	100
Gil Island State Nature Sanctuary	400	400	100
Gyzylagaj Marine National Park	122,820[xxv]	32,760	26.67
Samur-Yallama National Park (Coastal)	11,772	0	0
Shirvan National Park (Coastal)	54,374	0	0

3.2 Ramsar Sites

Ramsar sites are wetlands of international importance that have been designated under the criteria of the Ramsar Convention on Wetlands for containing representative, rare, or unique wetland types, or for their importance in conserving biological diversity. Contracting parties are expected to manage their Ramsar Sites to maintain their ecological character and retain their essential functions and values for future generations.

There are two Ramsar sites in Azerbaijan; Aghgol and Ghizilagaj (Ramsar n.d.). The former is an inland National Park, and is therefore not considered further herein. The latter is a more recently designated Marine National Park (IUCN 2018). Known as Ghizil-Agaj, the Ghizilagaj Ramsar wetlands of Great and Lesser Gyzylagach Gulf hold records of 273 bird species and support large wintering waterbird populations. The wetlands also support 47 freshwater and marine fish species including threatened sturgeons (CBD 2019).

It is unlikely that offshore wind development is compatible with maintaining Ramsar sites' ecological character and function and therefore Ghizil-Agaj Ramsar site has been included in the exclusion zone layer.

3.3 Key Biodiversity Areas

KBAs have been designated to cover the most important places in the world for species and their habitats. KBAs are identified using a global standard that includes criteria that were developed through a multi-stakeholder process. These criteria include quantitative thresholds that mean sites are globally important for the long-term survival of biodiversity. KBA identification is rigorous, transparent and can be applied consistently in different countries and over time.

Sites qualify as KBAs if they meet one or more of 11 criteria, clustered into five higher-level categories: threatened biodiversity, geographically restricted biodiversity, ecological integrity, biological processes, and irreplaceability (KBA Criteria n.d.). The KBA criteria are broadly aligned with IFC PS6 criteria for critical habitat, although KBA criteria are wider, and therefore not all KBAs will qualify as critical habitat. All BirdLife International Important Bird Areas (IBA) are also classified as KBAs, although

xxv Scientific Net for the Cauca Mountain Reg 2020, https://sustainable-caucasus.unepgrid.ch/layers/geonode_data:geonode:Priority_Conservation_Areas_WGS84 some would not meet the updated global KBA standard, and therefore might be treated as regional or national KBAs (see Section 3.3.1). All existing Alliance for Zero Extinction (AZE) sites are also KBAs.

Azerbaijan has 14 designated KBAs with marine components, extending along its 600 km coast on the Caspian Sea (see Table 2). The majority of these sites were designated based on their international significance for wintering and breeding waterbirds, and threatened fish species. Four of the KBAs are important areas for Endangered *Pusa caspica* (Caspian seal) (IUCN 2015): Absheron Archipelago (north) and Pirallahi; Shahdidi Spit; Kura Delta; and Gyzylagach State Reserve.

Designation as a KBA does not confer legal protection. However, the IUCN recommends that environmentally damaging industrial activities and infrastructure should be avoided within KBAs[xxvi] and therefore all KBAs have been included within the exclusion zone layer. Priority marine biodiversity associated with each KBA is summarized in Table 2.

3.3.1 Important Bird and Biodiversity Areas

The BirdLife Global Seabird Programme has identified Marine IBAs that include seabird breeding colonies, foraging areas around breeding colonies, non-breeding (usually coastal) concentrations, migratory bottlenecks, and feeding areas for pelagic species. The methodology for the designation of marine IBAs is described in the marine IBA toolkit (BirdLife International 2010). Although Azerbaijan has no Marine IBAs, the ten IBAs listed in Table 2 have marine components (BirdLife International 2021) and therefore have been included within the exclusion zone layer.

TABLE 2: KBAS IN AZERBAIJAN WITH MARINE COMPONENTS AND ASSOCIATED PRIORITY BIODIVERSITY

KBA	Area (ha)	KBA Triggers[xxvii,xxviii,xxix,xxx,xxxi,xxxii]	
		Threatened Species	Priority Biodiversity / Congregations
Absheron Archipelago (north) and Pirallahi Bay (IBA) & Shahdidi Spit (IBA)	15,450	**Caspian seal** – *Pusa caspica.* **Waterbirds** - *Aythya ferina, Melanitta fusca, Podiceps auritus.* **Sturgeons, barbs and carps** - *Huso huso, Acipenser stellatus, Acipenser ruthenus, Acipenser persicus, Acipenser nudiventris, Acipenser gueldenstaedtii, Cyprinus carpio, Luciobarbus brachycephalus, Luciobarbus capito.*	Islands of Absheron support breeding birds including *Tadorna ferruginea, Porphyrio porphyrio, Larus cachinnans.* Wintering and migration of swans, ducks, grebes and coots. Shahdidi Spit is important for passage and wintering pelicans and storks.
Alat Bay-Baku Archipelago	9,251	**Waterbirds** – *Oxyura leucocephala.*	Majority of islands are active mud volcanoes. Concentrations of migrating waterbirds in Alat Bay and around the islands, which are mostly populated during breeding season. Old petroleum platforms provide nesting grounds for cormorant, gulls and terns.

xxvi https://portals.iucn.org/library/sites/library/files/resrecfiles/wcc_2016_rec_102_en.pdf
xxvii BirdLife International n.d.; Key Biodiversity Areas n.d.
xxviii Zazanashvili et al. 2020a
xxix Sultanov et al. 2000
xxx Sultanov 2020
xxxi Babayev et al. 2020
xxxii Succow 2009

KBA	Area (ha)	KBA Triggers[xxvii,xxviii,xxix,xxx,xxxi,xxxii]	
		Threatened Species	Priority Biodiversity / Congregations
Divichi Liman (IBA)	6,522	**Waterbirds** – *Oxyura leucocephala, Branta ruficollis, Marmaronetta angustirostris, Aythya ferina, Melanitta fusca, Podiceps auritus.* **Barbs and carps** – *Cyprinus carpio, Luciobarbus brachycephalus, Luciobarbus capito.*	Congregation of waterbirds during autumn migration. Majority of birds of Caspian flyway pass through this area including *Pelecanus crispus* Wintering waterfowl and breeding colonies of herons and coots.
Gylnanyi Island (IBA)	195	—	Holds the largest colony of Larus *cachinnans* in Azerbaijan, and one of the largest in the Caspian. Significant breeding populations of *Tadorna ferruginea, Sterna hirundo*, and *Sterna albifrons*. Up to 10,000 waterbirds occur from October until April.
Gyzylagach State Reserve (IBA)	137,369	**Caspian seal** – *Pusa caspica.* **Waterbirds** – *Vanellus gregarius, Anser erythropus, Aythya ferina, Melanitta fusca, Branta ruficollis, Podiceps auritus, Leucogeranus leucogeranus, Marmaronetta angustirostri..* **Sturgeons, barbs, and carps** – *Huso huso, Acipenser stellatus, Acipenser ruthenus, Acipenser persicus, Acipenser nudiventris, Acipenser gueldenstaedtii, Cyprinus carpio, Luciobarbus brachycephalus, Luciobarbus capito.*	One of the most significant wintering and breeding sites in the entire Western Palearctic. The four main sections hold populations of both marine (Greater Gyzylagach) and freshwater species (Lesser Gyzylagach). The reserve holds the largest breeding colonies of storks in Europe. There are also breeding colonies of cormorants, herons, and egrets. Despite dramatic declines from 10 million wintering birds in the first half of 20th century, total number of ducks, waders, and coots still reaches half a million. Significant spawning and feeding grounds for 54 fish species.
Kura Delta (IBA)	15,781	**Caspian seal** – *Pusa caspica.* **Waterbirds** – *Aythya ferina, Nyctalus lasiopterus, Numenius tenuirostris, Podiceps auratus, Marmaronetta angustirostris, Oxyura leucocephala.* **Sturgeons, barbs, and carps** – *Huso huso, Acipenser stellatus, Acipenser ruthenus, Acipenser persicus, Acipenser nudiventris, Acipenser gueldenstaedtii, Cyprinus carpio, Luciobarbus brachycephalus, Luciobarbus capito, Salmo caspius.*	Wintering populations of diving ducks, grebes, swans, and terns. One of the most important sites for wintering *Pelacanus*, and holds the largest wintering population of Netta *rufina*. Kura Delta is also characterized by high numbers of wintering and migrating waders. The breeding colony includes *Phalacrocorax carbo, Phalacrocorax phygmeus, Ardea cineria, Ardea purpurea, Egretta garzetta, Egretta alba*, and *Larus cachinnas*, reaching over a thousand nests. The delta holds stocks of 70 fish species, the majority of which are commercially important.
Pirsagat Islands and Los Island (IBA)	263	**Waterbirds** – *Branta ruficollis recorded as a vagrant.*	Breeding seabirds including gulls and terns — *Larus melanocephalus, Gelochelidon nilotica, Sterna hirundo and Sterna albifrons, and Thalasseus sandvicensis*
Sahil Settlement-Shelf Factory (IBA)	2,598	**Waterbirds** – *Aythya ferina.*	One of the most important sites for concentrations of wintering and migrating waterbirds, holds up to 100,000 individuals — significant numbers of *Anas platyrhynchos, Netta rufina, Aythya ferina, Aythya fuligula*, and *Fulica atra*.

KBA	Area (ha)	KBA Triggers[xxvii,xxviii,xxix,xxx,xxxi,xxxii]	
		Threatened Species	Priority Biodiversity / Congregations
Samur Delta (IBA) & Yallama Rivers	167,946	**Sturgeons, barbs, and carps** – *Huso huso, Acipenser stellatus, Acipenser ruthenus, Acipenser persicus, Acipenser nudiventris, Acipenser gueldenstaedtii, Cyprinus carpio, Luciobarbus brachycephalus, Luciobarbus capito.*	Shifting sand dunes
Sangachal Bay (IBA)	1,018	*Rare occurrences of Branta ruficollis and Aquila heliaca.*	Most birds visit the site during migration. Number of individuals can reach up to 25,000 — mostly diving ducks and *Fulica atra.*
Shorgel Lakes/ Shirvan Reserve (IBA)	66,648	**Waterbirds** – *Aythya ferina, Marmaronetta angustirostris.*	Southeast Shirvan coastline hosts wintering diving ducks — up to 20,000 wintering pochards, also wintering *Pelecanus crispus.*
Yashma Island (IBA)	801	**Waterbirds** – *Numenius tenuirostris.* **Sturgeons** – *Huso huso, Acipenser stellatus, Acipenser gueldenstaedtii.* **Caspian salmon** – *Salmo ciscaucasicus.*	Breeding colonies of herons, gulls, and terns. Wintering and passage waterbirds — with wide range of shorebirds including *Pelecanus crispus.*

3.4 Ecologically or Biologically Significant Areas

EBSAs are special areas in the ocean that support the healthy functioning of oceans and the many services that it provides. The Conference of the Parties (COP 9) to the Convention on Biological Diversity adopted the following seven scientific criteria for identifying EBSAs: Uniqueness or Rarity; Special importance for life history stages of species; Importance for threatened, endangered, or declining species and/or habitats; Vulnerability, Fragility, Sensitivity, or Slow recovery; Biological Productivity; Biological Diversity; and Naturalness. The identification of EBSAs and the selection of conservation and management measures is a matter for states and competent intergovernmental organizations, in accordance with international law (including the UN Convention on the Law of the Sea). The criteria do not include quantitative thresholds, but in principle they have a lot in common with WBG/IFC natural habitats definition and critical habitat criteria, and could therefore constitute and important high-level planning consideration for offshore wind development.

There are three EBSAs (Convention on Biological Diversity 2019) in Azerbaijan:

- Samur-Yallama;
- Kura Delta; and
- Gizilagach Bay Complex.

All EBSAs in Azerbaijan are included in the exclusion zone layer. The significance[xxxiii] of each of these EBSA designations is summarised in Table 3.

xxxiii Secretariat of the Convention on Biological Diversity n.d.

TABLE 3: SIGNIFICANCE OF EBSAS IN AZERBAIJAN

EBSA	Significance
Gizilagach Bay Complex	Gizilagach Bay is one of the most important wetlands for wintering and breeding waterbirds in the Western Palearctic. The area is located on the main migration routes on the western coast of the Caspian Sea, hosting large flocks of feeding and resting birds. Wintering bird numbers were reported to be as many as 10 million within the complex and its surroundings.
Kura Delta	Kura Delta is an area of foraging, wintering, spawning migrations, and reproduction of all Caspian sturgeons except for Acipenser ruthenus (Sterlet). The area is also significant as a stopover ground for migratory birds, which have numbered up to 75,000 individuals in one record.
Samur-Yallama	A transboundary area between Azerbaijan and the Russian Federation, Samur-Yalama covers an area of 125,000 ha on both sides of the boundary. It includes the deepest nearshore area in the Caspian Sea with a steep underwater slope that provides an important migratory corridor and feeding grounds for a number of fish species. It also serves as a flyway segment and critical stopover and nesting area for waterbirds.

3.5 Priority Conservation Areas

WWF Caucasus and the Critical Ecosystem Partnership Fund (CEPF) are engaged in a joint initiative to contribute to biodiversity conservation projects in the Caucasus Ecoregion, which covers territory in Azerbaijan, Georgia, Armenia, Russia, Turkey, and Iran. As an outcome of studies undertaken by this initiative in collaboration with experts from the six countries that comprise the Caucasus, the first edition of the "Ecoregional Conservation Plan (ECP) for the Caucasus" was published in 2006 (Williams et al., 2006). Based on assessments on the biological significance and state of biodiversity in the Caucasus Ecoregion, a total of 56 Priority Conservation Areas (PCAs) were defined to help focus conservation actions set forth in the Plan (2006), followed by an updated edition in 2012.

The first step in defining PCAs was to identify key taxa and areas important for them. Then the important areas for all taxa were overlaid, habitat representation in the overlay was evaluated and PCAs were identified and delineated (Zazanashvili *et al.*, 2012, p. 19). PCAs in Azerbaijan with coastal and marine components included, Samur-Yalama, Agzubir Lake (Divichi), Gobustan-Absheron, Shirvan, and Gyzylagach.

With emergence of new landscape-level approaches to conservation, the most recent edition of the ECP in 2020 applies a different methodology prioritising sites that are critically important from a global and regional perspective. ECP 2020 incorporates a relatively new concept of conservation landscape and applies the KBA approach replacing the PCA approach used in previous editions (Zazanashvili *et al.*, 2020b). Actions in ECP 2020 now target a total of 231 KBAs in the Caucasus Ecoregion, 14 of which are the KBAs in Azerbaijan with coastal and marine components as discussed in Section 3.3.

3.6 Protected Areas summary

Overall, there are 14 protected areas with marine or coastal components in Azerbaijan, of various designations, many overlapping each other (see Sections 3.1 to 3.4). These are summarised in Table 4, with their corresponding national and international protected area designations.

TABLE 4: SUMMARY OF LPA AND IRA IN AZERBAIJAN WITH MARINE COMPONENTS

Site[xxxiv]	Legally Protected Areas (LPA)			Internationally Recognized Areas (IRA)					EBSA
	National Park	MPA	Sanctuary	KBA	IBA	MPA	AZE Site	Ramsar Site	
Absheron Archipelago (north) and Pirallahi Bay									
Alat Bay-Baku Archipelago									
Divichi Liman									
Gylnanyi Island									
Gyzylagach State Reserve									
Kura Delta									
Pirsagat Islands and Los Island									
Sahil Settlement-Shelf Factory									
Samur Delta									
Sangachal Bay									
Shahdidi Spit									

xxxiv Some of these areas are named differenly in national and international databases. Table 4 follows the KBA nomenclature, as the KBAs are larger than the overlapping LPAs in all instances.

Site[xxxiv]	Legally Protected Areas (LPA)			Internationally Recognized Areas (IRA)					EBSA
	National Park	MPA	Sanctuary	KBA	IBA	MPA	AZE Site	Ramsar Site	
Shorgel Lakes/ Shirvan Reserve									
Yallama Rivers									
Yashma Island									

4 MARINE MAMMALS

Azerbaijan supports a single endangered marine mammal — *Pusa caspica* (Caspian seal) is a small-bodied, ice-breeding phocid seal endemic to the Caspian Sea and the only marine mammal found there. The population has gone through a rapid decline of about 90 percent from more than 1 million at the beginning of 20th century. The seals migrate through their range in the Caspian Sea with seasonal migration between northern, middle, and southern sections. In winter, they breed in shallow waters in the north, and in early April they migrate southward, dispersing for foraging (Dmitrieva et al. 2016).

In the Azerbaijan sector of the Caspian Sea, seals used to have significant haul out sites occupied by thousands of individuals in the Absheron Peninsula and Archipelago, Pirallahi Bay, and Shahdidi Spit. Recent records indicate that only a couple of hundreds of seals are counted on a regular basis in these areas, in addition to fewer sightings in Kura Delta and Gyzylagach (IUCN 2015 ; Sultanov et al. 2000). These areas that are significant for the Caspian Seal in Azerbaijan are all included in the LPAs, KBAs, and EBSAs as discussed in Section 3. No additional digitised spatial datasets were found for the species, but there are survey data available on annual occurrences and migration that could be useful to inform MSP, site selection, and ESIA as listed in Table 2.

5 BIRDS

5.1 Threatened Waterbirds in Azerbaijan EEZ

There are 10 threatened waterbird species whose IUCN global ranges overlap with the Azerbaijan EEZ (Table 5). LPAs and IRAs with marine components that are significant for threatened waterbirds are highlighted in Section 3, particularly the IBAs listed in Table 2, which have been included in the exclusion zone layer. No additional digitised spatial data were found in relation to threatened bird species; however, additional sources of bird survey and sightings data that could be useful to inform MSP, site selection, and ESIA are available.

TABLE 5: THREATENED MARINE BIRD SPECIES OCCURRING IN AZERBAIJAN

Latin Name	Common Name	IUCN status	Range area km^2
Leucogeranus leucogeranus	Siberian Crane	CR	2,290,000
Numenius tenuirostris	Slender-billed Curlew	CR (likely extinct)	303,000
Vanellus gragarius	Sociable Lapwing	CR	1,670,000
Oxyura leucocephala	White-headed Duck	EN	17,600,000
Anser erythropus	Lesser White-footed Goose	VU	7,060,000
Aythya farina	Common Pochard	VU	27,800,000
Branta ruficollis	Red-breasted Goose	VU	1,140,000
Marmaronetta angustirostris	Marbled Teal	VU	14,600,000
Melanitta fusca	Velvet Scoter	VU	14,900,000
Podiceps auritus	Horned Grebe	VU	52,900,000

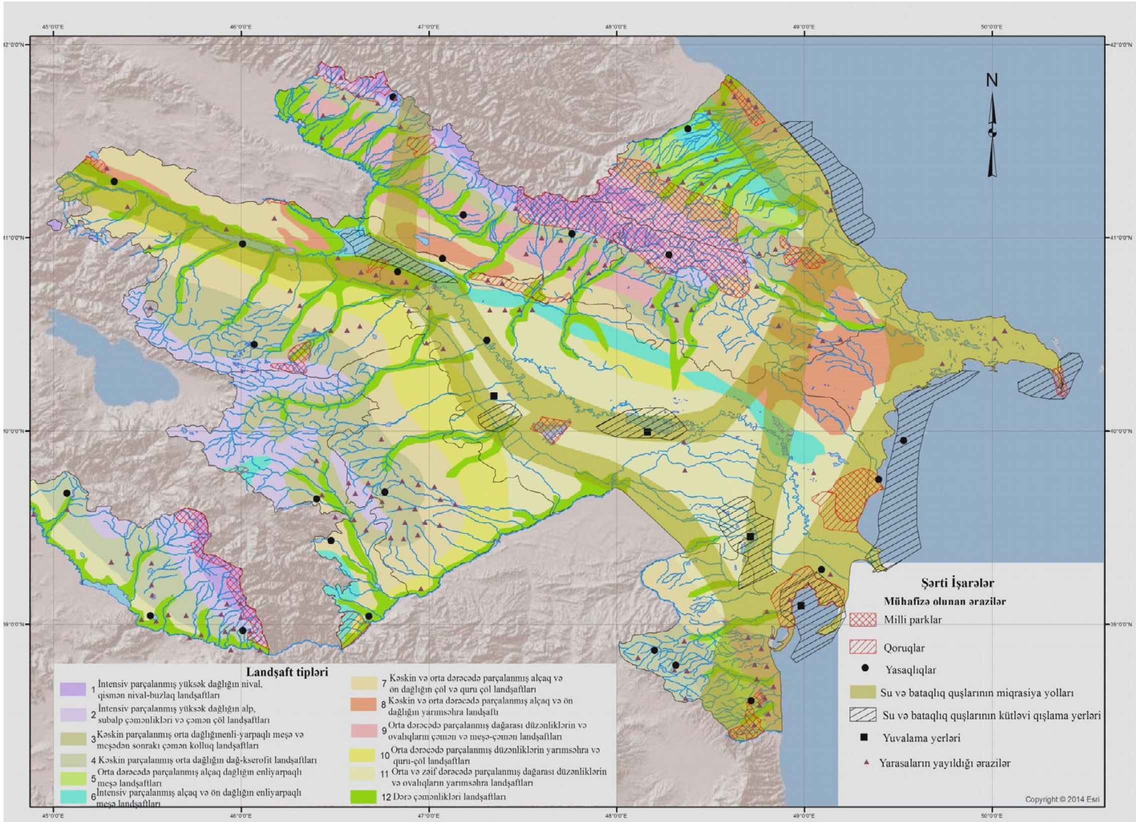
5.1 Waterbird Congregations in Azerbaijan EEZ

Azerbaijan has one of the largest wintering waterbird populations of the Caspian-West/Siberian-East African flyway, reaching 700,000 individuals. There are four marine areas that have been identified as being important for congregatory water birds in the Azerbaijan EEZ (Figure 1) (EaPGREEN Partnership for Environment and Growth et al. 2016):

- Area 1 encompasses Samur Delta-Yallama Rivers-Divichi Liman
- Area 2 includes Pirallahi Bay-Absheron Arhipelago-Shahdidi Spit
- Area 3 extends from Baku Archipelago to southern coasts to include Kura Delta
- Area 4 is Gyzylagach Bay.

The areas identified in Figure 1 overlap and extend beyond corresponding KBAs as listed in Table 2. The larger marine areas identified as important for water birds are provisionally included in the restriction zone, although adequate large scale bird surveys should be undertaken as a priority before wind developments are located within these areas.

FIGURE 1: IMPORTANT WINTERING BIRD AREAS (GREEN HATCH): SOURCE EAPGREEN, 2014



The waterbird population reaches its peak from December to January and is dominated by ducks and coots. Numbers of birds are reduced by half by February, and increase again from February to April-May with the start of the breeding season. It is estimated that around 200,000 birds have nesting grounds on Azerbaijan coasts. As many as 40,000 of these birds breed on islands and old oil platforms of the Absheron and Baku Archipelago, the majority of which are represented by 4 species: *Phalacrocorax carbo* (Great cormorant), *Larus cachinnans* (Caspian Gull), *Sterna hirundo* (Common Tern), and *Thalasseus sandvicensis* (Sandwich Tern). The mixed colonies in Kura Delta and Gyzylagach Reserve breeding populations are also represented by the same cormorant, gull, and tern species, as well as herons, including: *Ardea purpurea* (Purple Heron), *Ardeola ralloides* (Squacco Heron), *Nycticorax nycticorax* (Black-crowned Night Heron); egrets; *Bubulcus ibis* (Cattle Egret); *Egretta egretta* (Little Egret); and *Plegadis falcinellus* (Glossy Ibis) (Sultanov 2019).

Absheron and Baku Archipelago, Kura Delta, and Gyzylagach Reserve are also protected areas (see Section 3) and included within the exclusion zone layer. No additional digitised spatial data was found in relation to breeding waterbird species.

5.3 Flyways / Bottlenecks

Migratory marine birds receive impacts from offshore wind in the form of collision with turbines, barriers effects, and displacement. The entire Azerbaijan coastline is a major flyway for migrating waterfowl and seabirds, which have breeding grounds in Kazakhstan, southern Russia, and western Siberia, and migrate to the southern coasts of the Caspian Sea for wintering (EaPGREEN Partnership for Environment and Growth *et al.* 2016).

Non-marine migratory bird species can also be impacted offshore wind if turbines are located on migratory bottlenecks. The Besh Barmag bottleneck is located 80 km to the north of Baku and forms a narrow coastal plain crossed by migrating waterfowl, seabirds, and non-marine species. The direction of the coastline overlaps with the north-south orientation of the migration route. A total of 316 migratory species have been recorded during spring and autumn, the most common of which is *Sturnus vulgaris* (Common Starling) with more than 900,000 individuals, followed by *Tetrax tetrax* (Little Bustard), *Phalacrocorax sinensis* (Great Cormorant), *Chroicocephalus ridibundus* (Black-headed Gull), *Corvus fruilegus* (Rook), *Melanocorypha calandra* (Calandra lark), *Alauda arvensis* (Eurasian Lark), and *Pastor roseus* (Rose-coloured starling), each exceeding 100,000 individuals during migration. Another 23 species were observed in numbers between 10,000 and 100,000 migrating individuals, in addition to waterbirds that exceed 1% of their population/flyway population (Heiss et al. 2020). The Besh Barmag bottleneck also supports passage of threatened non-marine species; *Neophron percnopterus* (Egyptian Vulture; EN), *Aquila clanga* (Greater Spotted Eagle; VU), *Aquila nipalensis* (Steppe Eagle, EN), *Aquila heliaca* (Eastern Steppe Eagle; VU), *Falco cherrug* (Saker Falcon; EN), *Vanellus gregarious* (Sociable Lapwing; CR), and *Streptopelia turtur* (European Turtle Dove; VU) (Heiss 2016).

6 FISH

The Azerbaijan EEZ is inhabited by 12 threatened anadromous and semi-anadromous fish species (Table 6), most of which are endemic to the Caspian Sea. There are also other endemics; *Cobitis amphilekta* (Azerbaijani spined loach), *Salmo ciscaucasicus* (Caspian salmon), *Salmo caspius* (Caspian trout) *Alosa curensis* (Kura shad), and *Sabanejewia caspia* (Caspian spined loach), which have not been assessed by the Red List.

Kura Delta, Lesser and Great Gyzylagach Bay areas, and Lenkaran coasts are the most significant habitats for subadult fish stocks of the Azerbaijan sector of the Caspian Sea, used by sturgeon, salmon, and carp species as feeding grounds. Herrings and kilka also reach this area for feeding, while they use the Middle Caspian, including Absheron Peninsula and the Samur-Yallama-Divichi sections of the Azerbaijan EEZ for breeding. With spawning and feeding locations distributed throughout, the entire Middle and Southern Caspian Sea that overlaps with Azerbaijan EEZ is considered a sensitive fish habitat (Ministry of Ecology and Natural Resources of Azerbaijan Republic 2002).

The aforementioned areas; Kura Delta, Lesser and Great Gyzylagach are LPA and IRA designations that include fish as specific features of interest. Fish are also identified as important features of all three EBSAs (see Section 3). No additional digitised spatial data has been identified in relation to fish.

TABLE 6: THREATENED FISH SPECIES IN AZERBAIJAN

Latin Name	Common Name	IUCN status	Range area km^2
Acipenser gueldenstaedtii	Russian Sturgeon	CR	
Acipenser nudiventris	Ship Sturgeon	CR	
Acipenser persicus	Persian Sturgeon	CR	
Acipenser stellatus	Stellate Sturgeon	CR	
Huso huso	Beluga	CR	
Alosa volgensis	Volga shad	EN	
Clupeonella engrauliformis	Anchovy Sprat	EN	
Clupeonella grimmi	Southern Caspian Sprat	EN	
Acipenser ruthenus	Sterlet	VU	
Cyprinus carpio	Common Carp	VU	
Luciobarbus brachycephalus	Aral Barbel	VU	
Luciobarbus capito	Bulatmai Barbel	VU	

7 NATURAL HABITATS

Azerbaijan does not have an official list of threatened marine habitats. The available data provide classification of landscape types, including the coastline, but not habitat-level information with associated species assemblages (except for studies in limited areas). While there is no digitised spatial data on the extent of habitats, the following natural habitats have been identified based on localized studies and related maps:

Shifting dunes: Samur-Divichi lowlands encompass the largest continuous shifting dune complex and lagoons in Azerbaijan, covering an area of 10,000 ha. This area overlaps with three KBAs — Samur Delta, Yallama Rivers, and Divichi Liman — where the northern part is also designated as Samur-Yallama National Park and EBSA (see Section 3). No additional digitised spatial data have been found on other dune formations along the coasts of Azerbaijan.

Zostera noltii seagrass beds: *Z. noltii* (LC) is a small seagrass species that occurs in intertidal and subtidal areas of up to 10 metres depth in the Eastern Atlantic, Baltic, Mediterranean, Black, Aral, and Caspian seas, as well as western Africa, Canary, and Cape Verde Islands. This fast-growing species forms single-species habitats and is the only seagrass found in the Caspian Sea. According to the IUCN Red List, the species is not under any direct threat but has gone through local declines due to loss of water clarity; however, these are not significant enough to trigger threat categories (IUCN 2007).

Sangachal Bay is the only area identified extent of seagrass habitat. It falls within a KBA. WCMC's World Atlas of Seagrass (UNEP-WCMC & Short 2018) provides a number of point locations for *Zostera* beds within the Azerbaijan EEZ, some of which overlap with Gyzylagach State Reserve KBA in the exclusion zone. There are also several other point locations, outside of LPAs and IRAs. Point locations do not provide sufficient resolution for inclusion in either the exclusion or restriction zones and require further assessment during MSP, site selection and/or ESIA.

Mud volcanoes: Baku and Absheron Peninsula Mud Volcano Group State Nature Sanctuary has eight marine mud volcanoes that form islands, of which Gylnanyi Island and Los Island are designated LPAs and KBAs (see Section 3) and therefore included in the exclusion zone layer. No additional digitised spatial data were found on mud volcanoes.

7.1 Threatened Invertebrates

Mollusc fauna in the Caspian Sea has evolved under brackish conditions in relative isolation and therefore have unique characteristics. Two classes of Mollusca are found in the Caspian Sea; Gastropoda and Bivalvia, represented by 19 and 52 species that are restricted to the Caspian Sea, respectively (Wesselingh et al. 2019). Of these, only two are assessed by the IUCN Red List as critically Endangered (both possibly extinct *Dreissena caspia* and *Dreissena elata*), one Vulnerable species and seven Data Deficient. Digitised spatial data on Mollusca species distribution have been produced by Lattuada et al. 2020. The areas of highest species richness are distributed offshore along the Azerbaijan coasts of the Caspian Sea and largely occur outside of LPAs and KBAs. The areas of highest species richness (> 35 species per cell) have been included in the restriction zone layer, and associated risks are required to be further identified. No additional digitised spatial data were found on marine invertebrates.

8 SUMMARY

Sections 3 to 7 provide the rationale for the digitised spatial data included within the exclusion and restriction zone layers, to be taken into account within the Azerbaijan offshore wind roadmap. These are summarised in Table 7 along with the sources of the relevant digitised spatial data.

TABLE 7: SUMMARY TABLE OF DIGITISED SPATIAL DATA TO BE INCLUDED IN EXCLUSION AND RESTRICTION ZONE

Zone	Priority biodiversity value	Available digitized spatial data layer	Source
Exclusion Zone	LPAs and IRAs	Marine National Parks	www.protectedplanet.net
		State Nature Sanctuaries	
		Ramsar Sites	www.ibat-alliance.org
		KBAs, including IBAs and AZE Sites	www.ibat-alliance.org
		EBSAs	www.cbd.int/
Restriction Zone	Water birds	Waterbird Wintering Areas	www.unece.org
	Marine invertebrates	Distribution of endemic mollusks	doi.org/10.1594/PANGAEA.908169

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APPENDIX E: JOBS AND ECONOMIC BENEFIT: 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 has been 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 and industry reports.

The methodology's first input is the cost per MW of each of the supply chain categories at the time of wind farm completion. These costs are adjusted to local conditions, accounting for variables including local-supply capability, local labor rates, and transportation.

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 (US$)
M = Total operating margin (US$)
Y_a = Average annual wage (US$)
W_a = Non-wage average annual cost of employment (US$).

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. Labor costs are adjusted to local conditions by considering general in-country salary levels with other offshore wind markets.

FTEs relate to full-time equivalent job years, with part-time or part-year work considered as appropriate. A full-time job would normally be at least 7 hours per day over c230 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 in the report are by workplace rather than by residence and will include migrant/temporarily 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 Azerbaijan 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 Azerbaijan 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 expenditure.

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. Where a specialist vessel, for example, has been built in Azerbaijan 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.

Definitions and assumptions

The economic analysis was structured around theoretical projects. For each year of the theoretical projects, we made judgements of the Azerbaijani content for each of the supply-chain categories defined in Section 9. To simplify this analysis, we assumed that there is no real term increase in salaries and that changes in cost for the projects in between 2028 and 2032 are due to changes to technology and industry learning. As a result, the analysis is likely to underestimate the GVA.

Our analysis has assumed that work undertaken in Azerbaijan has a higher human resource intensity of European companies because lower wage costs and lack of competition in the Caspian Sea reduce the business case for investment in automation.

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1818 H Street, N.W.
Washington, DC 20433 USA
esmap.org | esmap@worldbank.org