Offshore Wind Phase II Technical Assistance for Sri Lanka

Study to expedite the development of wind energy in two high potential areas of the coast of Mannar and Puttalam

World Bank Group, ESMAP and UK Government

723176

21-11-2025

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Title
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Type of document
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Date
21-11-2025

Internal project number
723176

Client
World Bank Group, ESMAP and UK Government

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Brief overview of the study

The Consortium, consisting of RMA Energy and Pondera Consult, has been executing an extensive study for offshore wind under a Technical Assistance (TA) Support Program of the World Bank Group to the government of Sri Lanka. It is funded by the UK Government with support from the World Bank Group's Energy Sector Management Assistance Program (ESMAP).

This study (under Phase 2 TA) is intended to build further on the main findings from the Offshore Wind Roadmap (under Phase 1 TA). It focuses on conducting a pre-feasibility study for two high-potential areas for wind power development off the coast of Puttalam and Mannar provinces. **The main objective of this study is to create attractive market conditions for investors and advance the development of the first offshore wind projects in Sri Lanka.** The technical assistance also aims to: 1) to de-risk future project development activities, 2) to engage stakeholders and build capacity to create widespread support, and 3) to increase general knowledge of offshore wind in Sri Lanka.

The technical assistance consists of several integrated assessments as follows. A constraint assessment (Chapter 2) was carried out to identify potential risks and barriers for offshore wind energy, and to identify the best potential locations for development projects. This information, along with other aspects such as realistic scales and local context, was used to develop project concepts (Chapter 3). These project concepts include information about infrastructure characteristics such as turbines, foundations, layout and the grid. Several variations were made to conduct a comparative assessment on factors such as energy yield and (economic) feasibility.

Additionally, several more nationwide building blocks for offshore wind development were investigated. A port appraisal study (Chapter 4) was conducted to determine the readiness and required upgrades of Sri Lankan and nearby Indian ports, including an outlook on potential socio-economic opportunities. The electrical system of Sri Lanka was also analysed (Chapter 5) to obtain insights on how to integrate the power from offshore wind projects into the grid, including an overview of potential grid development and including power flow modelling. An assessment of favourable market conditions (Chapter 6) was conducted, including mitigation and solution measures for commercial risks and bankability issues. Finally, stakeholder engagement and capacity building activities (Chapter 7) were conducted throughout the entire duration of the study.

The summary of each chapter, corresponding to the six main tasks of this study, briefly covers the objectives, methods, findings, and recommendations, is provided below.

This study reaffirms the conclusion of the Roadmap that the offshore areas in Puttalam and Mannar have significant potential for offshore wind projects. Among them, Mannar appears to have the greatest potential due to a combination of favourable factors. The study also highlights the need for Sri Lanka to continue building on the progress already made in developing key building blocks for offshore wind, including port and grid infrastructure, supply chain development, setting favourable market conditions, continuing stakeholder engagement and capacity building, and execute further studies to mitigate risks and uncertainties. With the right efforts, the first offshore wind projects could be tendered in the next 2 to 3 years and commissioned by the mid-2030s. The report confirms that Sri Lanka's offshore wind development potential will be heavily influenced by, and dependent on, the progress of offshore wind deployment in neighbouring Tamil Nadu, India.

The findings of this study, particularly the identified information gaps and uncertainties, combined with knowledge from offshore wind development in comparable markets, will form the basis for the subsequent Phase 3 Technical Assistance. This next phase will focus on site-specific surveys to generate evidence-based data that will further de-risk development and advance offshore wind deployment. Specific recommendations for the surveys under Phase 3 Technical Assistance will be captured in a separate document in due course (Text box 1 provides suggestions based on this study).

Text box 1 Suggested priority surveys for site suitability

The study highlights the need for a deeper understanding of biodiversity, particularly marine mammals, birds, and bats, and the characterization of geotechnical and geophysical conditions, including sea depths and seabed composition. Moreover, local fishers actively use the Mannar and Puttalam coasts, raising concerns about offshore wind development and underscoring the need for further study and coordination.

The geotechnical and geophysical survey should capture bathymetric variability and provide a general understanding of subsurface conditions and soil properties at key locations to support site selection and feasibility assessment.

Similarly, the ecological characterization survey should assess potential project areas by identifying present species, understanding their seasonal distribution, frequency, and migration routes, and determining overall suitability for development.

To maximize efficiency, it is strongly encouraged to combine survey efforts—for example, conducting marine mammal observations alongside geophysical surveys. Sri Lankan entities should take the lead in these efforts to build local capacity, with international experts providing technical support and strengthening offshore wind survey practices.

Summary of the six tasks of this study

Constraint Assessment

The Constraint Assessment evaluated the feasibility of offshore wind energy development in the offshore areas of Mannar and Puttalam by identifying and assessing key offshore constraints. It also helped identify mitigation measures to reduce risks and uncertainties while outlining potential suitable areas for offshore wind development.

A comprehensive assessment framework was established, encompassing technical, environmental, social, and safety considerations. Data from diverse sources, including global datasets, online literature, local expertise, site visits, and stakeholder consultations, were analysed. The main analyses were carried out using a Geographic Information System (GIS) as a mapping tool.

Several key constraints were identified, each varying in significance. The primary risks and uncertainties affecting offshore wind feasibility, along with potential mitigation measures, are summarized below in order of highest to medium risk:

- **Ecological (high risk):** The project areas are located in a wider region known as a biodiversity hotspot, particularly for avifauna (birds and bats) and marine mammals. However, there is limited knowledge regarding the presence, distribution of species, and the dynamics of nearby migration routes. Further research and on-site surveys are needed, with priority actions to be captured in a separate document during the Phase 3 Technical Assistance in due course.
- **Fishing (high risk):** The entire coastal area of Mannar and Puttalam is actively used by local fishers, with fishing hotspots located near the project boundaries. Local fishers have expressed concerns about offshore wind development. Additionally, illegal fishing activities by Indian fishermen also take place in Sri Lankan waters. Close coordination with local fisheries and aligned development efforts could help mitigate potential disturbances.

- **Wind speed (medium/high risk):** Both areas exhibit favourable wind speeds for offshore wind development. In Mannar, the mean wind speed at the proposed project site is 8.4 m/s at a 150 m Mean Sea Level (MSL) hub height. In the Puttalam area, slightly lower mean wind speeds of 7.7 m/s are observed at the same hub height. However, there is uncertainty regarding the wind speed gradient offshore in Puttalam, where wind speed variations appear to be more pronounced, potentially affecting the accuracy of wind resource estimates and layout design. Additional wind assessments are currently being conducted as part of a parallel study by the World Bank. Seasonal variation is high, which is an important consideration for offshore wind system integration. However, daily variation is low, with modelled wind speeds higher during non-daylight hours, which can be highly complementary to Solar PV.
- **Water depth (medium/high risk):** Generally, both areas are relatively shallow and offer a suitable depth range for fixed-foundation offshore wind technology, with many areas ranging between 10 and 30 meters in depth. However, there is some uncertainty regarding the presence of shallow waters, particularly due to presumed sandbanks in Puttalam. Further bathymetric surveys are needed for precise siting, with priority actions to be captured in a separate document during the Phase 3 Technical Assistance in due course.
- **Seabed characteristics (medium risk):** Although no seabed conditions are expected to negatively impact the foundation design options, data, particularly on the spatial variation of seabed conditions, are limited. Geotechnical and geophysical surveys are therefore essential to assess soil properties, sediment types, and potential constraints, with priority actions to be captured in a separate document during the Phase 3 Technical Assistance in due course.
- **Shipping (medium risk):** Although the project areas are located outside major international shipping lanes, local shipping activities are present in Puttalam. Strong future coordination and alignment with the maritime sector, along with potential zoning and marking/lighting systems, could help mitigate potential disturbances.
- **Tourism (medium risk):** Although not a primary tourism destination, coastal tourism activities do take place near both project sites. Ongoing stakeholder engagement throughout the planning process is essential.
- **Military (medium risk):** Military activities overlap with the project areas, although there are no dedicated military zones within them. Close engagement with the Ministry of Defence and the Navy is necessary to establish operational agreements.
- **Mining activities (medium risk):** The project areas are subject to hydrocarbon exploration activities; however, no active mining operations have been identified within them. Continuous dialogue with the Ministry of Energy and the Petroleum Development Authority should be maintained.
- **Coastal residents (medium risk):** While the project areas are not located near the most densely populated coastal areas, there could be opposition from residents along the adjacent coastline due to the potential visibility of the wind farm from shore. Informing residents, addressing their concerns, conducting thorough impact assessments during the Environmental and Social Impact Assessment (ESIA), and holding public awareness campaigns can help reduce opposition and build local support.
- **Culturally sensitive areas (medium risk):** Similarly, potential visual interference is a key consideration, as the offshore wind farm may be visible from culturally sensitive areas along the coast. Stakeholders from these areas should be actively engaged throughout the process to address concerns and ensure their perspectives are considered.
- **Other wind projects (medium risk)**: Several onshore wind projects are located near the coast. Although a 5 km exclusion zone to the coast is applied in this study, potential wake effects may still reduce energy yield and increase fatigue for downwind existing onshore wind farms. Wind resource modelling will help improve the understanding of wake effects and, consequently, inform mitigation measures such as optimal siting (since wake effects typically decrease with distance) and the design of offshore wind projects (which can be optimized to reduce or withstand wake effects).

A spatial analysis incorporating all identified constraints was conducted, mapping out exclusion zones and suitable areas for offshore wind deployment. The following exclusion zones are proposed:

- Water depths shallower than 10 meters and deeper than 50 meters to enable cost-effective foundation structures and installation methods;
- A 5-kilometer safety / precautionary buffer zone from Adam's Bridge National Park is proposed to minimize potential negative effects on ecological values;
- A 5-kilometer distance from the coastline is proposed to minimize potential negative effects on ecological values, coastal activities, and people;
- A 1-kilometer distance from the marine border (EEZ) with India is proposed to avoid any potential border issues.

It is important to emphasize that while these exclusion zones are proposed, no definitive obstacles have been identified within the project areas at this stage that would entirely preclude offshore wind development. The suggested exclusion zones and the preliminary available areas for offshore wind are shown in Figure 1 and Figure 2 (i.e., colour-blocked areas). Notably, relatively large areas remain potentially available for offshore wind development (i.e., areas with parallel diagonal stripes), which, in theory, could accommodate multi-GW projects in both regions. However, further research is required to confirm their suitability. These areas were considered for the design of the reference projects (see next task).

Figure 1 High-priority offshore wind areas with exclusion zones (Mannar)

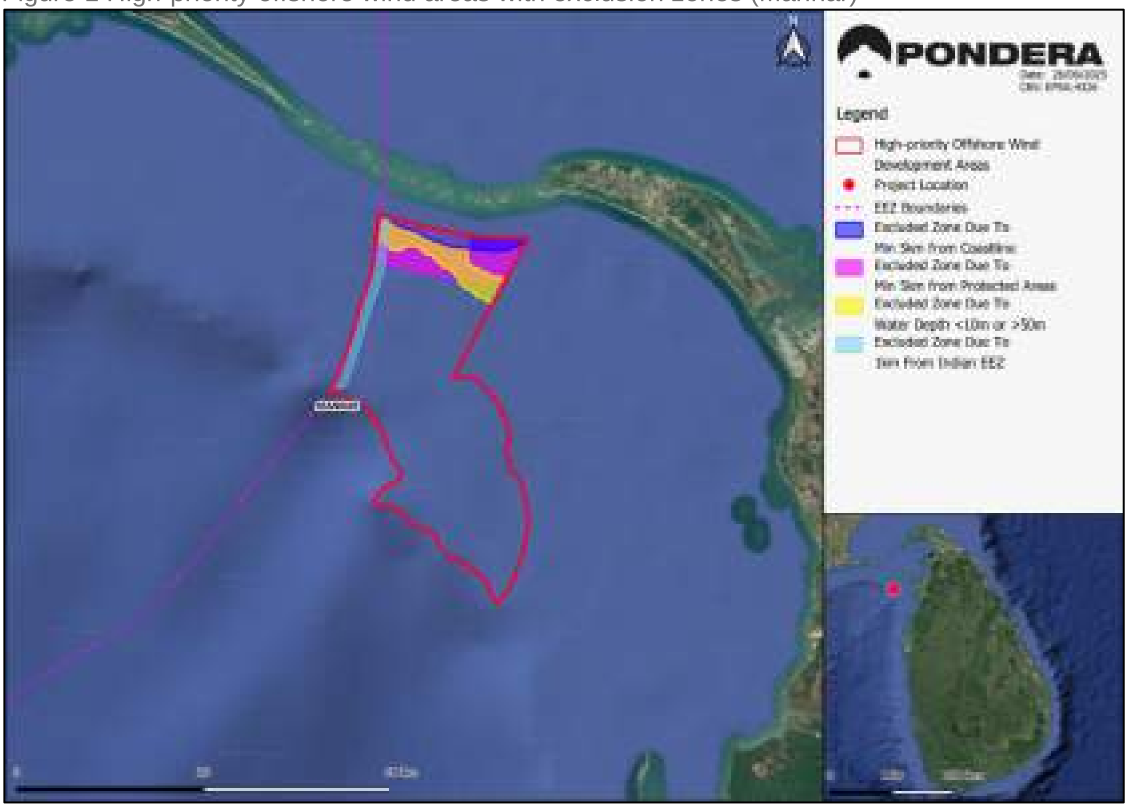
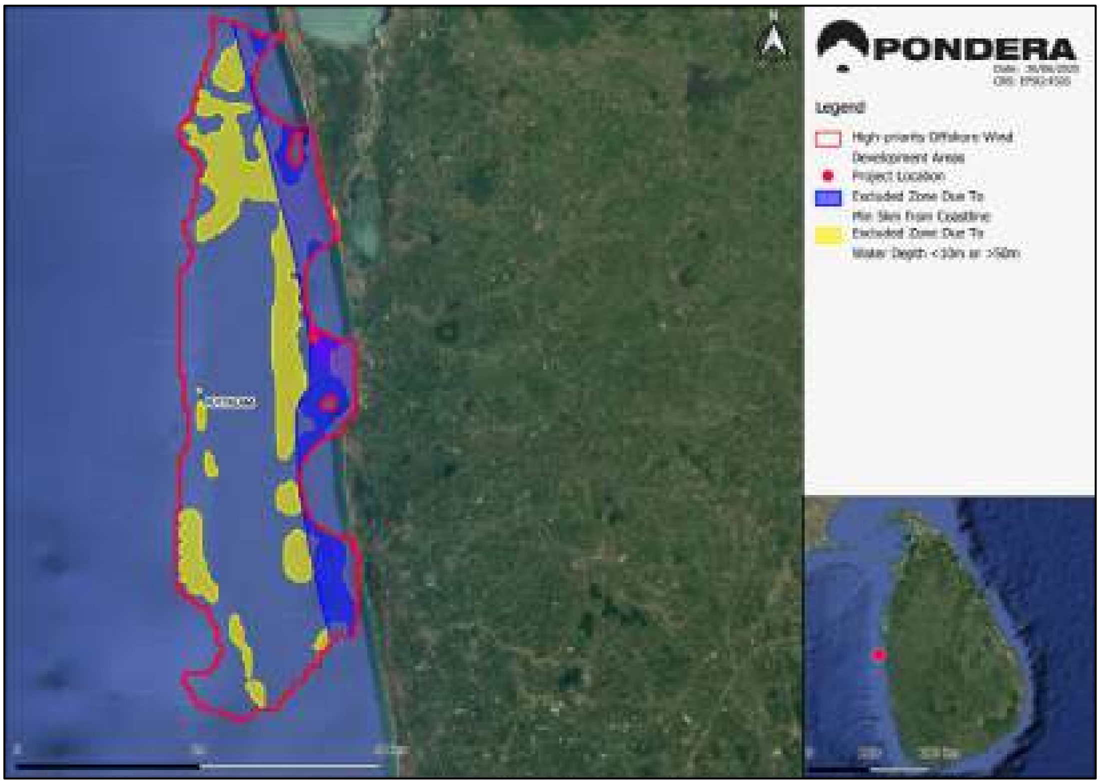


Figure 2 High-priority offshore wind areas with exclusion zones (Puttalam)



Project concept

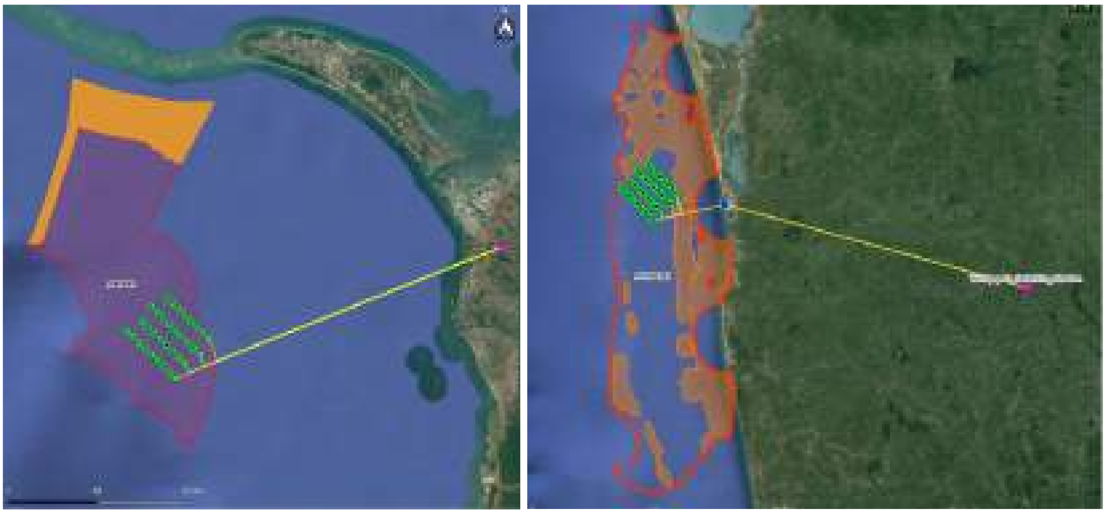
Building on insights from other tasks in this study, this chapter develops reference wind farm layouts, considering wind climate, various constraints and technology options.

Wind data from the Everoze report[1], calibrated using Vortex data and validated against ERA5 data, formed the basis for the wind climate assessment. While data validation showed a reasonable correlation, it also underscored the need for on-site wind measurement campaigns to reduce uncertainty.

A 500 MW project concept was developed for each area, utilizing 34 benchmark IEA-15 MW turbines with a 240 m rotor diameter and a 150 m hub height on monopile foundations. Layouts were designed as regular rectangular grids, accounting for prevailing wind directions and wake effects. The electrical system designs incorporate 132 kV array cables and onshore substations (further described in the Task Electrical System). The reference projects are shown in Figure 3.

[1] Vortex FDC. (2023, March 17). *Sri Lanka offshore wind – Wind resource and mapping* (Report No. VORTEX017-R-01-B). A report for the World Bank under MSA with Vortex.

Figure 3 Reference project (left Mannar, right Puttalam)



Energy yield modelling, conducted using WindPRO 4.0, revealed a significantly higher Annual Energy Production (AEP) in Mannar compared with Puttalam (see Figure 4), primarily due to higher mean wind speeds and lower wake losses.

Several alternatives were developed and compared, focussing on performance, energy yield and Levelised Cost of Energy (LCoE).

For Mannar, the following alternative project concepts were developed:

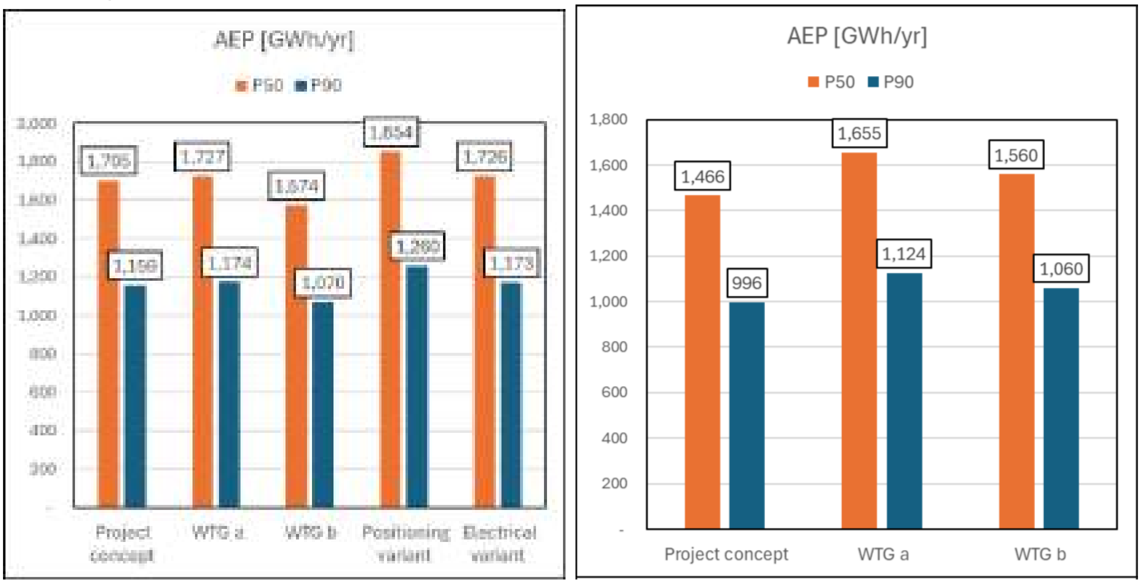
- WTG a = smaller wind turbine with lower power-to-rotor ratio, suitable for lower wind speeds (type: WB-8.6-200);
- WTG b = larger wind turbine (type: WB-18-250);
- Positioning Variant = layout optimized to reduce wake losses, featuring two longer rows of wind turbines;
- Electrical = includes an offshore substation.

For Puttalam, the following alternative project concepts were developed:

- WTG a = smaller wind turbine (type: WB-8.6-200);
- WTG c = lower power-to-rotor ratio, suitable for lower wind speeds (type: GW184/6.45MW).

The results of the AEP for the concept variants are visible in Figure 4. The positioning variant in Mannar has the highest AEP, but due its layout (spread perpendicular to the prevailing wind) reduces opportunities for phased development for OWP.

Figure 4 Results P50 and P90 AEP calculation of various project alternatives (left Mannar, right Puttalam)

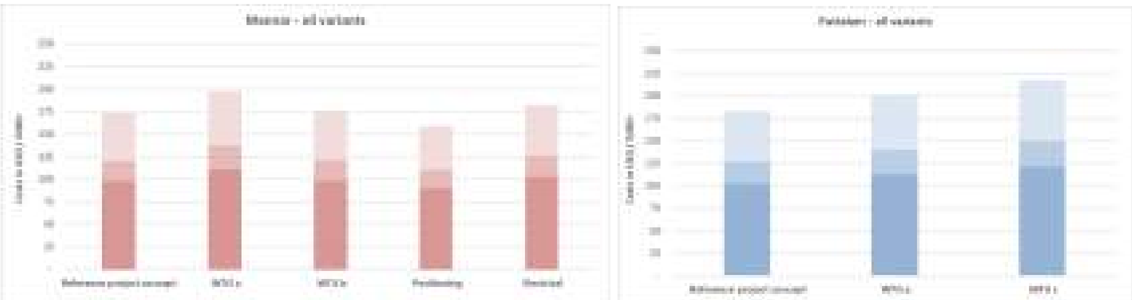


The LCoE was calculated for the concept variants using inputs such as the project timeline, costs (investment costs, i.e., CAPEX, and annual O&M costs, i.e., OPEX), discount rate or WACC, and AEP under three cost scenarios:

1. The relatively high price levels of 2024 will remain unchanged in the coming years (100%);
2. Current prices will drop back to the 'regular' 2019 price levels (80%);
3. The price level based on a projected local supply chain (economies of scale due to rapid APAC development and relatively cheap local labour) (70%).

The result of the LCoE calculation (see Figure 5) showed a wide range of outcomes, from 102-217 USD/MWh (Puttalam) to 89-189 USD/MWh (Mannar). In general, Mannar appears more attractive from a financial viability perspective. The LCoE for the reference project is higher than in the Roadmap, due to increased CAPEX (from 2.5 to 3.5-4.0 million USD/MW). It is important to note that there are significant variations and uncertainties in the LCoE calculations. This highlights the need for future work to narrow down the bandwidth of variants and create more certainty about the factors that strongly influence the LCoE. The 'value' of offshore wind in the electricity mix is still to be determined via dispatch modelling (as a post-project activity).

Figure 5 LCoE results for variants (Mannar=left, Puttalam=right). Darker colours being the lower cost bound (i.e. 70%) and lighter colours being the surplus for the 80% and 100% cost bounds



Port appraisal

The port appraisal assessed the readiness of Sri Lankan ports for offshore wind development and determined whether port upgrades are necessary. Data from the World of Ports database, field trips to port facilities, and publicly available sources such as the Ceylon Fishery Harbours Corporation website were used as inputs for the assessment.

The appraisal examined three types of offshore wind ports: 1) fabrication ports, 2) marshalling ports, and 3) O&M ports (SOV-based and CTV-based O&M ports). The ports assessed for their suitability to support offshore wind are shown in Figure 6. Given India's proximity to Sri Lanka and the expectation that offshore wind development will begin there earlier than in Sri Lanka, ports in India have also been evaluated for offshore wind development in Sri Lanka.

Figure 6 also shows the preferred ports for offshore wind development in Mannar and Puttalam, along with the necessary future upgrades.

Tuticorin port is recommended to support both fabrication and marshalling activities. Indian ports (like Tuticorin) are likely to lead regional offshore wind development while also servicing offshore projects in Sri Lanka (for manufacturing and marshalling). We analysed that Colombo port also has the potential to become a marshalling port, but significant upgrades would be necessary, including relocation of locks and gates and the procurement and installation of specialized equipment. In addition, the limited offshore wind project pipeline along Sri Lanka's west coast raises concerns about the economic viability of investing in Colombo port's development solely for marshalling activities. Given that marshalling operations occur for only a limited duration within the project lifecycle, the investment required for Colombo may not be justified. In contrast, upgrading Tuticorin for both fabrication and marshalling purposes represents a more strategic and cost-effective option for supporting offshore wind development in the region. Additionally, India's substantial offshore wind ambitions make it likely that large-scale ports like Tuticorin will be prioritized for regional projects.

Nevertheless, the port appraisal indicated that Tuticorin requires extensive upgrades, including dredging, breakwater widening, quay length expansion, and the procurement and installation of equipment to function as a fabrication port. Minor modifications, such as breakwater widening and equipment procurement, are also necessary for its development as a marshalling port.

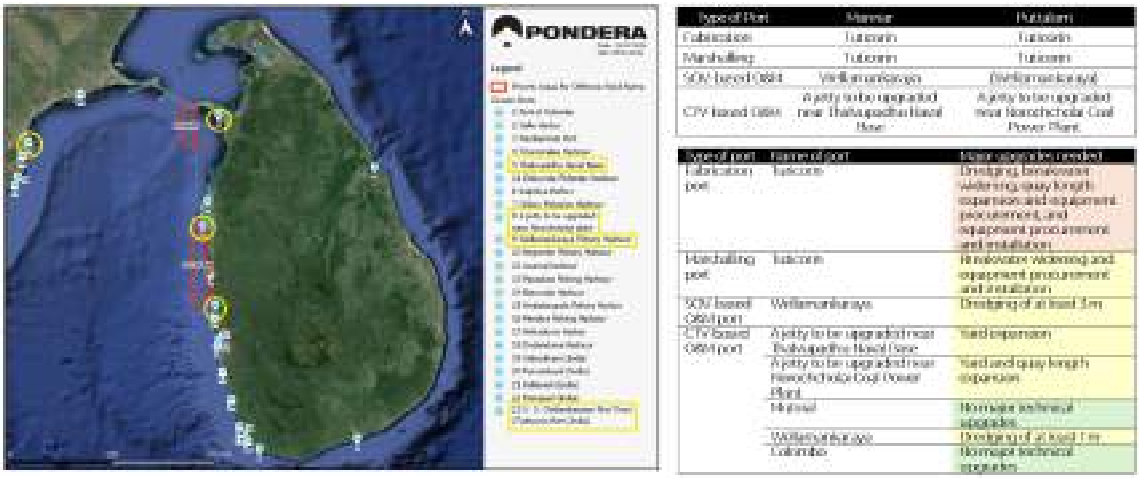
Regarding port development, Sri Lanka could focus on O&M ports. Several ports along the west coast have been identified as potentially suitable, with the following preferred options:

- For SOV O&M activities, Wellamankaraya is selected as the most promising port, only requiring dredging to become feasible. Wellamankaraya could potentially also serve future Indian offshore wind projects in the region.
- For CTV O&M activities jetty development near Thalvupadhu Naval Base and the Norochcholai Coal Power Plant are selected as the most suitable options for Mannar and Puttalam, respectively.

Development of O&M ports could contribute to economic growth in Sri Lanka, potentially creating an estimated 800 to 1,600 full-time jobs over 25 years for O&M activities.

An important takeaway from the analysis is that port development in Sri Lanka should be considered in the regional context of developments and opportunities in India.

Figure 6 Preferred ports for offshore wind in Mannar and Puttalam. Left: all ports considered (preferred in yellow). Top right: selected ports. Bottom right: required upgrades.



Electrical system of the Offshore Wind Farms and grid integration

The Sri Lankan electrical system was analysed to integrate power from offshore wind projects into the grid. Building on the Offshore Wind Roadmap, the study assessed site-specific grid connection topologies, including voltage levels, maximum capacity, and connection points. It also reviewed power flow potential and contingency scenarios. Studies were conducted for the milestone year 2035, focusing on the proposed electrical system configurations for offshore wind farms in Puttalam and Mannar and evaluating the capability of the existing and planned transmission network.

The high-level configuration of the electrical system, including array strings, submarine cables, and onshore substations, for the project concepts is shown Figure 3.

To integrate the proposed 500 MW Puttalam offshore wind farm into the Sri Lankan grid, the following electrical system and grid connection arrangement is proposed:

- Four 132 kV submarine cables will each connect 8–9 wind turbines and transmit the generated power to a new onshore substation.
- At the onshore substation, the voltage will be stepped up to 220 kV.
- A new 220 kV double-circuit overhead transmission line of approximately 50 km will be constructed from the Puttalam onshore substation to the Wariyapola grid substation.
- At the Wariyapola grid substation, the 500 MW Puttalam offshore wind farm will be integrated into the national grid.

To integrate the proposed 500 MW Mannar offshore wind farm into the Sri Lankan grid, the following electrical system and grid connection arrangement is proposed:

- Four 132 kV submarine cables will each connect 8–9 wind turbines and transmit the generated power to the existing Mannar grid substation over an average distance of approximately 53 km.
- At the Mannar grid substation, the voltage will be stepped up to 220 kV using transformers installed as part of the project, as the substation currently lacks 132/220 kV step-up transformers.
- Since the capacity of the existing 220 kV transmission line from Mannar grid substation to New Anuradhapura grid substation (via Vavuniya) is already allocated to other onshore wind farms, the construction of a 15 km 220 kV double-circuit overhead transmission line between Mannar grid substation and the HVDC substation is essential for power evacuation.

- To accommodate the offshore wind farm, the planned capacity of the transmission line between Mannar grid substation and the HVDC substation will be enhanced as part of the project.

Table 1 presents a summary of the identified offshore wind farm capacities that can be connected with the grid under different network upgrading scenarios. As summarized in the table, without additional network upgrades, only a limited capacity can be connected. Existing and planned upgrades in the network are not sufficient to interconnect large scale offshore wind in Puttalam and Mannar.

According to the CEB LTGEP 2023-2042, by 2035, 2,090 MW of wind power plants can be connected to the national grid, but with additional network upgrades. Studies and system stability analyses indicated that the power system can accommodate up to 1,000 MW of offshore wind capacity by 2035 (for both wind farms). Planned network upgrades include new transmission lines and substations to improve grid connectivity and manage power flows. Additional network capacity will be required to support these connections to ensure system stability and efficiency.

The planned interconnector with India potentially increases the capacity of the Mannar project. With planned and additional upgrades, combined with the interconnector, approximately 1,000 MW of offshore wind could be possible in Mannar by 2035.

Table 1 Offshore wind farm capacities possible to be grid connected by 2035 under different conditions

	Offshore wind farm capacity possible for grid connection	**Mannar**	**Puttalam**	**Remarks**
1	With the planned upgrades	250 MW	200 MW	Upgrading of the transmission network infrastructure is planned for Mannar in parallel with the ongoing onshore wind development in Mannar. However, only limited capacity is uncommitted. No substantial transmission network upgrades planned in Puttalam area.
2	With additional upgrades of the grid	500 MW	500 MW	Further upgrading of the transmission network in Mannar and Puttalam is possible to accommodate offshore wind.
3	With 1 and 2 above, in combination with the interconnector with India	1,000 MW	500 MW	500 MW of India-Sri Lanka interconnection capacity is assumed to be allocated to export wind power generated in Mannar to India. Offshore wind farm in Puttalam will still have transmission constraints, preventing export of generation by an offshore wind farm in Puttalam to India.

While Table 1 presents the offshore wind farm capacities that can be grid connected by 2035, this capacity can be further increased with increasing electricity demand in the system. For example, based on the current demand forecasts, by 2040, the capacity that can be connected in Mannar can be increased to 1,500 MW.

The grid analysis was completed in summer 2024. At the beginning of 2025, news emerged that the large-scale Adani project (250MW) was withdrawn, potentially making more network capacity for offshore wind available. This should be re-investigated, but it is outside the scope of this study.

Favourable market conditions
The favourable market conditions for offshore wind projects in Sri Lanka were assessed, including Sri Lankan macroeconomics, procurement options, and commercial risk and bankability considerations. Mitigation measures were proposed, where relevant. The assessment employed a secondary research method, synthesising existing data from research studies, articles, and in-house expert knowledge to derive findings and recommendations. An alignment exercise was conducted with a parallel WB study into the regulatory environment to ensure consistency in findings and recommendations.

The key insights regarding Sri Lanka's macroeconomic indicators related to offshore wind are provided in Table 2, with policy recommendations for improved conditions outside the scope of this study.

Table 2 Key insights on Sri Lanka macro-economics

Indicators	Key insights
GDP	• A growing GDP indicates economic strength, providing a stable environment for investments in offshore wind projects. • Although GDP growth levels have been fluctuating in recent years, even showing declines in economic activity, near term prognoses predict growth.
Currency Reserves	• Sufficient currency reserves improve financial stability, ensuring the country can meet financial obligations. • Sri Lanka's foreign currency reserves have fluctuated significantly over the last decade, hampering the ability to manage external shocks and meet its international financial obligations. More recently, reserves have increased to $5.4 billion, with no future targets set.
Inflation	• Low and stable inflation helps maintain predictable costs and financial stability, benefiting the economic viability of offshore wind projects. • During the 2022 economic crisis, Sri Lanka experienced a sharp increase in inflation, which was subsequently managed through rigorous monetary policies. Recently inflation levels have stabilized.
Foreign exchange rate	• A stable foreign exchange rate reduces currency risk for international investors and ensures predictable costs for imports. • The volatility of the USD/LKR exchange rate, especially in 2022, raises concerns for investor sentiment and foreign investment. Currency volatility adds uncertainty, potentially deterring new

Indicators	Key insights
	investments. The exchange rate improved and stabilised throughout 2023 and 2024.
Financial stability	• A stable financial environment attracts investment by reducing the risk of volatility in the offshore wind market. • Sri Lanka has recently faced financial stability challenges amid economic contraction, high inflation, and increased interest rates. Despite this, improvements in financial markets, foreign exchange liquidity, and IMF support suggest signs of stabilization and potential economic recovery.
Power Sector	• A well-developed and reliable power sector, with sufficient demand, provides the necessary infrastructure and grid capacity to support the integration of offshore wind energy into the national grid. • For Sri Lanka, although there has been some reduction between 2019 and 2022, electricity demand is projected to grow in the coming period, increasing the need to diversify into new generating sources including offshore wind. • Financial challenges persist within Sri Lanka's power sector, where state-owned utilities frequently incur losses. Due to tariff measures implemented since 2022, the situation has improved. • Gradual liberalisation of the power market and recently approved legal provisions toward market mechanisms are expected to increase competition and (foreign) investments.

Regarding procurement systems for offshore wind, this study builds on the recommendations from the Roadmap and assumes that the government-led pathway towards offshore wind will be followed. This assumption is based on the relatively small market size of offshore wind in Sri Lanka, links to the Tamil Nadu offshore wind market, the lack of developer appetite for risk in new markets and the absence of sufficient market competition. It is an important assumption, as the choice of procurement system influences the content and recommendations regarding favourable market conditions.

The key insights regarding commercial risks and bankability considerations related to offshore wind in Sri Lanka (split into technical, financial and environmental categories) are provided in Table 3.

Table 3 Key insights on commercial risks and bankability considerations

Section	Sub sections	Key insights
Technical	Supply chain	• Offshore wind projects in Sri Lanka face significant supply chain challenges due to competition for global resources and existing supply chain issues. • Aligning with India's offshore wind development could create a larger, more attractive market and foster a stronger regional supply chain (potentially leading to lower costs), leveraging established trade relationships.

Section	Sub sections	Key insights
		• Sri Lanka's existing maritime infrastructure and local engineering expertise offer potential for developing localized supply chain elements, supporting project construction and maintenance.
	Ports	• Current port capabilities insufficient for offshore wind development. • Chapter 4 provides an extensive port appraisal and recommendations on port usage and development. • Government and/or private investment in port facilities for offshore wind projects is essential.
	Grid	• Ensuring efficient integration of offshore wind power (OWP) into Sri Lanka's grid requires expanding both regional and national capacities. • Chapter 5 provides an extensive grid connection assessment and recommendations on required grid upgrades. • The planned interconnector with India holds potential to significantly enhance grid absorption capabilities in the Mannar area. • Current financial constraints challenge CEB's capacity to fund necessary grid upgrades. • Clarifying responsibilities between developers and CEB regarding infrastructure development is crucial, weighing the advantages of streamlined project management against potential financial burdens and public sector investments.
	Compliance with standards	• Sri Lanka faces potential risks without national standards, including regulatory uncertainties and market limitations. • Developing standards can enhance project quality, competitiveness, risk management, environmental responsibility, and regulatory alignment, crucial for efficient project development and global market access.
Financial	Financial support mechanisms (FSMs)	• FSMs are essential for offshore wind development as they help to offer investors a more stable return and de-risk projects for lenders resulting in reduced financing costs and lower cost of energy. • There are generally three pricing mechanisms that can be adopted: o Fixed Pricing: Ensures stable and predictable revenue but may not capitalize on potential wholesale electricity market price increases. o Premium Pricing: Offers potential for higher revenue when market prices rise but includes risk if market prices fall (apply for Feed-in Premium and one-way CfD). o Competitive Pricing: Can drive down costs through competition but may result in lower margins for suppliers.

Section	Sub sections	Key insights
	Electricity price	• Electricity market price fluctuations pose a significant risk for offshore wind projects (not supported by FSMs), impacting revenue due to factors like market demand and government policies. • Sri Lanka, previously with the highest prices in South Asia, has seen reductions since October 2023. • Fixed price mechanisms such as FITs provide stable revenue, while premium pricing adds a buffer against market fluctuations. Although competitive bidding introduces some risk, this is typically managed through long-term PPAs with fixed tariffs and flexible terms. • Future offshore wind contracts in Sri Lanka are expected to move towards competitive bidding under the Electricity Act of 2024. However, rather than exposing projects to the free-floating wholesale market, the competitive bidding process will likely allocate long-term PPAs with fixed tariffs, ensuring predictable revenue with a designated public counterpart.
	Grants	• There are currently no national government funds available for offshore wind. • Two examples of funds for energy efficiency projects are the Sustainable Guarantee Fund managed by SLSEA and the (to be opened) Sustainable Energy Guarantee Fund
	Costs	• Offshore wind projects are very costly, with 500 MW installations running into billions, increasing financial risk and deterring investors. • The cost estimations for the LCoE in Chapter 3 have a high uncertainty, compounded by the lack of regional benchmarks. This is addressed by using various cost scenarios and a sensitivity analyses. • Sri Lanka's proximity to Tamil Nadu offers a potential cost advantage, as developers may integrate Sri Lankan projects with India's offshore wind market, sharing resources and procurement. This could reduce costs and is factored into the LCoE analysis in Chapter 3.
	Taxation and profit repatriation	• Currently, there are no corporate tax concessions, though imported equipment for power projects is exempt from customs duty and VAT. • To attract investors, it is advisable to establish favourable tax regimes and set clear arrangements for profit repatriation.
	PPA	• The PPA in Sri Lanka relies on CEB, historically reliable in payments despite recent financial challenges. It has a typical 20-year term, with recent PPAs about 10 MW projects coming with USD denomination, providing revenue stability.

Section	Sub sections	Key insights
		• For a bankable PPA, it is crucial to clearly define the responsibilities of both parties, particularly regarding grid connection. However, with the ongoing unbundling of the energy sector, it's unlikely that the PPA will address grid investment responsibilities, as this would fall outside the scope of the agreement between the developer and the off taker. • The Sri Lankan PPA should include clear curtailment compensation mechanisms, defined limits on curtailment duration, and risk-sharing provisions. • Comprehensive insurance coverage in the Sri Lankan PPA meet the essential requirements, although political risk insurance is not explicitly detailed. • There are ambiguities in defining default events and force majeure conditions • The Sri Lankan PPA's dispute resolution process involves a tiered approach starting with mutual discussions and potentially escalating to higher-level representatives or an Expert, but lacks clarity in Schedule 15, creating uncertainties. • Additionally, the PPA is governed by Sri Lankan law, which may be less appealing to international investors preferring a globally recognized legal system.
	Financing	• Offshore wind projects are typically financed through a mix of debt and equity, using a non-recourse structure to limit risk to the project itself. • Key factors include: o interest rates, which affects borrowing costs and is better managed through international funding; o maturity, which determines repayment timelines and influences total interest costs; o gearing, which impacts financial stability by balancing debt and equity levels, with higher gearing increasing risk and lower gearing requiring more initial investment.
	Domestic financial support mechanisms	• Financing offshore wind projects in Sri Lanka will rely heavily on international capital, but local banks are essential for managing currency risk by providing loans in LKR, aligning with local revenue streams and enhancing stability. These banks' local market expertise also improves financing solutions. • Grants and funds are examples of domestic financial support mechanisms, but none are currently available for offshore wind projects.
	International financial support mechanisms	There are various international financial support mechanisms: • ECA-backed loans: ECA-backed loans require projects to meet strict risk criteria, including rigorous due diligence and reporting, more demanding than those of commercial financiers.

Section	Sub sections	Key insights
		Transactions with OECD Arrangement-covered ECAs must strictly comply with their additional regulations. • IFI guarantees: Guarantees can pose challenges due to complex accounting and approval processes for contingent liabilities, potentially leading to overuse for political reasons. • IFI insurance: Insurance requires advanced financial markets and historical project data to effectively manage risks across the renewable energy sector. In Sri Lanka, the CEB's comprehensive report on sales and generation data for renewable energy projects serves as a valuable tool for insurers, offering insights that can aid in evaluating and pricing insurance for these projects. • Blended finance: 1) Determining optimal timing and duration for concessional funds in blended finance is challenging. 2) Local financial markets must align with international standards for projects to sustain themselves post-intervention. 3) Government-set prices and market monopolies can distort signals, risking viability despite concessional support. Sri Lanka's fixed-price PPAs and the "must-run, must-take" policy ensure revenue stability, aiding blended finance. However, regulated tariffs may deter self-sustaining market after blended finance intervention. • A/B loan: Structuring A/B loans is complex due to splitting the loan into two parts with differing requirements, risk assessments, and expectations. Coordination challenges arise in aligning interests and managing relationships effectively. • Green bonds: 1) Green bonds don't offer financial advantages over conventional bonds as interest rates are based on the issuer's credit rating, not the funds' purpose. 2) There is no guarantee proceeds will be used as intended, potentially diverted to other areas. 3) Committing funds to specific expenditures may force cutbacks elsewhere due to fiscal constraints. 4) Measuring their impact is complex and uncertain, posing challenges in proving additional spending achieves desired outcomes, which can deter future investments.
Environmental and social	Sharing Maritime Space	• Offshore wind projects face risks from competing interests, for the potential projects in Mannar and Puttalam mostly related to fishing, ecology, shipping, military, and tourism. • In Chapter 2 an extensive constraint assessment has been carried out, highlighting the key risks from competing interests and potential mitigation measures. Competing interests could lead to delays, increased costs or reduced energy yield. • Competing interests are best managed during the planning stage through strategic assessments such as MSP and subsequently with ESIA, both of which involve extensive stakeholder engagement.

<table>
<tr><th>Section</th><th>Sub sections</th><th>Key insights</th></tr>
<tr><td></td><td>Lender E&S safeguard requirements</td><td>Lender E&S safeguard requirements can be split into several categories, the below table indicates which are covered by various leading institutions on this topic.
<table>
<tr><th></th><th>Equator Principles</th><th>IFC</th><th>EHS Guidelines</th><th>ADB</th></tr>
<tr><td>ESIA</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td></tr>
<tr><td>Biodiversity and marine conservation</td><td>✓</td><td>✓</td><td></td><td></td></tr>
<tr><td>Pollution prevention and control</td><td>✓</td><td>✓</td><td></td><td></td></tr>
<tr><td>Climate change adaption and mitigation</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td></tr>
<tr><td>Social engagement</td><td>✓</td><td>✓</td><td></td><td></td></tr>
<tr><td>Cultural heritage</td><td>✓</td><td>✓</td><td></td><td></td></tr>
<tr><td>Labour and working conditions</td><td>✓</td><td>✓</td><td>✓</td><td></td></tr>
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From Table 3 it is evident that many factors are required to create favourable market conditions for offshore wind in Sri Lanka. This study makes an initial attempt to provide an overview and recommendations. Further work and research are needed to support the rollout of offshore wind. Valuable lessons can be learned from offshore wind development in mature markets.

Stakeholder Engagement and capacity building

The primary goals of stakeholder engagement were to raise awareness, collect feedback, build capacity, and generate support for offshore wind projects. Offshore wind development is a new concept for the Sri Lankan community and, therefore, requires early and continuous stakeholder involvement, including government organizations and local communities. Moreover, long-term engagement is essential, particularly in the Mannar and Puttalam regions, where existing onshore wind projects and those currently in planning may have influenced perceptions of offshore wind initiatives.

A qualitative primary research approach was employed for the stakeholder engagement, gathering firsthand information through field trips, workshops, and online meetings to provide direct insights and contextual understanding.

Stakeholders were classified at three levels:

1. National-Level Stakeholders: Government and private organizations crucial for offshore wind development.
2. Regional-Level Stakeholders: The prominent regional-level government stakeholders are District Secretaries, Divisional Secretaries and representatives of local authorities. In addition, there are also non-government organizations (NGOs) working on environmental and social safeguards and NGOs working in the fisheries sector.
3. Project-Affected Stakeholders: Communities, organizations, and individuals who may be directly impacted by the project, including religious groups, fishing communities and tourism-related entities.

The following stakeholder engagement activities were performed as part of the study:

- Inception Mission: Held in November 2023, the project team (Pondera and RMA Energy) and World Bank had various one-on-one discussions with identified stakeholder organizations, making stakeholders aware of the offshore wind development activities.
- Workshops: After the inception mission, RMA Energy continued discussions with the executing agency, the Ministry of Power and Energy (MoPE). In January 2024, the ministry sent introductory letters to District Secretary Mannar, District Secretary Puttalam, coastal Divisional Secretaries of Mannar and Puttalam districts and 17 identified government organizations to request their assistance for future activities. Capacity-building workshops were arranged for regional and national stakeholder organizations. A series of workshops were held in Mannar (37 participants), Puttalam (32 participants) and Colombo (75 participants) between 26 February and 5 March, 2024. Additional efforts were made to increase the participation of women.
- Online Meetings with NGOs: An online meeting was arranged on the 13th of June 2024 with the relevant environment and social NGOs to inform them about the ongoing pre-feasibility study, to get their feedback, and to obtain relevant data for the analyses.
- Final workshops: A final series of workshops was held in Mannar (36 participants), Puttalam (33 participants) and Colombo (62 participants) from 17 – 21 March 2025 to present the findings of the pre-feasibility study and gather the final feedback. This helped refine the project conceptual design and ensured that the final report reflects the input of stakeholders.

Stakeholder engagement and capacity building should remain a priority effort in subsequent phases of offshore wind development, building on the achievements of this study.

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1 Introduction

1.1 Background and context

Energy is one of the key aspects in the entire socio-economic development process of a country. In 2024, Sri Lanka's energy mix in electricity generation consisted of coal (32%), oil (14%), hydro (32%), and various renewable energy sources (22%)[2,3]. Heavy reliance on fossil fuel imports amidst fluctuating fuel prices at the international level have increased electricity prices significantly over the years, along with pressure on the country's limited foreign currency reserves. This was one of the factors that led to the recent 2022 economic crisis. There is an opportunity to develop more renewable energy resources to reduce the country's reliance on fossil fuels and reach more price stability. This could also bring other potential benefits such as ensuring energy security and achieving decarbonization targets. In anticipation of Sri Lanka's interconnection with the Indian subcontinent grid, renewable energy could offer export opportunities.

One of the sustainable technologies that could support Sri Lanka to achieve a higher share of renewables in the electricity mix is offshore wind. Although there are no projects in operation, Sri Lanka has good natural conditions for offshore wind and there has already been private sector interest in developing projects. According to the Offshore Wind Roadmap for Sri Lanka[4] (hereafter abbreviated as 'Roadmap'), the offshore wind locational potential is estimated to be 56 GW (including 27 GW of fixed foundation in shallow waters and 29 GW of floating foundation in deeper waters)[5]. There are benefits to the deployment of offshore wind energy in Sri Lanka compared to onshore renewables, such as (but not limited to) (i) reduced impact on residences and land use conflicts, (ii) more constant electricity production, and (iii) larger available space and scale.

Despite the potential benefits, offshore wind is a complex and capital-intensive undertaking which takes years of development. It comes with novel risks and uncertainties. In an emerging market such as Sri Lanka, these risks and uncertainties are significantly heightened compared to more established markets, forming substantial barriers for potential investors and hindering the initiation of projects. This underlines the strong need for initiatives, like the current study, to support the government of Sri Lanka on offshore wind development. These initiatives aim to enhance understanding of the market's present preparedness while facilitating the establishment of an appealing and low-risk environment, encouraging industry and public sector participation, and paving the way for the realization of initial projects through targeted de-risking activities.

In regard to offshore wind initiatives in Sri Lanka, the World Bank has been actively engaged in collaborative efforts with the government since the 2019 study tour in Europe (see Text box 2 for a description of the program under which support initiatives, like this study, are executed). Following this, Phase 1 support was initiated, culminating in the publication of the Roadmap in 2023. This comprehensive, interdisciplinary study identified key offshore wind areas with high potential and investigated the status of various building blocks for offshore wind in the country. Subsequently, Phase 2 of Technical Assistance began in 2023 to address the Roadmap's recommendations. This phase comprises several components, including a regulatory gap analysis conducted by Tiruchelvam Associates, preparation work for wind resource data collection led by Andy Oldroyd, and the pre-feasibility study for two high potential areas presented in this report, conducted by Pondera and RMA. Phase 2 will conclude in 2024 and will offer guidance for the subsequent Phase 3 support, currently in the conceptualization stage. Phase 3, which is expected to be led by the Sri Lankan government in collaboration with other organisations, would involve more detailed follow-up activities, such as surveys, feasibility

[2] Statistical Digest CEB 2024

[3] Energy percentages are rounded.

[4] World Bank Group (2023). "Offshore Wind Roadmap For Sri Lanka,"

[5] The actual and realistic potential will most likely be significantly lower due to (a combination of) economic, technical, social, environmental and political factors.

studies, detailed design, wind data collection, and market engagement leading to tender seabed exclusivity for offshore wind development, construction and operation.

Text box 2 Explanation of the Offshore Wind Development Program and its relation to the current study

This report forms an integral component of the Offshore Wind Development Program, a global endeavour initiated by the WB in March 2019. Jointly led by the Energy Sector Management Assistance Program (ESMAP) and International Finance Corporation (IFC), the private sector arm of the World Bank, this program is dedicated to advancing offshore wind energy. Its primary aim is to facilitate the integration of offshore wind into the energy sector policies and strategies of WB client countries, while also supporting the preparatory groundwork necessary for the development of a portfolio of viable projects. Key facets of this program include scoping studies, country-specific roadmap analyses, and the provision of technical assistance.

This document specifically outlines a technical assistance study conducted for the government of Sri Lanka. This study constitutes the main component of a package of technical assistance being provided by the World Bank in support of the country's emerging offshore wind market. This assistance is based on the high-level recommendations made by the recently published Roadmap.

1.2 Study objectives

The primary objective of this study is to create attractive market conditions for investors and advance the development of the first offshore wind projects in Sri Lanka. In doing so the study will expand upon the insights and recommendations outlined in the Roadmap, emphasizing the following main pillars:

1. Conducting an extensive **pre-feasibility study** for two high potential offshore sites identified by the Roadmap in Mannar and Puttalam. The focal investigation will revolve around assessing the feasibility of offshore wind in these areas and identifying the conditions necessary for its viability.
2. Carrying out an **in-depth analysis of essential components** for offshore wind development (centred around potential offshore wind projects in Mannar and Puttalam), such as infrastructure, ports, and market structure, followed by defining favourable conditions for progress.
3. Providing a pathway and prioritization for **post-study activities and surveys** to continue the development process of offshore wind.
4. Continuing and broadening **stakeholder engagement** to foster awareness, gather input and feedback, build capacity, and garner widespread support for offshore wind development.

The outcomes of this study will contribute to reducing uncertainties associated with offshore wind development initiatives in Sri Lanka. Consequently, it will enhance the overall investment climate to attract developers, aligning with the overarching goal of expediting the realization of the first offshore wind project(s) in the country.

1.3 Scope of work

Activities and tasks

Figure 7 shows a graphic from the Roadmap (updated version) with a suggested approach for the development of offshore wind in Sri Lanka, comprising the various development stages and associating activities. Within the stage 'Government Activities', the following activities highlighted with a black dashed box are covered by this study, including spatial planning, site assessment, stakeholder engagement, wind modelling, environmental and social scoping, pre-feasibility study.

Figure 7 Suggested approach for offshore wind in Sri Lanka (source: Roadmap, updated version), and activities covered by current study

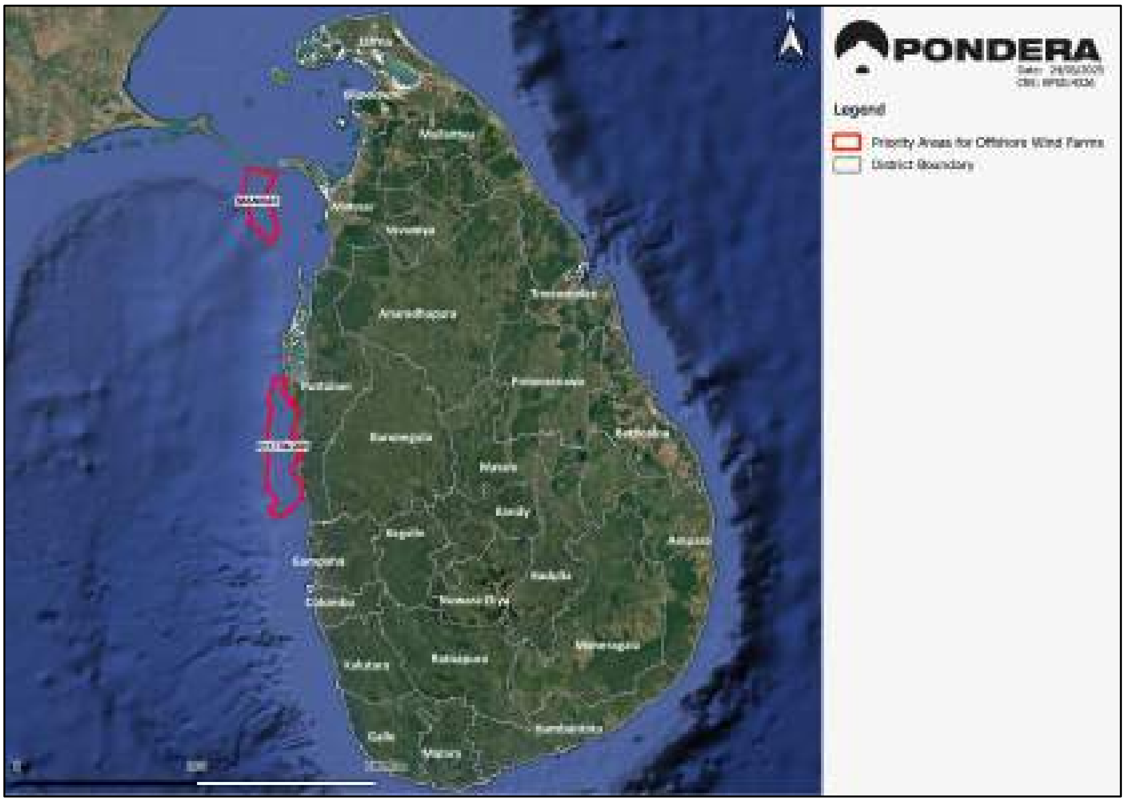
In order to achieve the objectives mentioned in Section 1.2, this study will carry out the following tasks:

1. Perform an in-depth constraints assessment for offshore wind to select the most suitable sites within the areas;
2. Establish realistically scaled offshore wind farm pre-feasibility level project concepts which are cost-effective and minimise potential impacts to surroundings;
3. Assess regional port capabilities to support the offshore wind project concepts, plus provide national pathways for potential upgrades and expansion;
4. Determine grid connection options to transmit electricity from the offshore wind farms, plus provide national pathways for potential upgrades and expansion;
5. Perform a holistic assessment of commercial risk and bankability issues for the offshore wind project concepts and suggest mitigation measures and pathways to create favourable market conditions;
6. Perform extensive stakeholder engagement during the entire lead time of the study.

Each of the above task requires a different technical approach and methodology, which will elaborated in more detail in the specific chapter (to navigate see Section 1.4).

Offshore wind projects
Whereas the Roadmap investigated the opportunities for offshore wind within the entire Sri Lankan marine space, this study is focused on the two high potential sites of Puttalam and Mannar (see Figure 8). These two project areas were identified by the Roadmap as priority areas for further investigation. When referring to offshore wind in this study (in terms of the potential, feasibility and potential consequences), it specifically addresses the potential, feasibility, and consequences of offshore wind in the two high potential sites of Puttalam and Mannar, and focusses on the technical feasibility of the defined project concepts.

Figure 8 Map of Sri Lanka with the two priority areas for offshore wind in this study



Collaboration with India

It's unlikely that Sri Lanka will develop its own standalone offshore wind industry, given the industry's global nature, heavy upfront investments that require a large pipeline of projects and India's ambitious plans in this sector. Instead, it's more feasible to consider Sri Lanka as part of a larger region, including India, with significant offshore wind potential. Collaboration with India, including on an interconnector, port development activities, and overall market alignment, will thus be an important aspect of this study. The World Bank's efforts to foster regional collaboration are shortly explained in Text box 3.

Text box 3 The World Bank's efforts to fostering regional collaboration between Sri Lanka and India

The World Bank offshore wind team is working across both countries and will use this position to foster regional collaboration and alignment on relevant offshore wind aspects. There are also a number of other offshore wind initiatives in India which are relevant to Sri Lanka and these will be assessed and adopted where appropriate.

1.4 Report structure

After the executive summary and this introduction in which the background, objectives and scope of work have been presented, Chapter 2 presents the results of a constraints assessment collating information on the feasibility of offshore wind in the project areas and to selecting the most suitable locations. Based on this information, project concepts are developed in Chapter 3. A port appraisal is presented in Chapter 4, looking at current capabilities in Sri Lanka and India and provide pathways for required port development. Chapter 5 elaborates on the electrical system to connect the project concepts to the grid, including recommendations on grid development and assessing a potential interconnector with India. Commercial risks and bankability issues, together with mitigation strategies to create an attractive market are given in Chapter 6. Finally, Chapter 7 provides an overview of the stakeholder engagement plan including the outputs and findings from its current position.

2.1 Preamble

The initial constraint assessment outlined in the Roadmap highlights Mannar and Puttalam as potential sites for offshore wind (see Figure 3 for the locations). A more detailed constraint assessment is needed for these areas to confirm the feasibility for offshore wind and to pinpoint the most suitable sites. Moreover, it will support in identifying potential project risks which should be mitigated. Various factors, including technical, environmental, safety and social considerations, will be taken into account to evaluate any potential risks. Additionally, a data uncertainty and gap analysis will be conducted to identify areas where additional information or surveys may be required to further refine the assessment and informed decision-making.

2.2 Review of previous work

Important prework for this constraint assessment is the Roadmap, in which the entire marine space of Sri Lanka is assessed at a high level and which ultimately led to the identification of priority areas for offshore wind. The Roadmap identified exclusion zones and restriction zones, which are set out in Table 4.

Table 4 Definition of various zones in the Roadmap

Items as part of exclusion zones in Roadmap	Items as part of restriction zones in Roadmap
- Marine national parks; - Nature reserves; - Sanctuaries; - Key Biodiversity Areas (KBA), including Important Bird Areas (IBA), Ramsar sites, and UNESCO-MAB[6] Biosphere Reserve; - Sea turtle nesting beaches; - Seagrass beds, mangroves, and coral reefs; - Military exercise areas; - Airport radar; - Oil & gas operations.	- Ecologically or Biologically Significant Marine Areas (EBSA); - Important Marine Mammal Areas (IMMA); - Habitat for Dugong; - Highest density shipping areas; - Subsea cables.

Based on the Roadmap, it's not foreseen that the various exclusion zone items (in Table 4) will pose significant constraints in the two project areas, which are outside of the exclusion zones. However, the entire project area of Mannar falls within the restriction zone with high biodiversity values, which are Ecologically or Biologically Significant Marine Areas (EBSAs) and Important Marine Mammal Areas (IMMAs). These areas are known as important habitats for dugong, whales and various marine species. In addition, the west coast of Sri Lanka is particularly important for migratory seabirds, with up to 400,000 birds flying southwards during the southwest monsoon from June to November[7] (De Silva 1997).

This study will review the restriction and exclusion zones from the roadmap to confirm presence and accuracy, as well as to accommodate any updates. For example, since the publication of the

[6] UNESCO stands for United Nations Educational, Scientific and Cultural Organization, and MAP stands for Man and the Biosphere

[7] De Silva, R.I. (1997) Watching seabirds on the West Coast of Sri Lanka. Oriental Bird Club. https://www.orientalbirdclub.org/seabirds

Roadmap, Important Shark and Ray Areas (ISRA) have been identified, including Baththalangunduwa ISRA[8], which is located within the Mannar area. Table 5 highlights each item considered in this constraint assessment (further introduced in the next section) and outlines the main findings from the Roadmap in relation to the project areas.

Table 5 Main findings from Roadmap related to items considered for Constraint Assessment

Items for constraint assessment	Main findings from Roadmap related to the project areas
Wind resources	Based on GWA. Puttalam area has wind speeds at 150m height ranging from 7 to 8.5 m/s and 8.5-9 m/s in Mannar.
Water depths	The bathymetry off the western coast of Sri Lanka indicates that there are relatively shallow waters (<50m) suitable for fixed foundations.
Seabed characteristics	Overall, there don't appear to be any significant seabed obstacles.
Natural hazards	Earthquakes are not considered a major concern, but sites near the shore should consider the risk of tsunamis and potential scour caused by low-amplitude tsunami waves.
Military zones	Included in the exclusion zone.
Aviation and radar	SLAF zones and international airports should be treated as exclusion zones, with a 15km buffer around airports for precaution.
Archaeology	Not considered in the Roadmap.
Unexploded ordnance	Not considered in the Roadmap.
Ecology	Although Sri Lanka has no official list of threatened Natural Habitats, several ecosystems are highly important both ecologically and economically. This includes pearl mussel beds, seagrass beds, mangroves, coral reefs and coastal sand dunes. Sri Lanka hosts a rich variety of marine mammals, with a total of 27 recorded species. Among these, six species are considered globally threatened, including the Blue Whale and dugong. These species have been observed in various locations around Sri Lanka, such as the Gulf of Mannar, the waters between Galle and Mannar. The significance of the marine mammal populations has been recognized through the delineation of EBSA and IMMAs. Sri Lanka has no marine areas IBAs, however up to 400,000 seabirds migrate along the west coast during the southwest monsoon from June to November. There are also several

[8] https://sharkrayareas.org/portfolio-item/baththalangunduwa-isra/

Items for constraint assessment	Main findings from Roadmap related to the project areas
	coastal IBAs that include marine bird species in their designation. These coastal IBAs have been included as exclusion zones. Sri Lanka supports five threatened species of marine turtles, and there are many nesting beaches along the west coast of Sri Lanka. EBSAs and IMMAs may be feasible for development if they are carefully managed, and development activities are coordinated to avoid key sensitive periods for biodiversity. These sites are therefore included in the restriction zone. Adam's Bridge Marine National Park is included in the exclusion zone.
Offshore infrastructure	The submarine cables in Sri Lanka are mainly concentrated near Colombo and Hikkaduwa. Offshore wind activities like cable laying and material transport are usually feasible near these cables. While not directly restricted, they should be considered in offshore wind farm planning. Structures linked to oil and gas infrastructure create significant constraints for wind farms, surrounded by restriction zones. Multiple oil and gas wells in Palk Bay and the northern Gulf of Mannar are part of the exclusion zone.
Mining activities	Not considered in the Roadmap.
Other wind projects	Not considered in the Roadmap.
Shipping & anchorage	The shipping density in Sri Lanka is highest around Colombo and Hikkaduwa/Galle in the southwest, with primarily tankers. Northern waters like Mannar Bay see fewer vessels, but shipping should be considered for offshore activities due to widespread presence and potential risks. No official shipping routes exist, but dense traffic areas, like an informal route south of Sri Lanka, are marked as restriction zones due to high density.
Fishing & aquaculture	Sri Lanka's fisheries sector is crucial for the economy, supplying vital animal protein. Different fishing techniques may be affected differently by offshore wind infrastructure.
Leisure and tourism	It is advised to place offshore developments away from tourism hotspots. Despite this, the presence of 17 wind power plants in Sri Lanka has not affected coastal tourism activities to date.
Coastal residents	Not considered in the Roadmap.

Items for constraint assessment	Main findings from Roadmap related to the project areas
Culturally sensitive areas	Cultural heritage has not been specifically mapped for roadmap exercise. There are no offshore sites included in the UNESCO world heritage list.

2.3 Assessment framework

2.3.1 Overview of constraints

Table 6 lists all the constraints which are considered in this study. Each item is classified and accompanied by an explanation of its relevance to offshore wind energy, including whether it presents an opportunity or a hindrance.

Table 6 Constraints considered in this assessment

Items	Category	How it can affect offshore wind	Opportunity / Hindrance
Wind resources	Technical	Higher wind speeds increase the viability.	Opportunity
Water depths	Technical	Greater depths usually increase complexity and costs. Conversely, depths that are too shallow also pose challenges for installation.	Hinderance/Opportunity
Seabed characteristics	Technical	Determine the type, construction method and costs of foundation structures.	Hinderance/Opportunity
Ecology – areas	Environmental	Sensitive[9] or protected areas are usually excluded for offshore wind development. Side projects of offshore wind, such as coral reef, pearl beds or seagrass restoration initiatives, could benefit sensitive areas.	Hinderance/ Opportunity
Ecology – Avifauna	Environmental	Presence of threatened species and large populations of migratory species may impact offshore wind by guiding site selection, infrastructure design and operation to minimize environmental harm.	Hinderance

[9] This also includes marine natural habitats such as coral reefs, sea grass, mangroves

Items	Category	How it can affect offshore wind	Opportunity / Hindrance
Ecology – Marine mammals	Environmental	Presence of threatened species and large populations of migratory species may impact offshore wind by guiding site selection, infrastructure design and operation to minimize environmental harm.	Hinderance
Aviation and radar	Safety	Turbines could interfere with radar operation and low-altitude flight operations.	Hinderance
Military zones	Safety	Could compete for space, interfere with radar systems, and underwater communications. Strong collaboration with the navy could also be beneficial, for instance, when the offshore wind farm is equipped with additional communication systems, helping improve radar and surveillance coverage of the offshore area.	Hinderance/ Opportunity
Mining activities	Safety	Mining activities can impact offshore wind by competing for space, requiring careful planning to avoid operational interference.	Hinderance
Natural hazards	Safety	Could damage equipment leading to negative impact on the stability and safety of the overall structure.	Hinderance
Offshore infrastructure	Safety	Offshore infrastructure (such as cables and pipelines) can impact offshore wind by competing for space, requiring careful planning to avoid operational interference.	Hinderance
Unexploded ordnance	Safety	Presents a risk to offshore wind projects, causing potential delays, increased costs, and safety hazards during	Hinderance

Items	Category	How it can affect offshore wind	Opportunity / Hindrance
		construction, often requiring clearance operations.	
Shipping & anchorage	Safety	Shipping and anchorage could compete for space and limit opportunities for offshore wind.	Hinderance
Other wind projects	Safety	Potential wake losses (and associated reduced technical performance).	Hinderance
Archaeology	Social	Archaeological discoveries during offshore wind surveys can delay projects and increase costs due to regulatory requirements and potential redesigns to avoid disturbing significant sites or artifacts. Archaeological finds reporting protocols can increase knowledge and understanding of historic sites and features.	Hinderance/ Opportunity
Coastal residents	Social	Coastal residents can object to offshore wind development, as some might be impacted by visual impact and potential property values.	Hinderance
Culturally sensitive areas	Social	Can affect offshore wind by requiring careful planning to avoid disturbing important cultural sites or traditions.	Hinderance
Fishing & aquaculture	Social	Fishing can affect offshore wind by conflicting with turbine placement and disrupting fishing grounds, requiring collaboration and planning for coexistence. Development of nursery areas (such as coral reef, pearl beds and seagrass restoration) could benefit the fishing industry.	Hinderance/ Opportunity

Items	Category	How it can affect offshore wind	Opportunity / Hindrance
Leisure and tourism	Social	Offshore wind can impact the attractiveness of an area (both positive and negative).	Hinderance/ opportunity

Table 7 indicates the constraints which are not considered in this chapter and provides reasoning for it.

Table 7 Constraints not considered in this assessment

Items	Category	Relation to offshore wind energy	Reason why not considered
Distance to grid	Economic	Denotes how close the wind farm is to the electrical grid, influencing transmission efficiency and infrastructure costs.	Will be assessed in Chapter 3.
Distance to port	Economic	Distance to ports impacts offshore wind by affecting logistical challenges and costs.	Will be assessed in Chapter 4.
Geopolitically sensitive areas	Environmental	May present challenges due to security concerns, regulatory complexities, or impacts on international relations.	A 1 km buffer zone to the marine border with India is considered sufficient to exclude potential risks.
Disposal sites	Environmental	Marine disposal sites can impact offshore wind development by complicating installation, altering seabed conditions, harming marine ecosystems, and posing operational safety risks.	No data available. Additionally, consultations with the Navy during the site visits in Mannar revealed that marine disposal sites in Sri Lanka are usually located in waters deeper than 50 meters, thus lying outside the project areas. This constraint (including risks from UXOs) will be covered by subsequent geophysical surveys during the FS stage.
Hydrodynamic properties	Technical	Wave conditions, currents, tidal variability, sediment transport, water quality, and coastal dynamics can have significant impacts on	Not considered to be relevant at this pre-Feasibility stage. Information about wave energy is briefly described in Chapter 2.

Items	Category	Relation to offshore wind energy	Reason why not considered
		offshore wind farm development and operation.	Hydrodynamic properties will be covered under the metocean campaign during the FS stage.

2.3.2 Data collection

Data sources have been identified for each of the defined constraints. These encompass existing datasets, government records, scientific literature, and maps, to gather both primary and secondary data. Depending on the constraints identified, data from appropriate collection methods are selected, such as but not limited to remote sensing, GIS analysis, expert consultation, and site visits. To aid the collection of data from government and institutions, formal data request letters from MoPE have been used to formalise and expedite the collection process. Collected data are systematically recorded using an internal data tracking template detailing the data name, type, and acquisition date. All data collected has been verified for quality and applicability. Where available, several data sources have been used and compared to provide a better overall assessment of the potential constraint.

The specific data sources used per constraint item are listed in Section 2.4 Site Assessment.

2.3.3 Evaluation of constraints

It is important to allocate sensitivities to each constraint item, to identify factors that highly influence the feasibility of offshore wind and site selection process. Table 8 indicates the assumed influence of the various constraints on the feasibility and site selection for offshore wind projects in the high priority areas. It needs to be mentioned that these sensitivities vary per location, based on local conditions, and are explored on a case by case basis for proper confirmation.

Table 8 Assumed influence of constraints on the feasibility and site selection for offshore wind in project areas

Constraint items	Assumed influence	Explanation
Wind resources	High	Directly impacts project’s viability
Water depths	High	Directly impacts project’s viability
Seabed characteristics	High	Directly impacts project’s viability
Ecology – areas	High	Could form large exclusion zones
Ecology – avifauna	High	Could form large exclusion zones
Ecology – marine mammals	High	Could form large exclusion zones
Aviation and radar	High	Could form large exclusion zones
Military zones	High	Could form large exclusion zones
Mining activities	High	Could form large exclusion zones

Constraint items	Assumed influence	Explanation
Natural hazards	Medium	Adverse effects can usually be mitigated by measures
Offshore infrastructure	Medium	Adverse effects can usually be mitigated by measures
Unexploded ordnance	Medium	Critical areas can usually be avoided, or negative effects can be mitigated
Shipping & anchorage	Medium	Critical areas can usually be avoided, or negative effects can be mitigated
Other wind projects	High	Could form large exclusion zones
Archaeology	Medium	Critical areas can usually be avoided, or negative effects can be mitigated
Coastal residents	Medium	Critical areas can usually be avoided, or negative effects can be mitigated
Culturally sensitive areas	Medium	Critical areas can usually be avoided, or negative effects can be mitigated
Fishing & aquaculture	High	Could form large exclusion zones, extensive engagement required to deliver mitigation.
Leisure and tourism	Medium	Critical areas can usually be avoided, or negative effects can be mitigated. In fact, offshore wind could bring benefits to local tourism.

** Based on local conditions, these sensitivities vary from site to site, and should be investigated for proper confirmation*

At the end of this chapter, in Section 2.6 Qualitative assessment of risks and mitigation strategies, the overall risk of the constraints will be assessed based on the evaluation criteria Table 9. The assessment will only be conducted for the offshore project areas, although the proposed onshore infrastructure for grid connection is described in Chapter 5. Detailed assessment of the onshore export cable routing and onshore infrastructure will be required at a feasibility stage once connection points are confirmed. Based on the findings from section 2.4 Site Assessment, the influence factors in the previous Table 8 will be evaluated (factors with high influence will be considered as potential project risks) in Table 12 at the end of this chapter.

Table 9 Evaluation criteria for constraints during qualitative assessment

Potential risk of constraint related to offshore wind		
Low	**Medium**	**High**
Constraint is not anticipated to affect the feasibility and site selection of offshore wind in the project area.	Constraint is anticipated to affect the feasibility and site selection of offshore wind in the project area, but mitigation measures can be implemented to alleviate potential negative effects.	Constraint is very likely to significantly affect the feasibility and site selection of offshore wind in the project areas, requiring strict mitigation measures to address potential negative effects.

2.4 Site Assessment

2.4.1 Technical Constraints

Wind Resources

General description

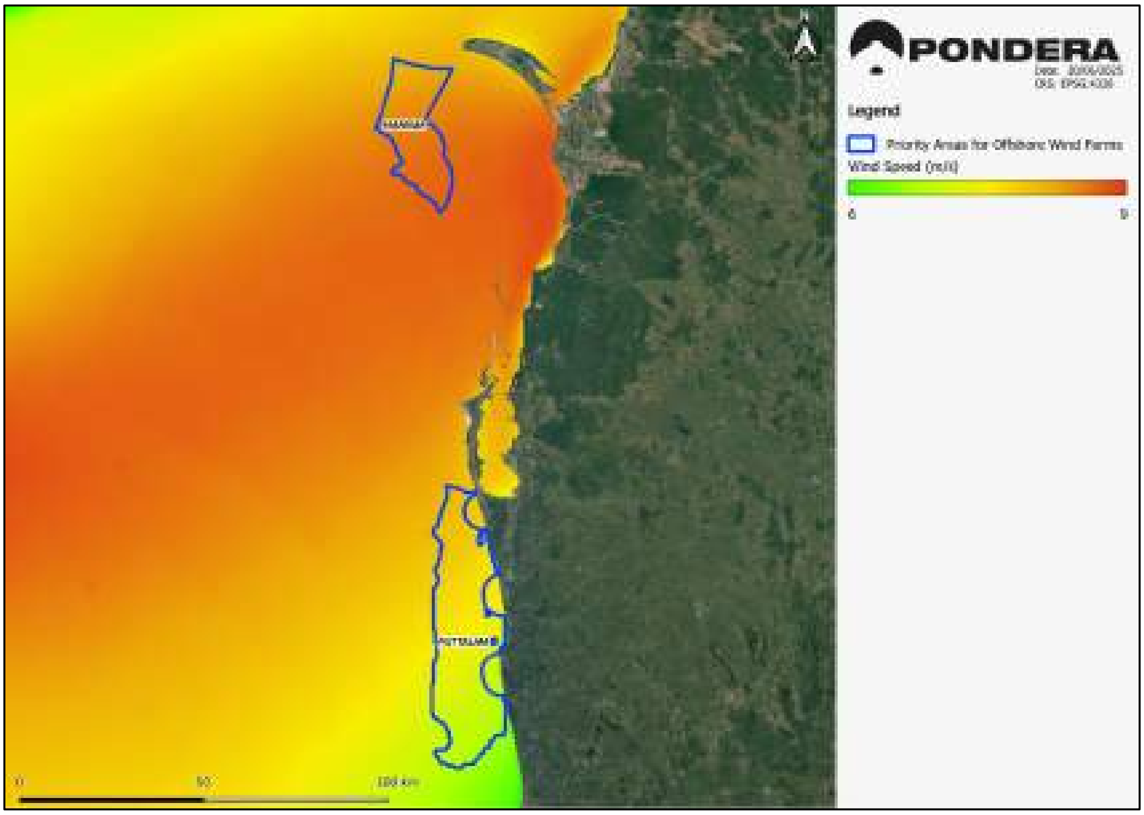
Wind speed is a crucial factor in the site selection process for wind farms. High wind speeds directly translate to increased kinetic energy available for turbine conversion, leading to higher electricity generation potential and economic viability.

Figure 9 shows the annual average wind speeds based on the Global Wind Atlas (GWA) data for the project locations at 100-meter elevation. It indicates that Puttalam showcases an average wind speed ranging from approximately 6 to 8 m/s, with the majority of areas experiencing wind speeds between 7 and 8 m/s. Wind speeds dip below 7 m/s in the southeast of the site, which is closer to the shore, and while in the northwest sector, wind speeds exceed 8 m/s. In contrast, the wind conditions in Mannar are consistently favourable, with wind speeds surpassing 8 m/s across the majority of the area, with only a small northern fraction of the site experiencing wind speeds between 7 and 8 m/s.

The significant variations in wind speeds across different areas within the Puttalam site present a key consideration for locating offshore wind, with uncertainty arising as small changes to the position of the gradient can lead to under- or overestimated wind speeds. It is possible, if the gradient moves to the north, that much of the area will have wind speeds too low for the feasible exploitation of offshore wind. This emphasizes the necessity for wind measurement campaign to enhance the development of offshore wind farms within this area. In contrast, Mannar demonstrates more uniform wind conditions, resulting in less uncertainty and offering a more stable foundation for offshore wind planning.

The wind data for the two sites were also assessed by Everoze using Vortex data. Additionally, in the study conducted by Andy Oldroyd, global datasets such as ERA5 were evaluated to verify the reliability of these model data in representing the wind patterns in Sri Lanka. Detailed information on these studies is mentioned in Chapter 3.

Figure 9 Wind speed gradient map at 100m. Reds and oranges are considered feasible winds speeds for offshore wind development (Data source: GWA)



The wind direction within the two sites in the Gulf of Mannar area is governed by the monsoon seasons. Sri Lanka's climate is influenced by its topography and the regional wind patterns of the Southwest and Northeast monsoons, resulting in four distinct seasons throughout the year.

The First Inter-monsoon season, from March to April, is characterised by convectional rain, thunderstorms, and lower wind speeds compared to the other monsoon seasons (6-7 m/s). This season occurs between the end of the Northeast Monsoon and the onset of the Southwest Monsoon. The Southwest Monsoon (Yala Season), lasting from May to September, brings strong winds (8-10 m/s) and heavy rainfall primarily to the southwestern region of the country. The Second Inter-monsoon season, from October to November, features scattered showers and thunderstorms, and higher wind speeds compared with the First Inter-monsoon (7-8 m/s), as the influence of the Southwest Monsoon wanes and the Northeast Monsoon (Maha season) begins to set in. Finally, the Northeast Monsoon, from December to February, is marked by winds from the northeast, delivering substantial rainfall mainly to the northeastern and eastern parts of the island and an increase in wind speeds (6-9 m/s) in the northern and eastern regions.

The temporal variation in wind speeds by hour and months within Puttalam and Mannar has also been assessed using estimated wind energy production by Vortex, as indicated in Figure 10 and Figure 11. It can be concluded that the wind patterns at the 125-meter height of the two sites follow the regional wind patterns as described above. The highest wind speeds are witnessed during June to September (Southwest Monsoon), with peak intensity in June. The lowest wind speed in Mannar was observed during the second inter-monsoon (November), while the lowest wind speed in Puttalam is during the first inter-monsoon (April). The high seasonal variation predicted in both high-priority development areas is an important consideration, specifically for how it integrates into the energy system and more generally for the feasibility of offshore wind in Sri Lanka.

The temporal variation by hour within the two sites shows more limited daily variation, compared to seasonal variation. Daily variation in Puttalam is larger than in Mannar, with both sites showing the lowest wind speeds during daylight hours, which can be highly complementary with other generation forms such as Solar PV, which generate only during the day.

Figure 10 Energy output hourly profile at 125 m MSL – Puttalam Area (source: Vortex)

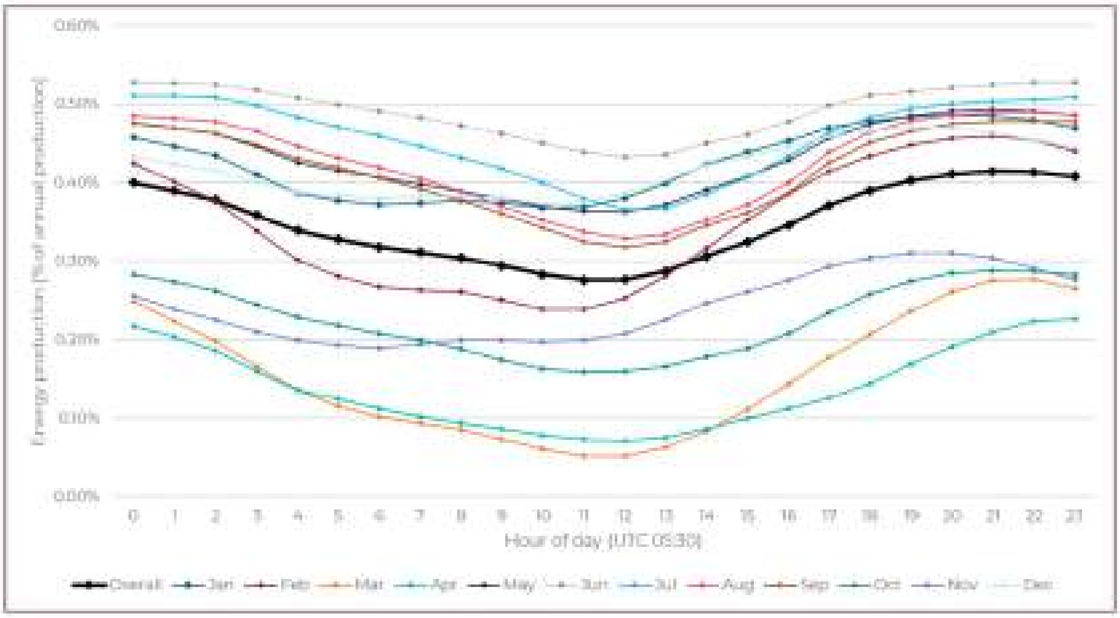


Figure 11 Energy output hourly profile at 125 m MSL – Mannar Area (source: Vortex)

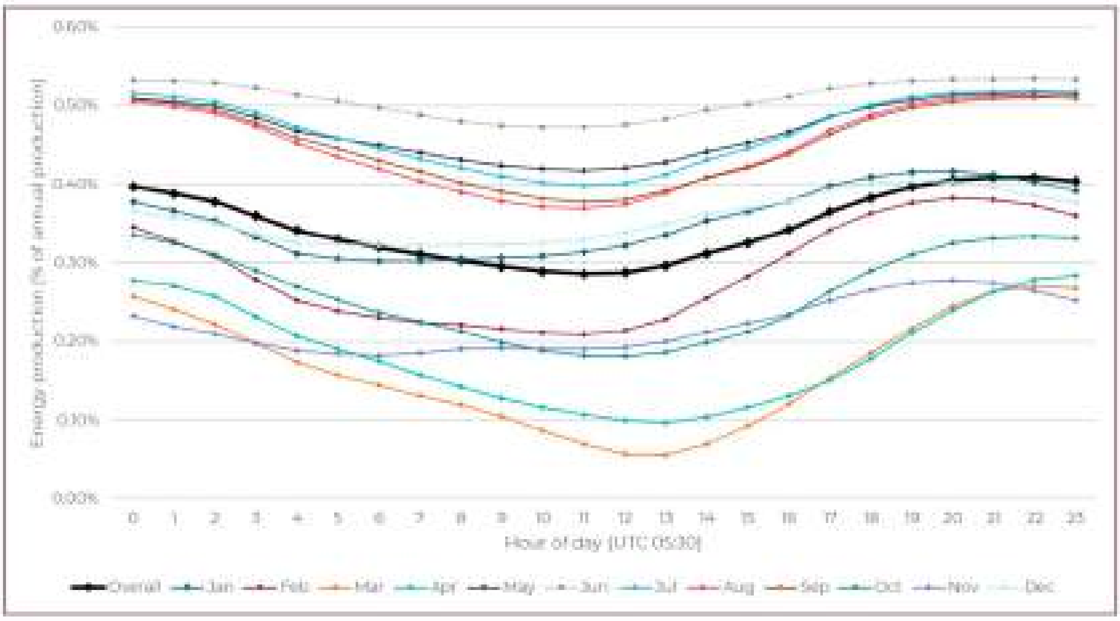
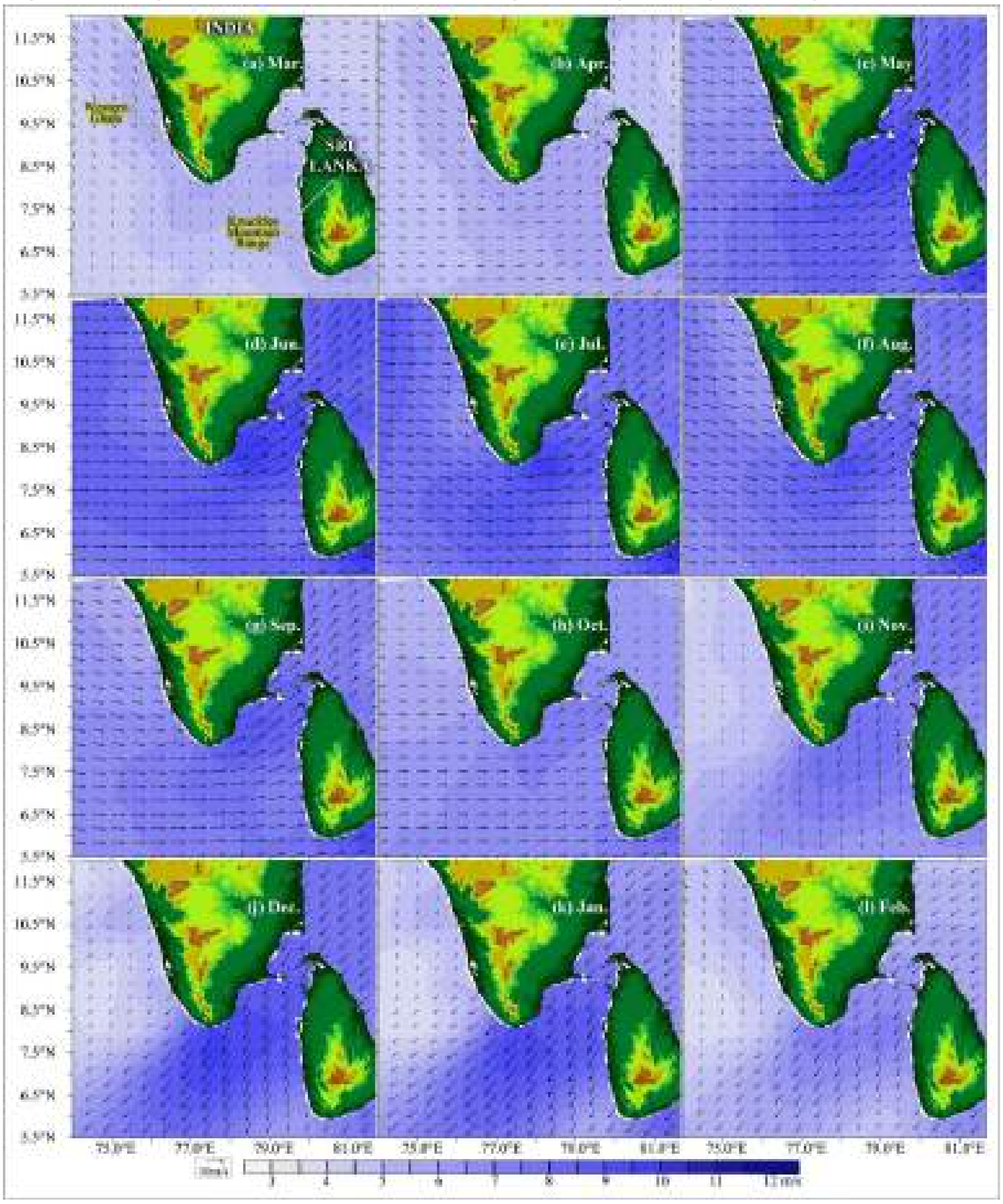


Figure 12 indicates the temporal variation of wind direction in the wider region. In the Gulf of Mannar area, during the Southwest Monsoon, there are well-organized south-westerly winds. These winds peak in June and remain strong until September, gradually weakening as October approaches. By November, they shift direction to become north-easterly, reaching their peak intensity during December-January. Notably, surface winds in the Gulf of Mannar are consistently stronger than those in adjacent regions, likely influenced by regional topography.

Additionally, large-scale climate phenomena such as El Niño, La Niña, the Indian Ocean Dipole (IOD), and the Madden-Julian Oscillation (MJO) also influence the region's climate and wind patterns, further information on these events is mentioned in the Section Natural hazards.

Figure 12 Regional wind direction and average wind speeds by month (Retnamma et al., n.d.)



A further description of the wind climate is given in section 3.3 Wind climate, which includes, among other aspects, wind direction distribution. As wind speed directions do not vary significantly within the study areas and therefore do not influence site selection, they are not further elaborated upon in this section.

Most suitable sites within the priority areas

The general influence of wind resources on the feasibility assessment and site selection exercise for offshore wind is considered to be high.

Given the provided context on wind speed, Mannar offers a wider selection of locations for placing a wind farm, given the significant consistent area with wind speeds exceeding 8 m/s, especially the central and southern regions. Conversely, the optimal location for a wind farm in Puttalam is limited to the northern half of the site. A site in the southern quarter of Puttalam is unlikely to be sufficiently windy for economic exploitation.

Information about the (spatial and temporal) variation of wind directions is not considered to be a distinctive factor in the site selection process but will be considered in the concept development in Chapter 3.

Uncertainties and data gaps

While the used sources, such as GWA, Vortex and ERA5 provides an acceptable overview, its spatial and temporal resolutions may not fully consider factors affecting offshore wind speeds, such as coastal topography and local wind patterns. Moreover, most available met mast data primarily represent onshore wind speeds, making it difficult to estimate offshore wind speeds. This uncertainty underscores the importance of validating against local measurements and the necessity of site-specific data collection and modelling to enhance wind resource assessments. Further elaboration on assessing the wind resource will be provided in Chapter 3.

Water depths

General description

Water depth is a critical factor in determining the foundation type for offshore wind farms. In shallow waters (up to around 50 meters), fixed-bottom foundations like monopiles or jackets are commonly used, anchored securely into the seabed to support turbines. In deeper waters where fixed-bottom foundations are impractical, floating platforms are possible.

The water depth of the sites has been assessed using both the GEBCO[10] global bathymetry data and local bathymetry data[11] (for Mannar). In Figure 13, both datasets are compared. It indicates that the project areas lie within shallow waters, predominantly between 0 to 40 meters below Mean Sea Level (MSL). Helpfully, the general distribution of water depths between the two datasets is aligned. However, the local data shows more variation in depth over smaller areas, suggesting a more complex seafloor topography, with ridge morphology adjacent to the northeast of Mannar. GEBCO data depicts larger, more homogeneous areas, potentially missing finer topographical details present in the local data. It is important to note that the datum reference for the local dataset is not specified.

The GEBCO dataset, as the best available dataset covering the entire marine area, is utilized to assess this constraint for the project sites, with appropriate assumptions adopted to accommodate the potential for high-resolution variability.

[10] GEBCO - The General Bathymetric Chart of the Oceans

[11] Digitalized bathymetry map from PDA, Sri Lanka.

Figure 13 Comparison between local data and GEBCO data for Mannar siting area

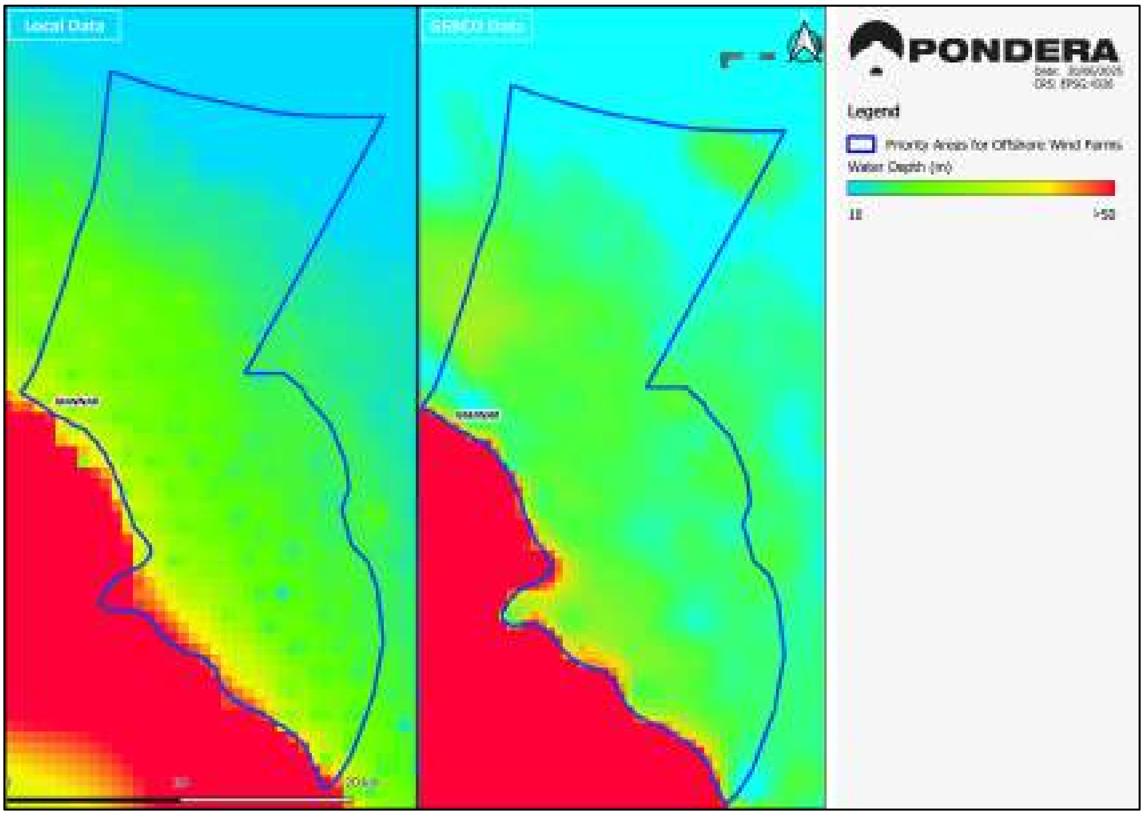
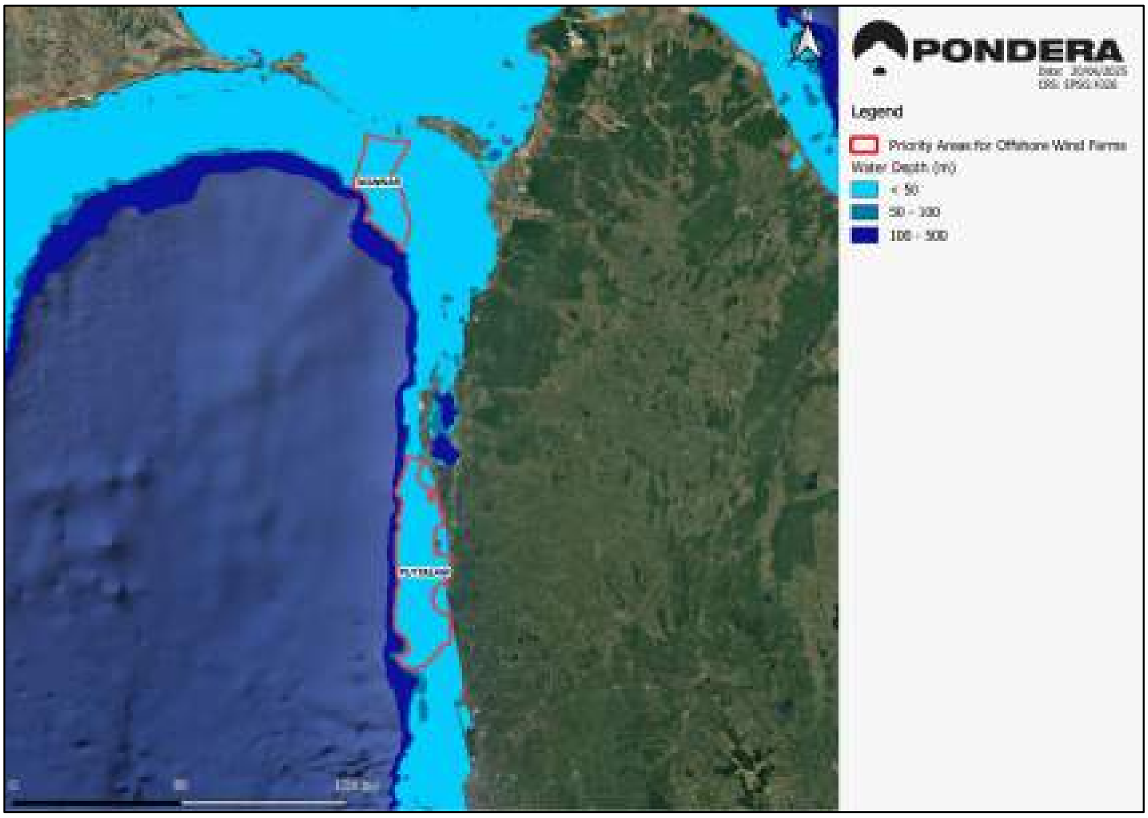


Figure 14 represents a very high level water depth categorization in the wider area based GEBCO data. Figure 17 in the next section provides a more detailed assessment regarding the distribution of water depths within the project areas. Additionally, based on the GEBCO database on undersea features, there are no subsea man-made features within or in close proximity to the project sites.

Figure 14 Water depths (Source: GEBCO)



As an alternative source, Figure 15 and Figure 16 show information about bathymetry, coral reefs, and other objects (such as shipwrecks) from open-source Navionics in Mannar and Puttalam respectively. The overall distribution of depths in this map matches that of the previously presented maps.

Figure 15 Information about bathymetry, coral reefs and marine objects in Mannar (source: [Navionics Charts and Maps | Marine Cartography](https://www.navionics.com))

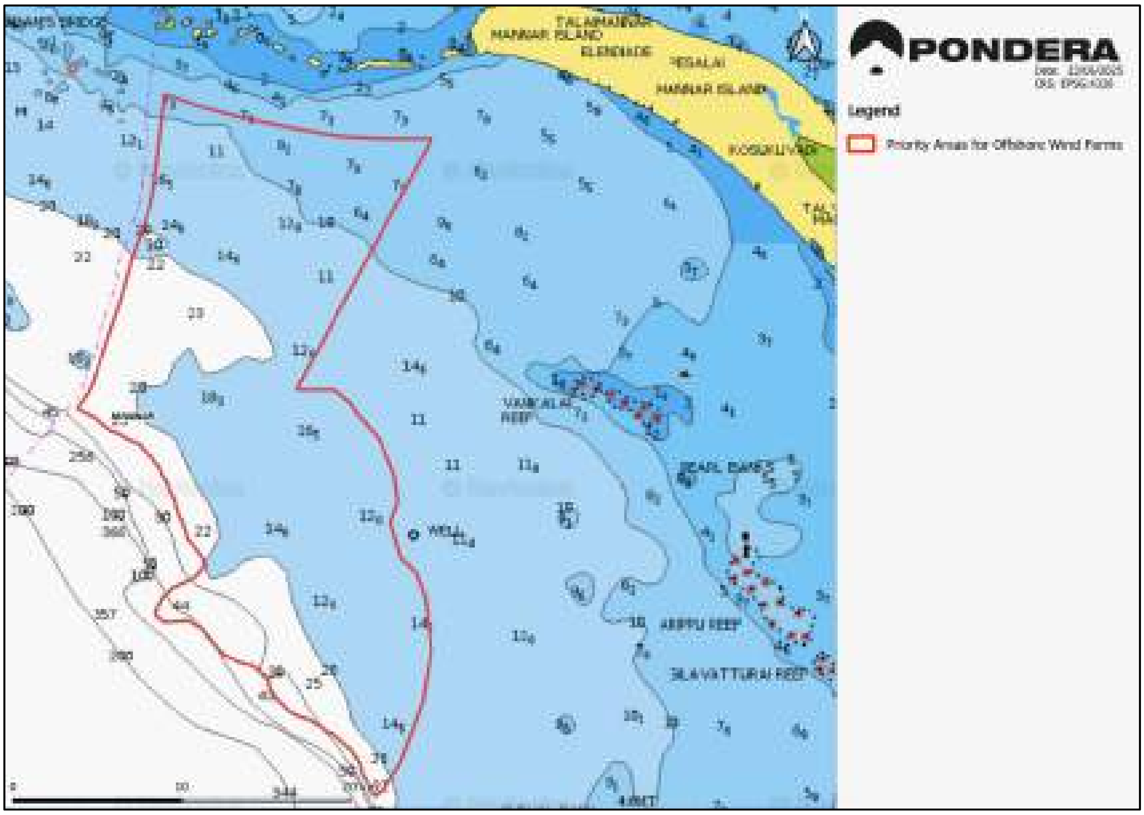
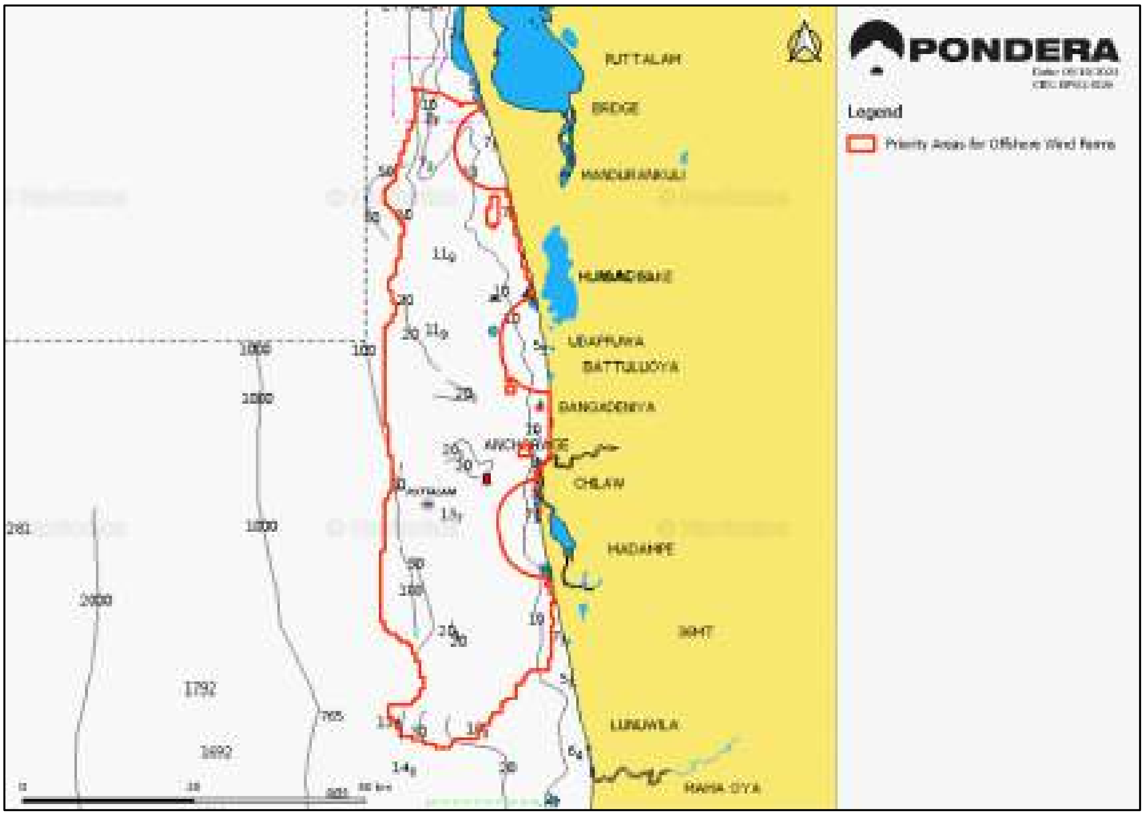


Figure 16 Information about bathymetry, coral reefs, and marine objects in Puttalam (source: [Navionics Charts and Maps | Marine Cartography](#))

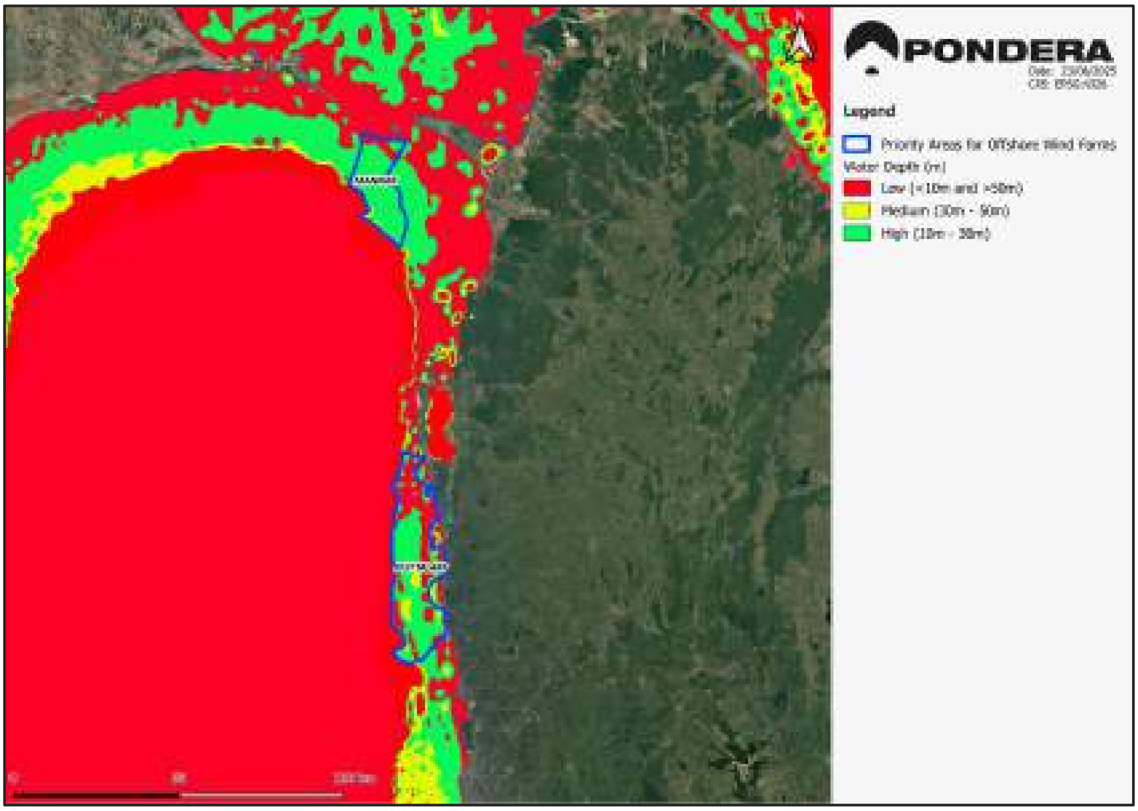


Most suitable sites within the priority areas

The general influence of water depths on the feasibility assessment and site selection exercise for offshore wind is considered to be high.

Figure 17 applies a scoring framework to the water depth constraint, in which water depths shallower than 10 meters and deeper than 50 meters are excluded to enable cost-effective foundation structures and installation methods. Large areas within both regions exhibit suitable water depth conditions, ranging between 10 and 30 meters (coloured green). In both regions, the northern areas appear to present depth constraints with water shallower than 10 meters, posing installation challenges for vessels typically used for large-scale offshore wind farms.

Figure 17 Scoring exercise for water depths



Uncertainties and data gaps

GEBCO utilizes diverse data sources[12] like ship soundings and satellite altimetry to compile bathymetric information. Inconsistencies in data quality and accuracy from these sources can introduce uncertainties in the final dataset. However, the positive correlation between GEBCO and local data reduces this uncertainty.

Processing techniques such as interpolation and smoothing further contribute to these uncertainties, particularly in regions with limited data coverage. Moreover, geological processes, sediment movement, and human interventions can alter bathymetric features over time, potentially rendering GEBCO data outdated in some areas.

As a Phase 3 activity after this study, on-site bathymetry surveys should be carried out.

Waves

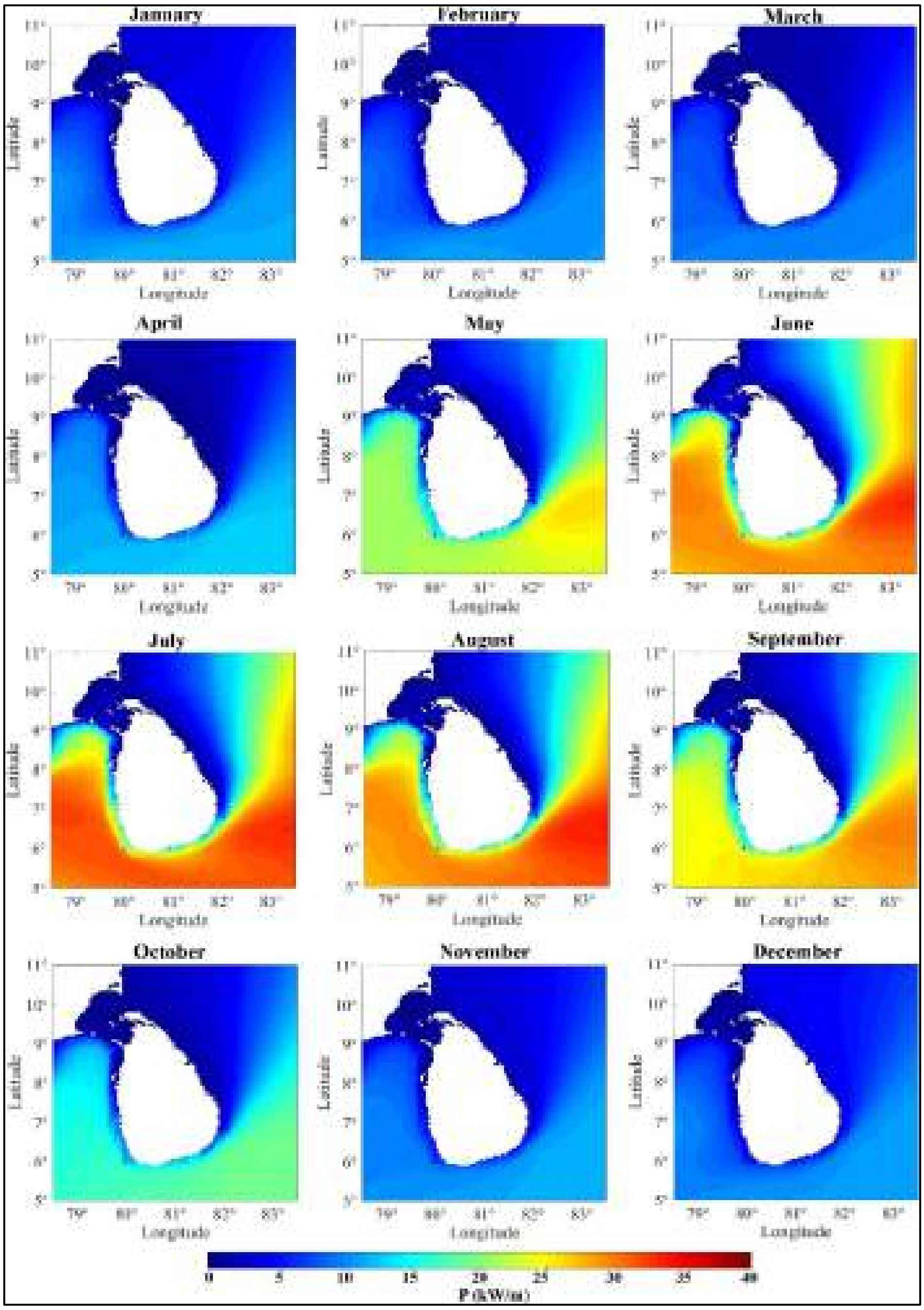
For offshore structures such as offshore wind farms, ocean waves are one of the most influential hydrodynamic properties. They impose substantial forces on offshore installations, profoundly impacting their design, stability, and structural integrity. The wave energy properties of Sri Lanka can be explained using the wave energy factor.

Figure 18 indicates the temporal variability of ocean waves. Like other factors such as wind patterns and climate, waves in Sri Lanka are also influenced by the monsoon. Being located in shallow water (less than 50 meters), both sites have available offshore wave power resources

[12] ship-based echo soundings, satellite altimetry, multibeam and single beam sonar data, gridded bathymetric datasets, regional bathymetric maps, contributions from regional mapping projects, scientific collaborations, and data from national hydrographic offices

that remain between 0 and 20 kW/m throughout the year, although it is significantly modulated by the southwest monsoon, which falls between May and September[13]. This also indicates the wave energy in two sites remain low to medium.

Figure 18 Temporal variability of wave energy (source: Karunarathna et al., 2020)



[13]Karunarathna_etal_E2020_Evaluation_spatio_temporal_variability_ocean_wave_power_resource_around_Sri_Lanka.pdf

Most suitable sites within the priority areas
Waves are important for offshore wind design and operation. However, based on current information, wave conditions in the project areas do not hinder offshore wind development. Therefore, they are not considered a constraint or influential factor in the site selection process.

Uncertainties and data gaps
Due to limited data availability on wave dynamics, this study is only capable of providing a general description of using the average wave conditions reported in existing literature. The uncertainty could be reduced by collection of high-resolution data through NARA and Sri Lankan universities.

As a Phase 3 activity after this study, on-site metocean surveys should be carried out, providing more information on wave dynamics.

Seabed characteristics

General description
Seabed characteristics play a decisive role in the type, construction method and costs of foundation structures.

At the time of this study, data on seabed characteristics for the project sites are unavailable and most public data on sediment types pertain to petroleum wells in deeper waters (more than 50 meters). Through expert consultation with the Sri Lankan Petroleum Development Authority (PDA), more understanding of the seabed has been generated. PDA has provided subsoil information from wells[14] in the wider region, of which the Pearl well is located within the Mannar site. Although subsoil information from wells typically focus on depths deeper than 200 meters, there is general understanding on the 0 – 200 meter depth (top layer) range available. It seems that this top layer, at least for the Pearl well, consists mostly of unconsolidated sediments (such as sand and clay) atop a layer of limestone. For the Pearl well the unconsolidated layer is about 300 meters thick and it may contain scattered inclusions of limestone rock.

Based on expert consultation (with PDA, as well as various other stakeholders during the February/March 2024 study tour), this general composition of the seabed subsoil (unconsolidated sedimentary soils overlying limestone) appears to apply more broadly in the wider region, including the two project areas, although variations are likely to occur. Specifically, the thickness of the unconsolidated sediment layer, its geophysical characteristics, and the proportion of limestone bedrock are expected to vary across the development areas. For example, it has been noted that the unconsolidated soils may be only 30 meters thick in the north of Puttalam.

Most suitable sites within the priority areas
Given the limited knowledge of the seabed, particularly the lack of understanding regarding spatial variation, identifying suitable sites for offshore wind within the project areas for this subject is challenging. However, based on the current information, there are no seabed structures that would hinder offshore wind development. The selection of an appropriate foundation type for the wind farm, based on the preliminary understanding of the seabed, will be determined in Chapter 3.

Uncertainties and data gaps
Due to limited data availability on seabed characteristics in Sri Lanka, this study is only capable of providing a general description of the seabed. If relevant data could be collected through NARA and Sri Lankan universities, it would significantly reduce the uncertainty.

[14] An offshore hydrocarbon exploration well is a drilled hole in the seabed to search for and extract oil and gas resources beneath the ocean floor.

As a Phase 3 activity after this study, on-site geotechnical and geophysical surveys should be carried out.

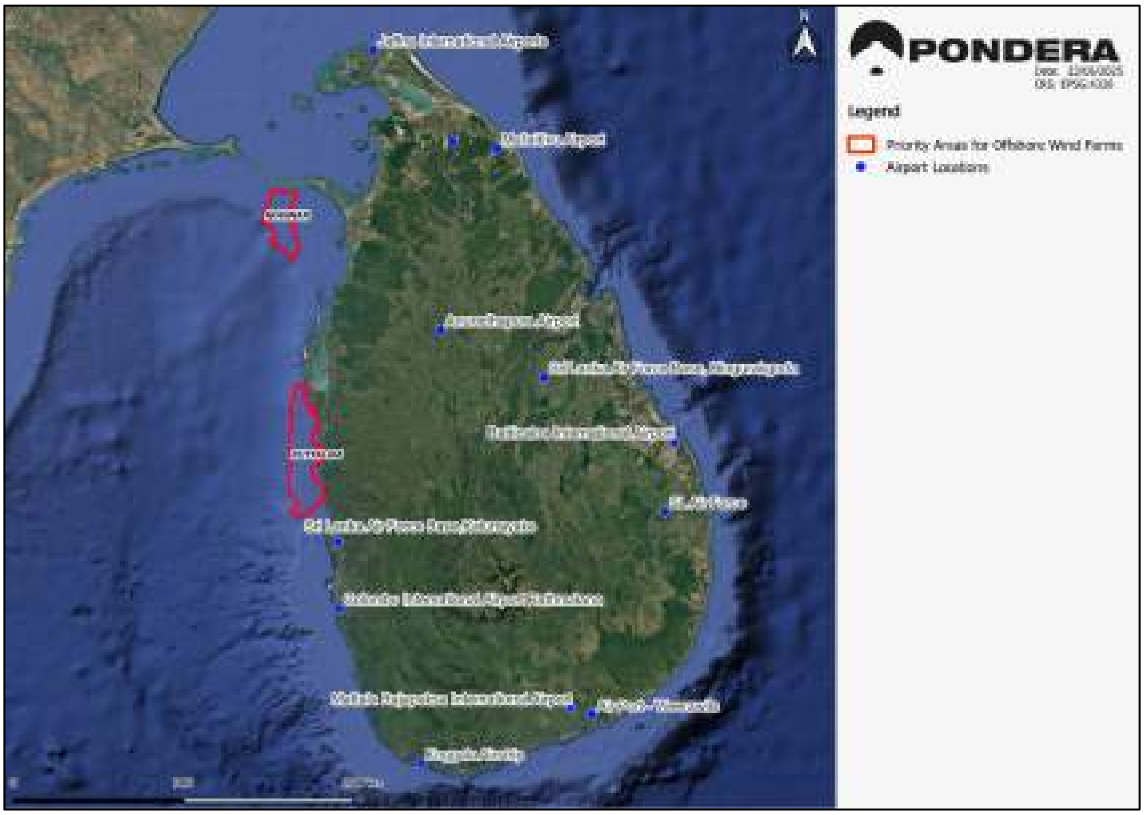
2.4.2 Safety Constraints

Aviation and radar

General description

It is usually recommended to maintain a certain distance (which can be up to 15 kilometres for precaution) between (offshore) wind turbines and airports to ensure aviation safety and minimize potential interference with radar systems and flight operations. The minimum distance depends on local regulations and characteristics of the airport and the wind farm and varies case by case. Figure 19 indicates the location of airports in Sri Lanka collected via the Sri Lanka GIS portal. According to the available data (Figure 19), no large airports lie within or close to the project areas. No height restriction zones, or important aviation radars have been identified in the vicinity of the offshore project areas.

Figure 19 Airport locations in Sri Lanka



Additionally, stakeholder engagement during the first workshop in Puttalam (February/ March 2024) learned that the district currently has a short runway (southwest – northeast orientation) for fixed-wing aircraft. It is not in use, but there are plans for expansion. It is used for helicopter operations, which could cause local height restrictions for infrastructure. However, the runway is located about 12 kilometres inland and is not expected to impact the offshore project areas, and establishing offshore wind turbines in the project areas will not impact the runway. It should be noted that when analysing the onshore grid solution (in the future), this constraint should be considered.

Most suitable sites within the priority areas
The potential influence of aviation and radar on the feasibility assessment and site selection exercise for offshore wind is generally considered to be high. However, due to the absence of known nearby large airports, height restriction zones and flight radar in the vicinity of the project areas, this is not considered to be a constraint or influencing factor at this stage.

Uncertainties and data gaps
As the data is collected via National GIS database and verified by local experts and site visits, no major uncertainties and data gaps are expected.

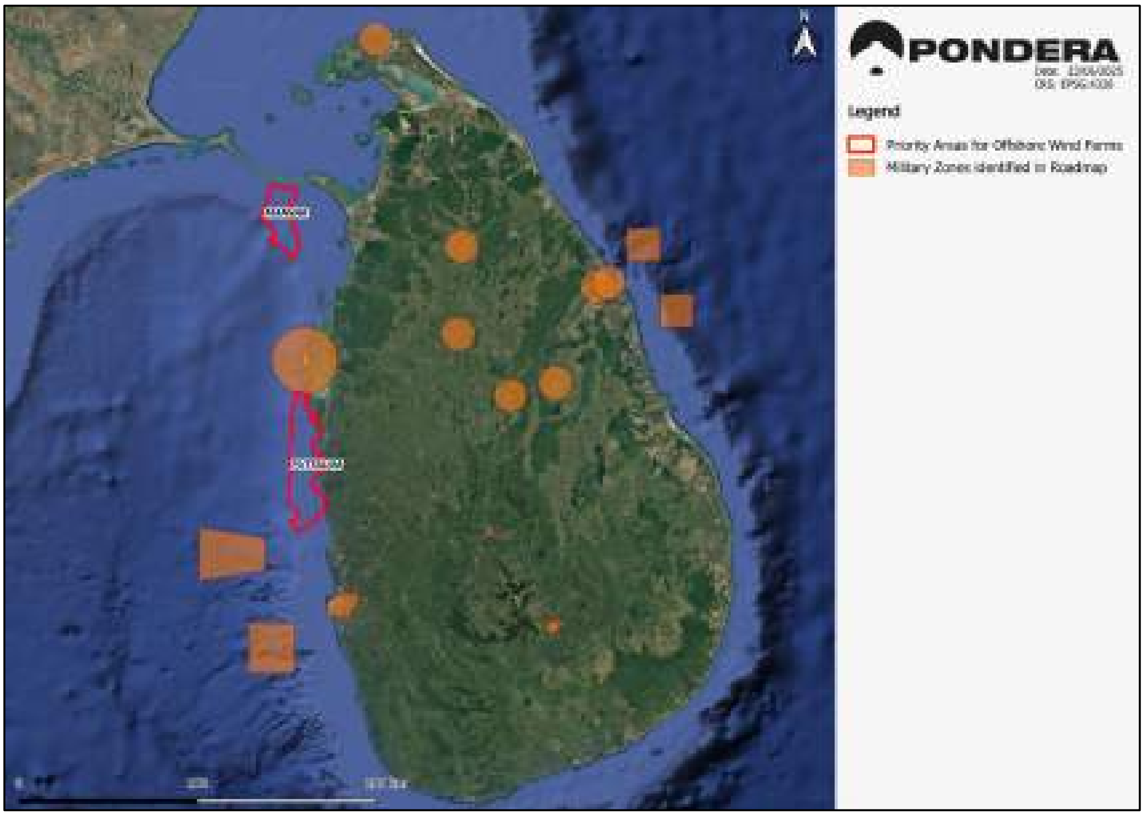
While there are presently no clear height restriction zones, future plans by local authorities may introduce such restrictions, potentially posing challenges for offshore wind farm development. Potential mitigation measures for this constraint include early collaboration with aviation authorities and establishing height restrictions and flight paths where offshore wind can coexist. Nevertheless, no future plans relevant to the offshore project areas have been identified during this study.

Military zones

General description
Military zones can significantly affect the development of offshore wind farms due to restricted access, security concerns, and potential conflicts with military activities. These zones may limit available areas for wind farm installation, disrupt construction and maintenance operations, and pose safety risks. Additionally, offshore wind farms near military zones could face regulatory hurdles or opposition from military authorities. To address this, military authorities should be consulted to understand concerns and establish buffer zones, while implementing advanced security measures for safe operations near military zones.

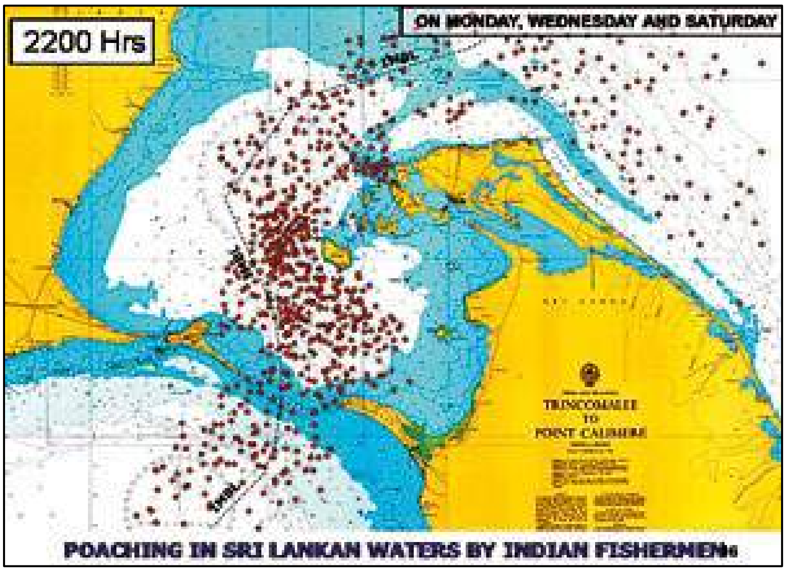
Military practice areas were identified in the Roadmap (see Figure 20) and excluded from priority areas for offshore wind, such as Puttalam and Mannar. This study has not encountered any conflicts with military areas and activities within or in the direct vicinity of the project areas. The closest military area is the Naval Gun Firing area adjacent to the north of Puttalam area.

Figure 20 Military zones (source: Roadmap)



Apart from the ‘official’ zones shown in Figure 20, there can be military activities within the entire project areas of Puttalam and Mannar. For instance, the Navy patrols the marine areas, and coastal radars cover the marine area. Navy officials were visited and consulted in the Mannar area during the site visits in March 2024 (no Navy officials were visited in Puttalam, as Navy activity is reportedly lower in that area). They mentioned that in Mannar, there is a network of around 18 coastal radars covering the nearby marine area, and an important task of the Navy is to prevent illegal trafficking and fishing. Illegal fishing has been reported, with foreign boats entering Sri Lankan waters. This is illustrated in Figure 21.

Figure 21 Map of illegal fishing activity in Sri Lankan marine waters (red dots represent foreign fishing boats)[15]



Strong collaboration with offshore wind development could bring benefits to the Navy. For instance, when the offshore wind farm is equipped with additional communication systems, it helps improve radar and surveillance coverage of the offshore area. This could assist efforts to combat illegal trafficking and fishing.

Most suitable sites within the priority areas

The typical impact of military zones on the feasibility assessment and site selection process for offshore wind is generally deemed to be high. However, as there are no known 'official' military areas in the project areas and the expected military areas are identified and excluded from the priority areas for offshore wind development, hence, this is not seen as a constraint or influential factor for the site selection process. However, strong collaboration is needed to align future activities and to prevent conflicting interests.

Uncertainties and data gaps

The publicly available data on military zones and activities is limited and subject to change. Ongoing consultation with the Sri Lankan government should be undertaken to confirm the conclusions drawn in this study regarding potential military constraints.

Mining activities

General description

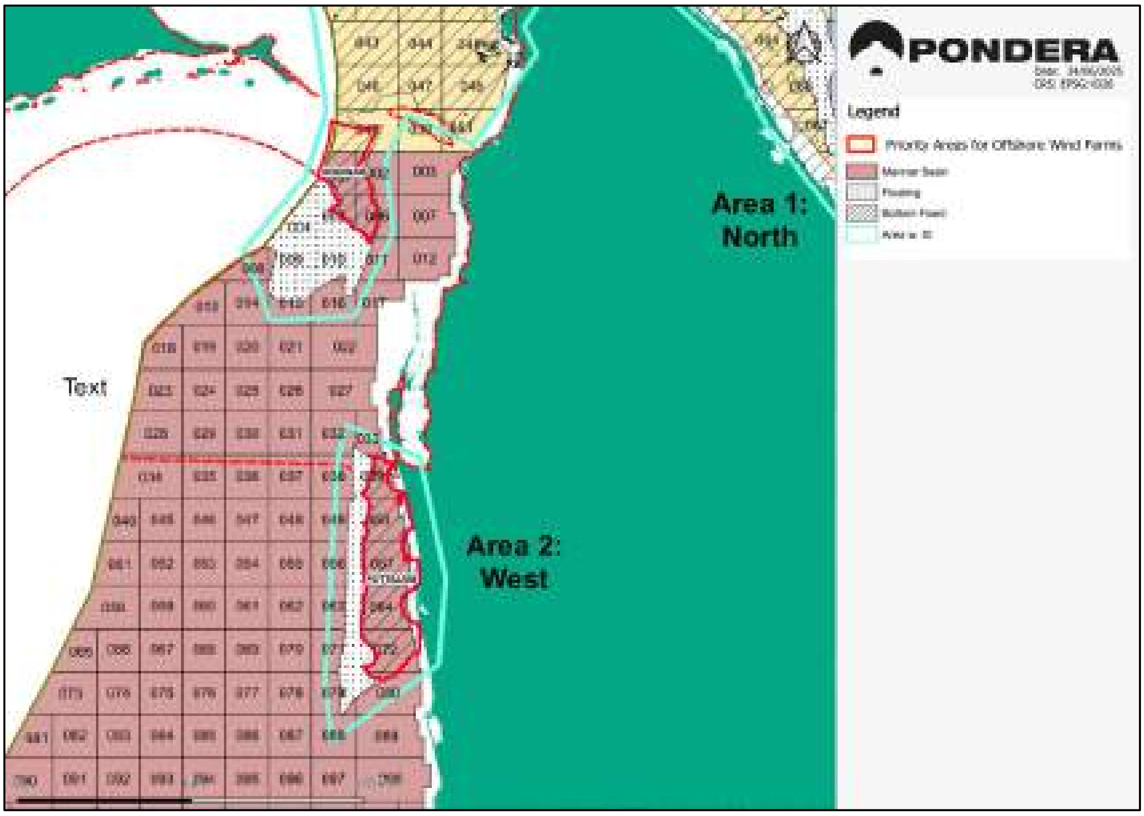
Examples of offshore mining activities (in Sri Lanka) include the following items: minerals, fossil fuels, phosphate, and rare earth elements. Offshore wind could interfere with mining activities, including competition for marine space, disturbance to the marine environment, and safety risks. Careful planning and coordination are crucial to manage conflicts and ensure the sustainable coexistence of both industries. Usually, specific buffer distances between mining areas and offshore wind farms are applied in this regard.

Based on initial study findings, there are currently no known mining activities within or close to the project areas. Additionally, no mining activities have been reported during the site visits and stakeholder engagement activities. This needs to be verified in consultation with PDA.

[15] Source: [Satellite photos catch Indian fishermen in Lankan waters (sundaytimes.lk)]

Figure 22 depicts the block map for offshore surveys in relation to the project areas. Parties interested in exploring the potential for mining activities can obtain a survey permit within specific blocks for a designated period. The issuance of survey permits for exploration may lead to potential conflicts of interest, although offshore wind and mining activities can coexist with proper management. An example is the Scottish Innovation and Targeted Oil and Gas (INTOG) offshore wind leasing round[16]. The Mannar area overlaps with blocks 001, 002, 005, 006, 011, and 049, while the Puttalam area overlaps with blocks 039, 050, 057, 064, 072, and 080. At the time of writing this report, no survey permits have been granted for blocks that overlap with the project areas. The co-existence of offshore wind and oil and gas is usually easier to achieve when both developments are in an early stage, so they can be aligned, as is the case in Sri Lanka.

Figure 22 Offshore block map for survey (by PDA) in relation to project areas



Most suitable sites within the priority areas

The potential influence of mining activities on the feasibility assessment and site selection exercise for offshore wind is generally considered to be high (due to the traditionally strong position of the mining industry, particularly hydrocarbon extraction). However, due to the absence of known mining activities in the project areas, this is not considered to be a constraint or influencing factor for the site selection exercise. Furthermore, both industries can potentially co-exist when carefully planned and managed (from an early stage).

Uncertainties and data gaps

Global data on mining lacks comprehensive coverage of specific regions like Sri Lanka, while national data is limited in scope and availability. It is needed to check and verify potential mining

[16] A leasing round initiated by Crown Estate Scotland, designed to attract offshore wind projects specifically aimed at decarbonizing oil and gas operations and fostering innovation within the renewable energy sector.

locations and activities with state agencies on a continues basis. This is to further build on ongoing in-depth engagement (with parties such as PDA) to define and manage any conflicts.

Natural hazards

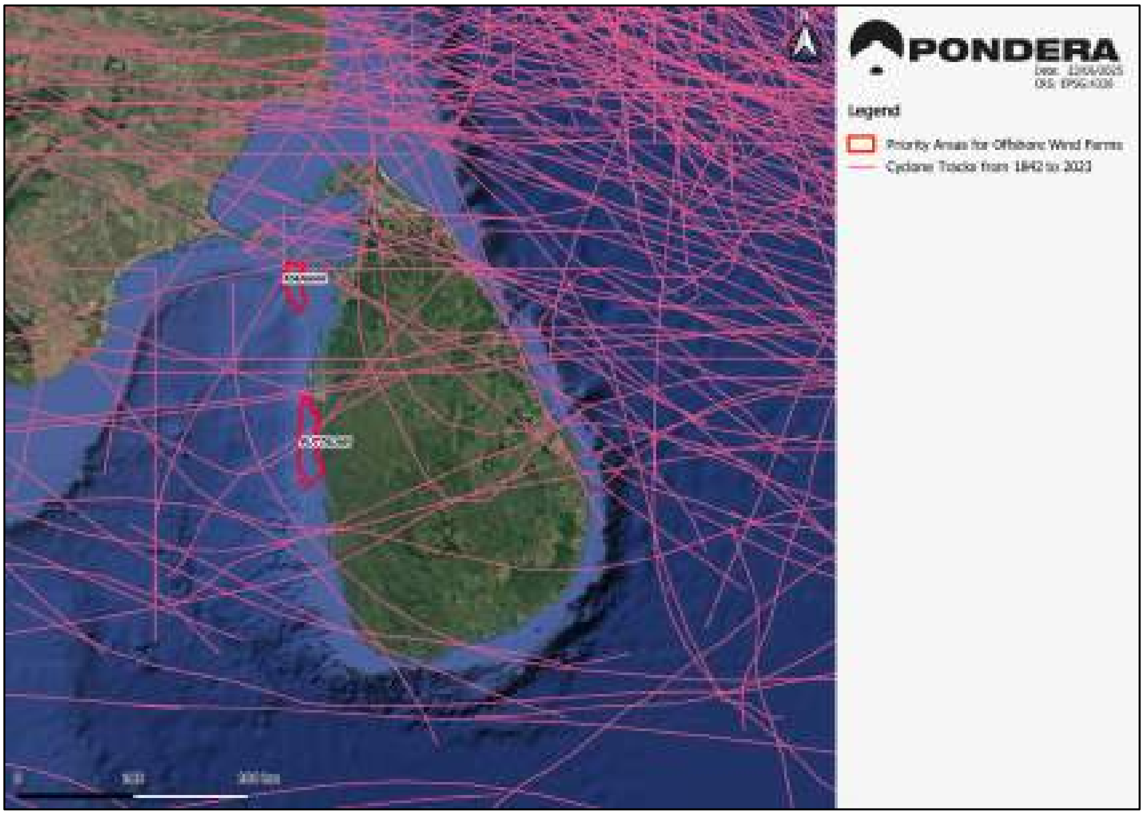
General description

Natural hazards can pose a threat to offshore wind by potentially damaging infrastructure, disrupting operations, and increasing project costs. The most likely natural hazards that could occur in the project areas are cyclones and seismic activity, and both are described in more detail below. Others, like monsoons (described previously in Section Wind Resources) and corrosive marine environments, are not considered distinctive factors within the project areas for the site selection and feasibility assessment and are not further elaborated in this section.

Tropical cyclones and climate conditions

Sri Lanka is vulnerable to tropical cyclones. Cyclone seasons in Sri Lanka typically occur during the northeast monsoon from December to February and the southwest monsoon from May to November, with most of the storms classified as tropical depressions (up to 17m/s) and tropical storms (up to 32.5m/s). It can be seen that cyclones occur throughout Sri Lanka and have even traversed the project areas. Figure 23 indicates the long track record of cyclones in Sri Lanka from 1842 to 2023, the data is collected from IBTrACS[17]. It can be seen that cyclones occur throughout Sri Lanka and have even traversed the project areas.

Figure 23 Cyclone tracks in Sri Lanka in the period 1842-2023 (source: IBTRACS)



[17] International Best Track Archive for Climate Stewardship

Apart from extreme events such as cyclones, climate conditions such as El Niño and La Niña (El Niño-Southern Oscillation – ENSO), Indian Ocean Dipole (IOD) phenomena and Madden–Julian Oscillation (MJO) can increase the frequency and intensity of storms and cyclones, posing safety risks to offshore wind farm operations. These phenomena are briefly touched upon below.

El Niño leads to wetter conditions in May, October, November, and December, and to drier conditions in January, February, March, July, and August. Except for the period from January to March, the impacts of La Niña are the inverse of those of El Niño. The ENSO cycle oscillates between La Niña (cold) and El Niño (warm) phases approximately every 3-4 years. According to the WMO, La Niña events typically occur every 3-5 years, while NOAA states that intervals can vary from 2 to 7 years based on historical records. However, ENSO is not a regular cycle and is not predictable in the same way as ocean tides[18].

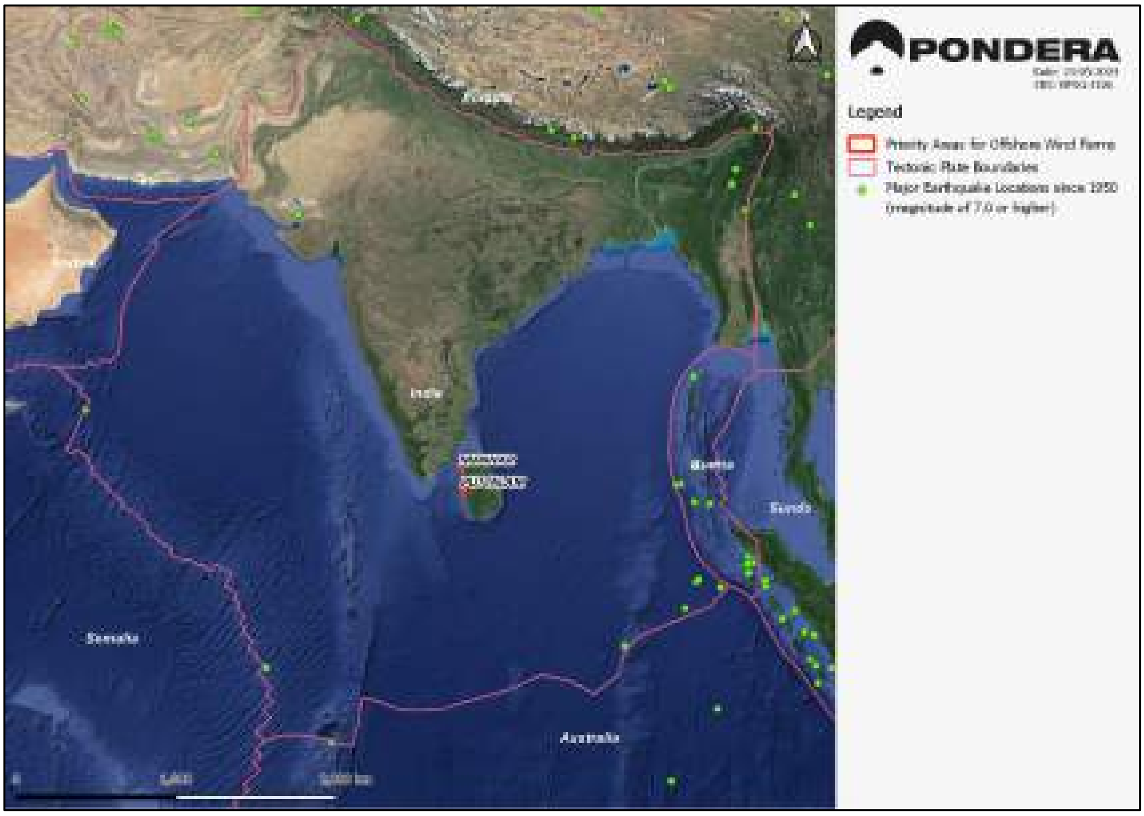
The IOD is an irregular climate phenomenon where sea surface temperatures in the western Indian Ocean alternate between warmer (positive phase) and cooler (negative phase) than in the eastern part. The IOD plays a crucial role in influencing southwest monsoon patterns and precipitation variability in Sri Lanka. Positive IOD events are associated with an increase in cumulative seasonal rainfall, the mean number of wet days, and heavy rainfall events. While specific rainfall intensity data for the two project areas is not reported, offshore rainfall tends to increase during positive IOD events.

The MJO is a 30-to-90-day climate phenomenon that moves eastward from the western Indian Ocean over Sri Lanka multiple times a year. It impacts weather and climate in the Indo-Pacific region by bringing deep clouds and intense convective activity during its active phase, affecting local precipitation and weather patterns[19]. The MJO progresses through eight phases, each representing a different position of enhanced convective activity as it moves eastward around the globe. In Sri Lanka, the most notable impacts occur during MJO Phases 1 to 4, which amplify the frequency, intensity, and duration of extreme precipitation events, particularly during the second inter-monsoon season, as indicated by data from rain gauges near selected project sites[20].

Seismic activity
In terms of seismic activity, Sri Lanka is generally considered to be in a low seismic hazard zone as it is located in the interior of the Indian tectonic plate (see Figure 24). While the country itself is not located directly on a major plate boundary and lacks major earthquakes, it can still experience earthquakes and seismic activity due to plate-moving northeast towards the Eurasia plate.

[18] The_El_Nino_event_of_2015_2016_in_Sri Lanka.pdf
[19] The impact of the Madden-Julian oscillation on spring and autumn afternoon diurnal convection in Sri Lanka | npj Climate and Atmospheric Science
[20] The Influence of Weather Patterns and the Madden-Julian Oscillation on Extreme Precipitation Over Sri Lanka - Deoras - 2023 - Geophysical Research Letters - Wiley Online Library

Figure 24 Tectonic plate boundaries and major earthquake locations (source: National Geographic)



Most suitable sites within the priority areas
It can be observed from Figure 23 that cyclones have occurred in the project areas, but they cannot be considered a distinctive factor for site selection (as they can occur everywhere). Besides, the seismic risk is considered as low. If present, the impact of these natural hazards can usually be mitigated through technical solutions to enhance the overall stability of the structures. Therefore, future offshore wind development should take into account the threat in design, execution and operation to mitigate any potential risks.

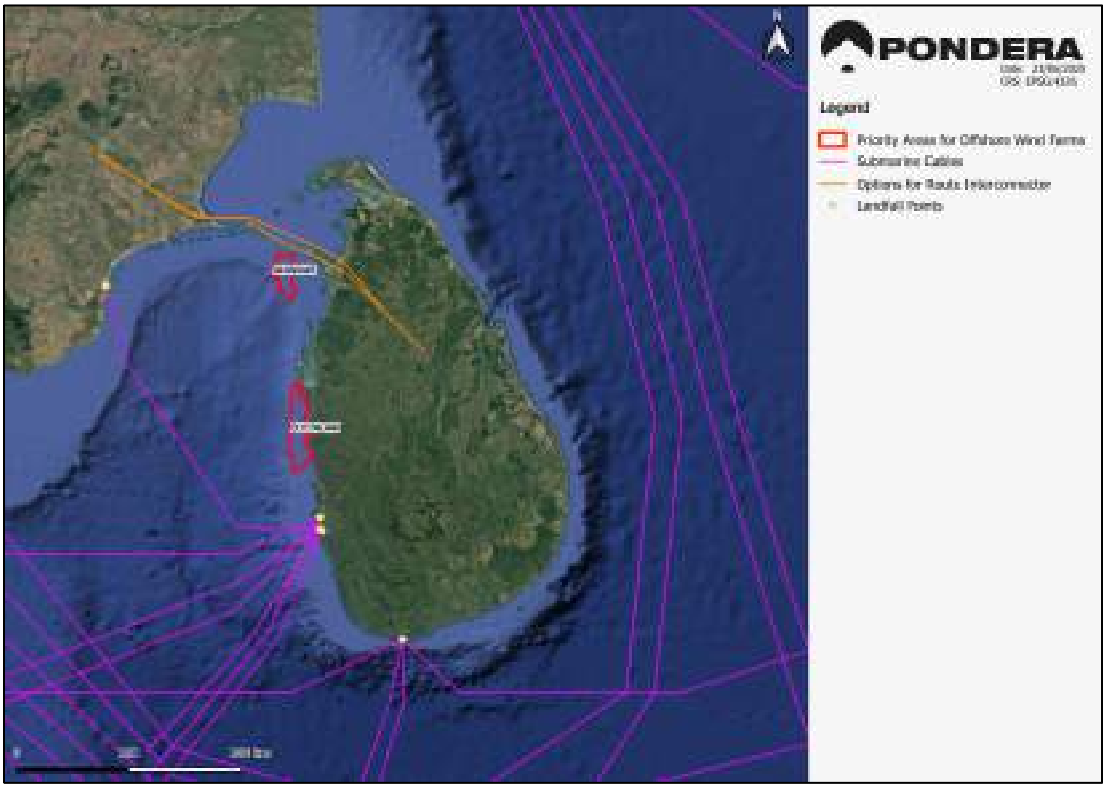
Uncertainties and data gaps
IBTrACS may lack complete information for some tropical cyclones, particularly for storms that occurred in remote or less monitored regions. This could result in incomplete tracks or missing data points, making it challenging to analyse the full extent of cyclone activity. However, since the potential impact factor for natural hazards is classified as low, uncertainties and data gaps related to this subject are not considered significant.

Offshore infrastructure

General description
The presence of offshore infrastructure can impact offshore wind through potential interference with existing cables, pipelines or (telecommunication) networks. Consideration of offshore infrastructure is crucial in planning to avoid spatial conflicts and optimize marine resource utilization. Data collected from SubmarineCableMap.com, as shown in Figure 25, indicates that Sri Lanka has 10 known submarine cables, but none of them are located close to the project areas. Additionally, no notable offshore infrastructure has been reported to be present in the project areas during the site visits and stakeholder engagement activities. The figure also shows

the potential route options for the planned grid interconnector between Sri Lanka and India. It can be seen that none of the two options envisage a route through the Mannar project area.

Figure 25 Offshore infrastructure (source: SubmarineCableMap.com)



Most suitable sites within the priority areas

Due to the absence of known offshore infrastructure in the project areas, this is not considered to be a constraint or influencing factor for the site selection exercise.

Uncertainties and data gaps

There could be uncertainties and data gaps associated with the accuracy and updating of global data sources like SubmarineCableMap.com. This may result in underestimating the presence of offshore infrastructure. It is needed to check and verify potential presence of offshore infrastructure in the project areas with state agencies in subsequent project phases. Any presence of offshore infrastructure in the project area will also be identified during future geophysical surveys.

Unexploded ordnance

General description

Unexploded ordnance (UXO) consists of explosive devices like bombs or mines that were deployed but did not detonate. Their presence could pose considerable safety hazards to activities related to the construction and operation of offshore wind farms. Mitigation measures include conducting thorough surveys and risk assessments to identify hazardous areas. Qualified professionals then carefully remove and dispose of UXOs following established safety protocols, or areas can be avoided.

According to published database by NOOA[21], there are no UXOs within or close to any one of the two project sites. However, local experts have reported incidents of dynamite fishing in the areas of the two sites. This practice can introduce additional safety risks and potential unexploded devices, necessitating careful monitoring and additional safety measures during project planning and execution.

Most suitable sites within the priority areas

UXOs can impact the feasibility assessment and site selection process for offshore wind because their presence poses safety risks. However, these risks can usually be mitigated by identifying and removing the UXOs prior to site activities (such as construction). Due to the absence of known UXOs in the vicinity of the project areas, this is not considered to be a constraint or influencing factor for the site selection exercise. UXOs can potentially be identified during geophysical surveys (during Phase 3 TA).

Uncertainties and data gaps

The available NOOA dataset represents known or potentially grouped UXOs on the ocean floor. However, the comprehensiveness and the accuracy of the locations may be uncertain and there is a lack of knowledge about dynamite fishing.

Shipping & anchorage

General description

The proximity of dense shipping routes to offshore wind farms can increase the risk of navigation hazards and collisions between vessels and wind turbines. In practice, shipping and offshore wind can co-exist by establishing vessel traffic zones and management, and by incorporating collision avoidance measures (for instance by marking and lighting systems).

Figure 26 indicates the shipping density in the seas surrounding Sri Lanka, acquired via the World Bank database. The dataset was compiled using IMF's analysis of hourly Automatic Identification System (AIS) positions recorded between January 2015 and February 2021. Each grid cell in the dataset represents the total number of AIS positions reported by ships, with dimensions of 0.005 degrees by 0.005 degrees, approximately equivalent to a 500m x 500m grid at the equator. The shipping density within the project sites and surrounding area is very low compared to other marine areas around Sri Lanka. However, it has to be mentioned that the data does not include local shipping without location tracking devices. In fact, the entire coastal region of Sri Lanka is used for various shipping purposes.

[21] Unexploded Ordnance Locations | InPort (noaa.gov)

Figure 26 Shipping density (source: World Bank)

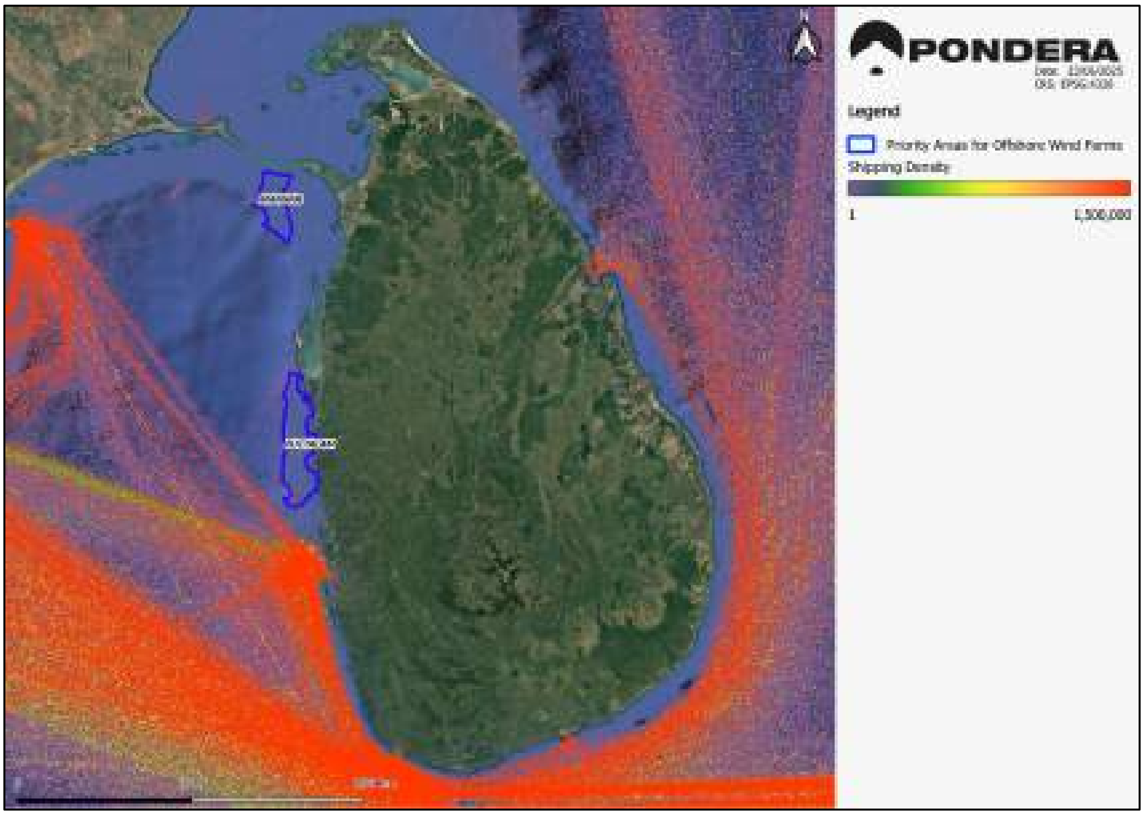
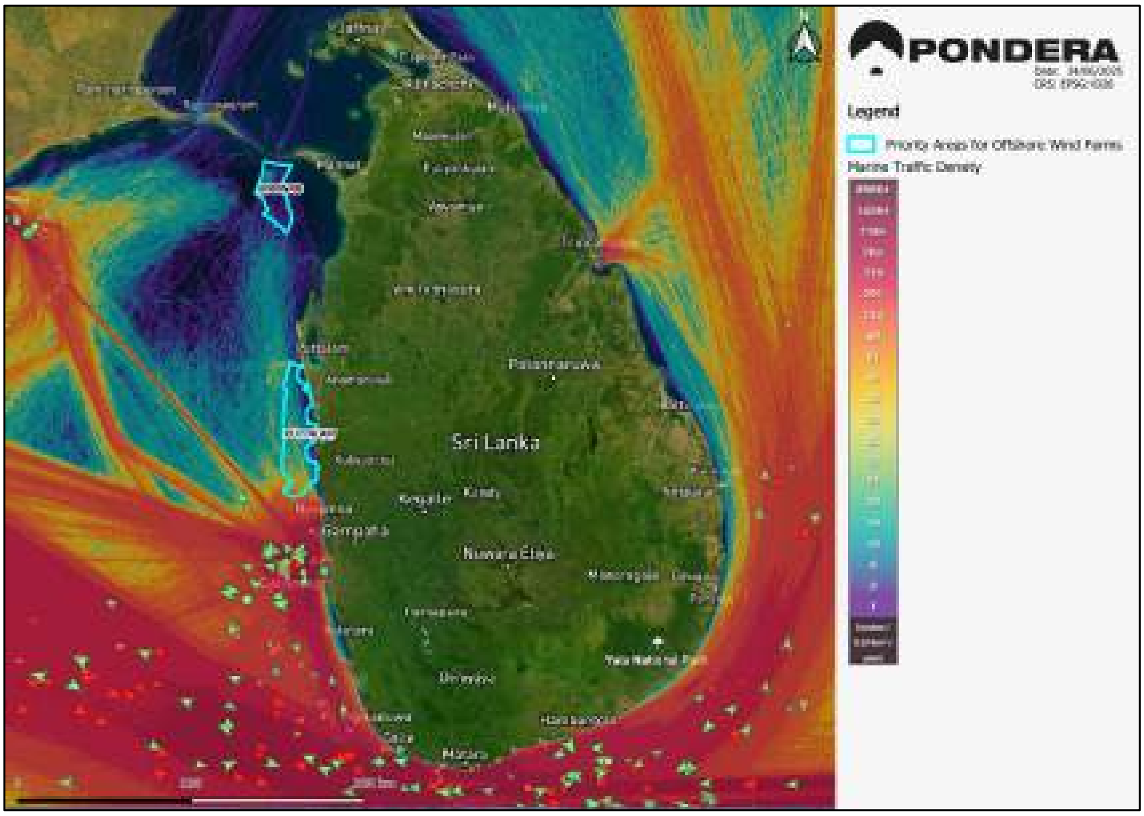


Figure 27 illustrates the shipping density within the two project sites, sourced from the MarineTraffic database. The data aligns with trends observed in the World Bank data, indicating generally low marine traffic in both areas. Notably, ships are tracked moving between the Mannar and Puttalam sites, likely due to fishing activities in the Gulf of Mannar. Areas with dense shipping within two sites (up to 42 routes per year for Mannar and 114 per year for Puttalam) are likely associated with fishing activities as well. Additionally, there are shipping lanes to the coal plant in Puttalam, which warrants consideration when planning for offshore wind projects.

Figure 27 Shipping density (source: Marine Traffic)



The project team has visited most of the coastal areas (over a period of time) adjacent to the project areas. The onsite observations regarding shipping density are in line with findings from the maps presented above (see example in Figure 28). The marine areas do not host high-frequency shipping. Types of shipping encountered by the project team mostly involved small-sized vessels, including fishing boats, navy vessels, and small vessels for tourism purposes. Larger vessels were seen around the coal supply jetty near Puttalam.

Figure 28 Picture (taken by the project team) facing south from the coal power plant jetty (towards Puttalam project area), showing onshore wind plants and calm open waters with low-density shipping

Most suitable sites within the priority areas
No major shipping routes traverse the project areas, nor are there any known anchorage areas, so it is not considered to be a hard constraint for the site selection exercise. However, shipping does occur in the areas, especially local shipping and ships to the coal plant jetty, making it an important factor to consider during subsequent project planning stages.

Uncertainties and data gaps
As with many global data sets, the uncertainties of used databases on shipping could arise due to various factors, such as incomplete reporting from certain regions, inaccuracies in vessel tracking or reporting systems, and limitations in data collection methods. Additionally, the databases may not always capture the most current or comprehensive information about shipping activities in specific region, especially when it involves local shipping without tracker devices. To assess potential disruptions to local shipping, it is essential to conduct additional mapping of the frequency and features of local maritime activity during post-study activities.

Existing wind projects

General description
Realizing offshore wind close to existing (onshore) wind projects could create conflicts as wind farms compete for physical space and wind resources. Siting projects too close to each other could result in energy yield losses and increased fatigue due to wakes[22].

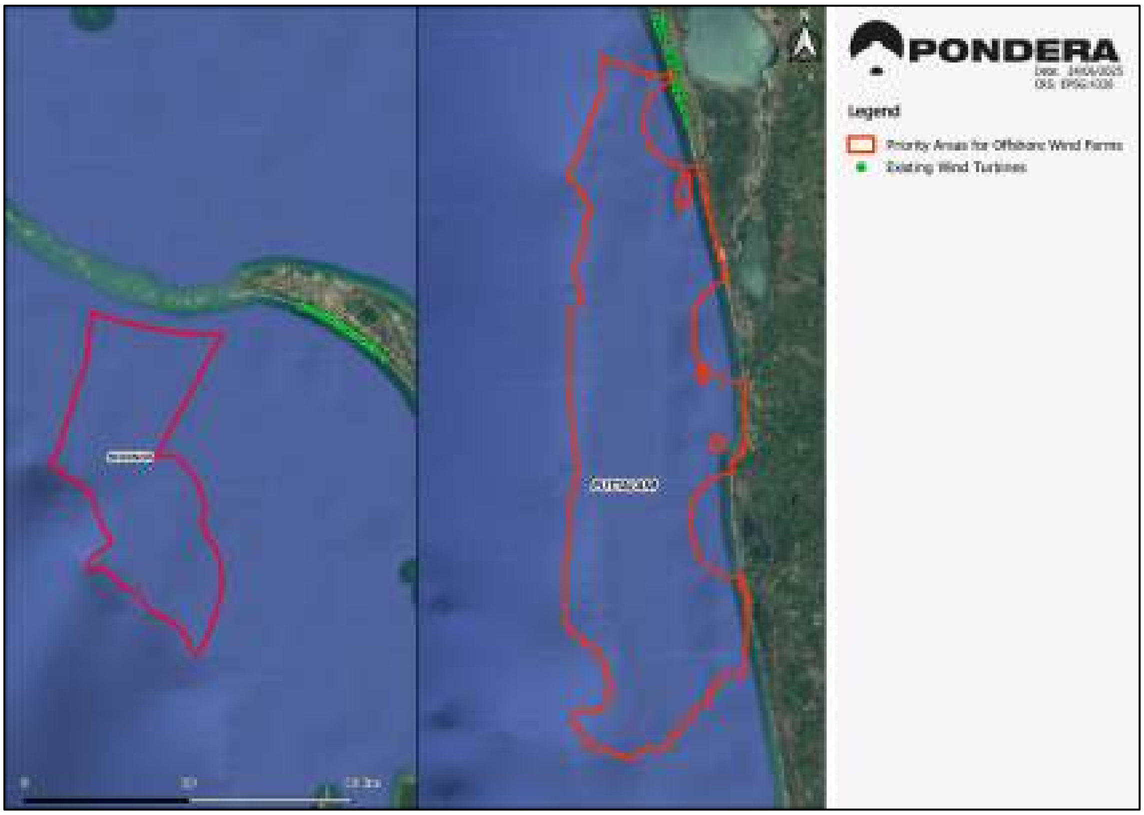
Figure 29 indicates the location of existing onshore wind farms near the project areas. The wind farm project adjacent to the Mannar priority area is the Thambapavani wind farm. This project includes 30 wind turbines with an installed capacity of 103.5 MW. The distance from the closest turbine of this wind farm to the Mannar offshore area boundary is approx. 10km. The project team visited the Thambapavani wind farm in March 2024 and received a presentation about the wind farm, including an on-site tour.

In terms of planned wind projects, a number of companies are considering development of onshore wind farms on Mannar island and adjacent coastal areas of the mainland, due to favourable wind conditions. However, the government has resolved that all onshore wind power developments in Mannar will be placed on competitive bidding. Accordingly, one 50 MW wind farm has already been competitively awarded in June 2025, while bids for two 50 MW wind farms were announced in May 2025, closing in July 2025.

Onshore development in Puttalam may be limited to a few more 10 MW wind farms to the north of the Lakvijaya coal power plant. In total, onshore areas adjacent to the Puttalam offshore development area, has a total of 75 MW of onshore capacity in operation. Out of this capacity, areas to the south of the Lakvijaya coal power plant have the Mampuri 1 (10 MW), Mampuri 2 (10 MW) and Nirmalapura (10 MW) wind farms (these wind turbines are visible in Figure 28).

[22] Wake refers to the disrupted airflow behind a wind turbine caused by its rotor blades. This turbulence can reduce the wind speed and change its direction, affecting the efficiency of nearby turbines. Optimizing turbine layout and spacing helps minimize this effect and maximize energy production in (and among) wind farms.

Figure 29 Locations of nearby onshore wind projects



Most suitable sites within the priority areas
Placing offshore wind turbines in the downwind area of an existing wind project (or vice versa) will create wake effects, although these effects lessen over distance. For both project areas, but especially Puttalam, this might be an important factor to consider in the northeastern areas as existing projects are located nearby along the coast. Generally, wake effects decrease when wind projects are located farther apart from one another. The 5 km buffer zone used along the coast to reduce potential impacts on environment and social receptors will also mitigate the potential negative effects of wakes between wind projects to some extent. Advanced modelling is required to quantify the order of magnitude of wake effects between wind farms.

Uncertainties and data gaps
The overview of the existing projects is considered to be reliable as it is checked across various sources and confirmed by national experts within our team. The overview does not include future planned projects (in planning, permitting or construction phases), which could affect offshore wind projects (in the future) in the same way existing operational projects do.

2.4.3 Environmental Constraints

General description
Ecology can significantly impact the feasibility and site selection of offshore wind projects. Offshore wind has the potential to cause direct and indirect adverse impacts on both onshore and offshore biodiversity. These impacts encompass risk of bird and bat collisions with turbine blades and power lines, displacement of wildlife, habitat conversion and degradation, collision with vessels and underwater noise disturbance affecting marine mammals. Additionally, offshore environments may experience benthic disturbance, changes in habitat structure and

hydrodynamic changes due to the installation of new structures, which can attract new habitat-forming species, including invasive alien species.

This section includes the following items, in which both areas and species will be covered:

- Legally Protected Areas (sub-type: Marine Protected Areas), Key Biodiversity Areas and Ramsar Sites;
- Other internationally recognised areas such as Ecologically or Biologically Significant Marine Areas (EBSA) Important Marine Mammal Areas (IMMA), and Sharks and Rays: Important Shark and Ray Areas (ISRA); and
- Important ecosystems and natural habitats, such as coral reef, pearl beds and seagrass
- Avifauna: Important Bird Areas (IBA), breeding colonies, bird migration routes.

Each item will be explained in more detail below. The screening process is conducted within 50km from the centre of project's sites.

Protected Areas and Key Biodiversity Areas

A protected area is a clearly defined geographical space, recognised, dedicated and managed, through legal or other effective means, to achieve the long-term conservation of nature with associated ecosystem services and cultural values (IUCN Definition 2008). KBAs have been identified to cover the most important places in the world for species and their habitats. KBAs are identified using a global standard that include criteria that were developed through a multi-stakeholder process – however are not necessarily protected by law.

The assessment takes in account LPAs recognized by both National and International parties. Figure 30 highlights the presence of LPAs and KBAs within a 50 km[23] radius[24] from the Mannar project area. No UNESCO World Heritage Sites and Alliance for Zero Extinction[25] are identified within this area. The discrepancy between LPAs of the World Database on Protected Areas (WDPA) and the Sri Lankan government is addressed in the uncertainty and data gaps section.

The Mannar site boasts a diverse array of LPAs and KBAs within a 50 km radius, encompassing terrestrial, aquatic, coastal, and marine environments. These include Adam's Bridge National Park, Bar Reef Marine Sanctuary (Bar Reef Island), Valankai Sanctuary Ramsar, Vedithalathive, Giant's Tank, Mavillu, Vilaththkulam and Karadikkuli as LPAs, and Gulf of Mannar Marine National Park, Periyakalapuwa Mouth, Giants Tank and Amaipaddukkai as KBAs. Further details of all areas are provided in Table 10. The Bar Reef Marine Sanctuary, located within the Gulf of Mannar, is the largest marine protected area (MPA) in Sri Lanka and plays a role in conserving marine biodiversity. Evidence suggests that fish species migrate between the coral reefs of the sanctuary and the nearby Puttalam Lagoon, highlighting the interconnectedness of marine ecosystems within the Gulf of Mannar[26].

[23] Integrated Biodiversity Assessment Tool (IBAT) (ibat-alliance.org)
[24] Measured from the centre
[25] The Alliance for Zero Extinction is a global initiative dedicated to conserving species on the brink of extinction by safeguarding their remaining habitats.
[26] Gulf of Mannar-CBD

Table 10 LPAs and KBAs in Mannar

Category	Name	National/International	Description	IBA status
Protected Areas (PAs)	Adam's Bridge National Park	National	Adam's Bridge National Park highlights the presence of various fauna, including three dragonflies, two butterfly, 16 bird, and one mammal species. he park lies on the route of migratory birds that visit Sri Lanka. While marine ecosystems were not thoroughly surveyed, the waters surrounding the park reportedly host Indo-Pacific humpback dolphins, dugongs, and sea turtles. Currently, there are no infrastructure facilities — such as boats — and ad hoc boat tours are run by Sri Lanka navy and development should be restricted in this area	
	Vankalai	National	The Vankalai Sanctuary boasts diverse ecosystems, including thorn scrubland, pastures, grasslands, mangroves, and marine areas. It supports numerous waterbirds, fish species, and marine turtles and is an important site for migratory birds. Facilities — such as boats — have not yet been provided by the DWC and the area is still under the control of the SL Navy. The site is recognised as a Ramsar site, further details will be mentioned in the below section on Ramsar.	
	Bar Reef Marine	National & International	The Bar Reef Marine Sanctuary lies off the north west coast of Sri Lanka. This island hosts a rich array of	

Category	Name	National/International	Description	IBA status
			fish, coral, crustaceans, and marine plants and is among the largest and most pristine in Sri Lanka. It supports local fishing communities and provides habitat for endangered species like sea turtles.	
	Vedithalathivu (Vidataltivu Nature Reserve)	National	Vidataltivu Nature Reserve, situated adjacent to the Vankalai Sanctuary, stands as the third-largest Marine Protected Area in the region. It serves as a significant stopover for migratory birds and hosts a variety of rare species. This reserve encompasses extensive oceanic areas, safeguarding vital sea grass habitats essential for the sustenance of Dugongs. Additionally, it includes terrestrial zones preserving Sri Lanka's largest mangrove ecosystem. These mangroves grow along the coast, facing the open sea, offering crucial protection against cyclones, storm surges, and tsunamis.	
	Gaint's Tank	International	Giant's Tank, situated in Mannar district, is among Sri Lanka's largest irrigation reservoirs, playing a pivotal role in water storage and supply to approximately 160 smaller tanks in the region. Recognized as a sanctuary, it serves to safeguard a crucial water source in an otherwise arid landscape. The reservoir's vast expanse of water and surrounding vegetation, characterized by	

Category	Name	National/International	Description	IBA status
			reed grasses and water lilies, provides a conducive habitat for a diverse array of bird species, including ducks, grebes, and coots. Notably, the floating vegetation supports species such as the Pheasant-tailed jacana and the White-breasted waterhen. Given its significant avian diversity and abundance, Giant's Tank is considered one of Sri Lanka's foremost sites for bird conservation efforts.	
	Mavillu (Part of Wilpattu Forest Complex)	International	The area is characterized by a variety of ecosystems, including permanent and seasonal rivers, ancient irrigation tanks dating back to 2,000 years, coastal salt marshes, and scrubland behind the beach. These habitats support a wide range of animal species, including 23 species of freshwater fish, 17 species of amphibians, 57 species of reptiles, 253 species of birds, and 45 species of mammals. Notably, the site is renowned for its populations of globally threatened large mammals and endemic bird species.	
	Vilaththkulam (Part of Wilpattu Forest Complex)	International	Refer to Mavillu	
	Karadikkuli (Part of Wilpattu Forest Complex)	International	Refer to Mavillu	

Category	Name	National/International	Description	IBA status
Key Biodiversity Areas (KBAs)	Periyakalapuwa Mouth	-	The area lies within Vankalai Sanctuary. Refer to Vankalai Pas	
	Giants Tank	-	Refer to Giant's Tank Pas	x
	Gulf of Mannar Marine National Park	-	The Gulf of Mannar, situated between India and Sri Lanka, is renowned for its rich biodiversity, comprising over 3,000 species of animals and plants inhabiting diverse habitats such as coral reefs, mangroves, and seagrasses. This marine ecosystem supports a wide variety of life, including 168 species of migratory birds, 5 species of marine turtles, 450 species of fish, 79 species of shellfish, 100 species of sponges, and 260 species of mollusks. Additionally, the Gulf of Mannar Marine National Park is designated as a Biosphere Reserve by UNESCO and serves as a Marine Protected Area under Indian law	x
	Amaipaddukkai	-	A small area located within Vedithalathiveu Refer to Vedithalathivu	x

Additionally, the Indian portion of the Gulf of Mannar has been designated as a marine biosphere reserve, while the Sri Lankan side, including the Bar Reef Marine Sanctuary, provides further protection for marine life in the area.

Figure 30 Nearby protected areas and key biodiversity areas for Mannar project area (source: WDPA)

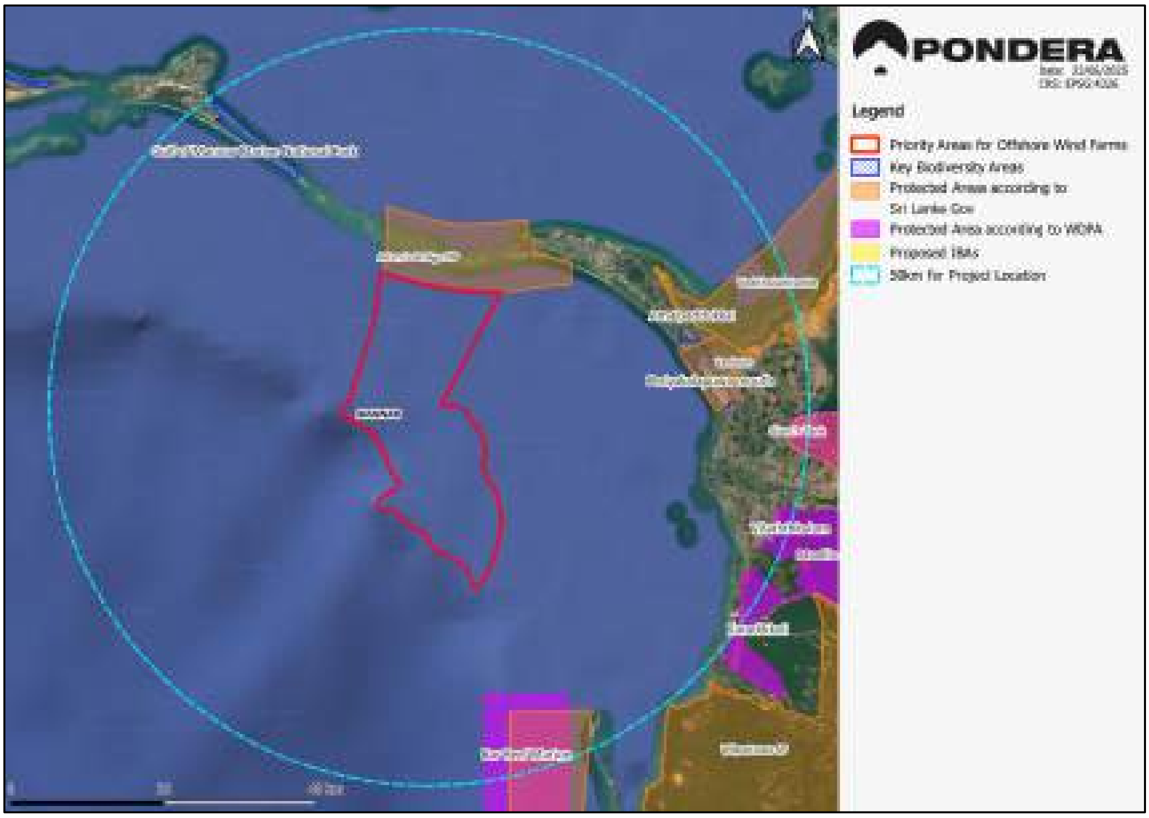


Figure 31 highlights the presence of LPAs and KBAs within a 50 km radius from the Puttalam project area. In Puttalam, KBAs include Mundel Lake, Anaiwilundawa complex, and Periyakadawela, alongside LPAs, namely Anaiwilundawa and Kotuattawahla. Further details of all areas are provided in Table 11. Anaiwilundawa complex is the only LPA according to the Sri Lankan government.

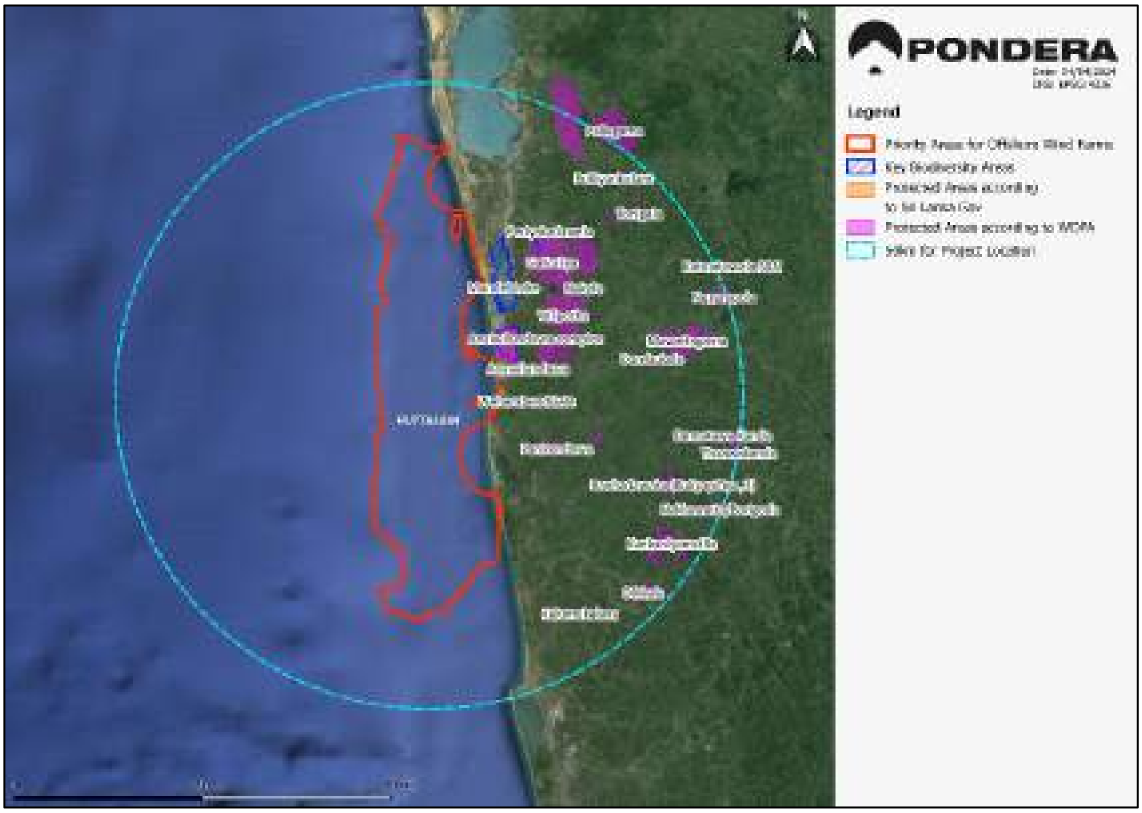
Table 11 LPAs and KBAs in Puttalam

Category	Name	National & International	Description	IBA status
Protected Areas (PAs)	Anaiwilundawa	National & International	Anaiwilundawa and the Anaiwilundawa complex, situated within Puttalam lagoon, encompass a diverse range of coastal saltwater ecosystems and freshwater lakes. These areas are vital for avian conservation and biodiversity protection within the Puttalam district. The unique combination of environments has fostered the development of a distinct ecological niche, providing	

Category	Name	National & International	Description	IBA status
			nesting and breeding grounds for a multitude of bird species. These wetlands support a rich biodiversity, hosting over 150 species of birds, 20 species of mammals, 70 species of butterflies, and more than half of Sri Lanka's freshwater fish species.	
	Kotuattawahla	National	Kotuattawahla SAN encompasses various ecosystems, including wetlands, forests, and other natural landscapes, providing habitats for diverse flora and fauna species. As a strict nature reserve, Kotuattawah SAN may have regulations in place to limit human disturbance and ensure the conservation of its natural resources.	
	Sellankandal	International	Reserved Forest.	
	Pallegama	International		
	Pulliyankulam	International		
	Pahala Divullewa	International		
	Anamaduwa	International		
	Tonigala	International		
	Galkuliya	International		
	Etaritiya	International		
	Wilpotha	International		
	Ambanmukalana	International		
	Abakele	International		
	Weherabendikele	International		
	Panirendawa	International		
	Kaduruwewa	International		
	Kalumukalana	International		
	Dikkele 1&2	International		

Category	Name	National & International	Description	IBA status
	Galagedara 2	International		
	Medikele .1	International		
	Kankaniyamullla	International		
	Nakkawatta/Barigoda	International		
	Dematawa Kanda	International		
	Kosdenikanda	International		
	Tissawakanda	International		
	Mawattagama	International		
	Dambukele	International		
	Nugampola	International		
Key Biodiversity Areas (KBAs)	Mundel Lake	-	The wetland has primarily been used for fisheries and prawn farming, excessive resource utilization beyond sustainable limits has disturbed the wetland system, leading to limited information on its biodiversity status	
	Anaiwilundawa complex	-	Refer to Anaiwilundawa	x
	Periyakadawela	-	Periyakadawela is recognized as a habitat for bird species of least concern, and the population density of these species appears to be relatively high within this area. Limited information is available for this site.	x

Figure 31 Nearby protected areas and key biodiversity areas for Puttalam project area (Source: WDPA)



Furthermore, as of 2024, new MPAs are expected to be declared in the Northwest of Sri Lanka. The boundaries of the new MPAs are visible in Figure 32. These MPAs were included in the Roadmap as exclusion zones, so the priority areas for offshore wind do not overlap.

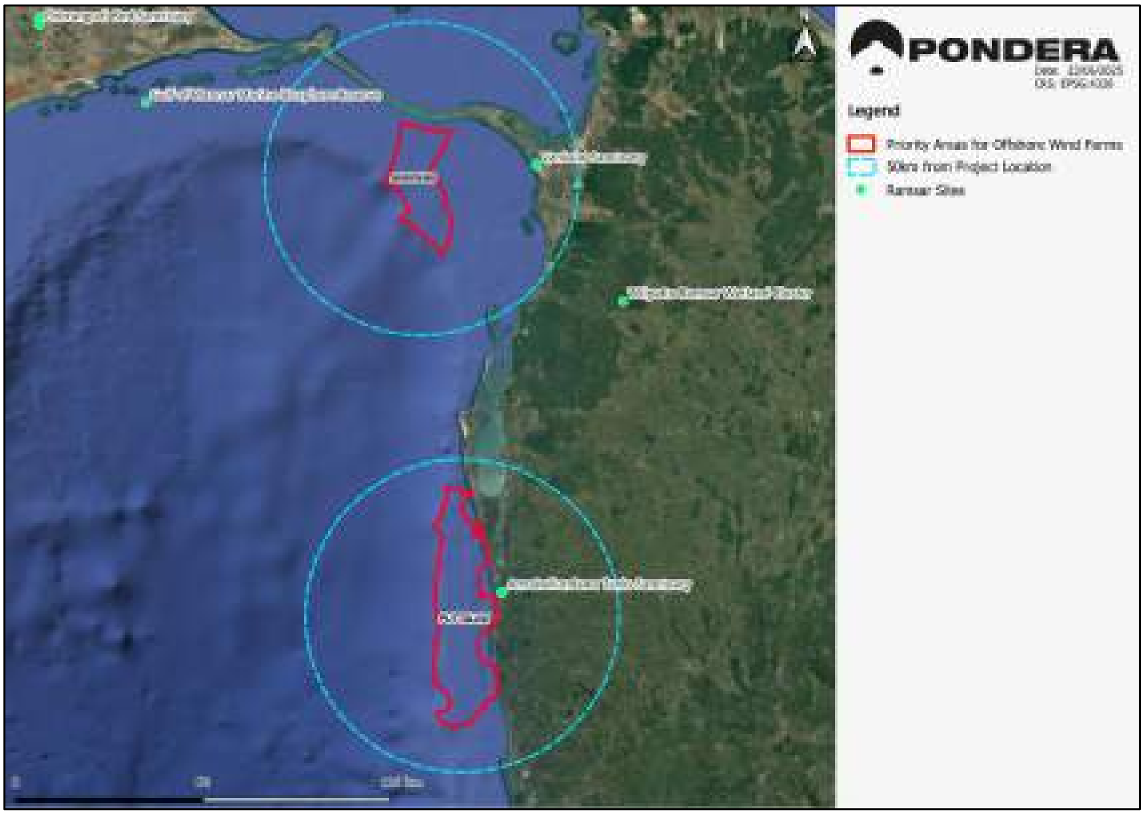
Figure 32 Boundaries of new proposed MPAs (purple layer) in the Northwest of Sri Lanka (source: Roadmap)

Ramsar Sites are wetlands of international importance designated by national governments under the Ramsar Convention for containing representative, rare or unique wetland types, or for their importance in conserving biological diversity. Figure 33 indicates the location of Ramsar sites within 50 km radius from the project areas, three of which have marine components: Wilpattu Ramsar site, Vankalai Sanctuary Ramsar site and Anaiwilundawa wetland Ramsar Site.

The Wilpattu Ramsar site encompasses various areas including the Wilpattu National Park, marine wetlands along the western coast extending offshore up to 10 kilometres, the Kalaoya estuary, the Modaragam Aru estuary, and the Mahawilachchiya freshwater reservoir. Wilpattu National Park stands out for its nesting community of larger waterbirds, including species like the Spot-billed Pelican *(Pelecanus philippensis)*, Painted Stork *(Mycteria leucocephala)*, Asian Openbill *(Anastomus oscitans),* and Black-headed Ibis *(Threskiornis melanocephalus).* The park's avifauna biodiversity extends beyond waterbirds, with over 130 non-aquatic bird species thriving in its vast monsoon forest and plains, providing ideal nesting and feeding grounds. These habitats also attract mixed-species feeding flocks, comprising both resident and migrant birds such as the Ceylon Junglefowl *(Gallus lafayetii)*, Black-rumped Flameback *(Dinopium benghalense)*, Asian Paradise Flycatcher *(Terpsiphone paradisi),* and Tickell’s Blue Flycatcher *(Cyornis tickelliae)*. Moreover, Wilpattu uniquely hosts the rare Malabar Trogon *(Harpactes fasciatus)* in dry-zone non-riverine habitats, underscoring the exceptional quality of its tall monsoon forest ecosystem. The Wilpatu Ramsar site, also covers part of the Gulf of Mannar and Palk Bay consist of the marine area which is a feeding habitat of the globally Vulnerable (VU) Dugong *(Dugong dugon)*, the globally VU sea horse *(Hippocampus kuda)* and 27 other species of marine mammals including Indian Ocean Humpback Dolphin *(Sousa plumbea*), Indo-Pacific Humpback Dolphin (*Sousa chinensis)*, Blue Whale *(Balaenoptera musculus),* Bryde's Whale *(Balaenoptera spp.),* Rough-toothed Dolphin *(Steno bredanensis),* Sperm whales *(Physter macrocephalus)*. Also, Whale shark *(Rhincodon typus)* visit the marine area of the site for feeding. Deep-sea living shark species, Crocodile shark *(Pseudocarcharias kamoharai)*, which is a specialized inhabitant of the mesopelagic zone[27] and seldom recorded in the region, have also been recorded on several occasions from this area.

[27] A layer of the ocean that extends from about 200 to 1,000 meters below the surface.

Figure 33 Ramsar sites (map shows the GIS point locations, but the corresponding Ramsar areas cover a much wider area)



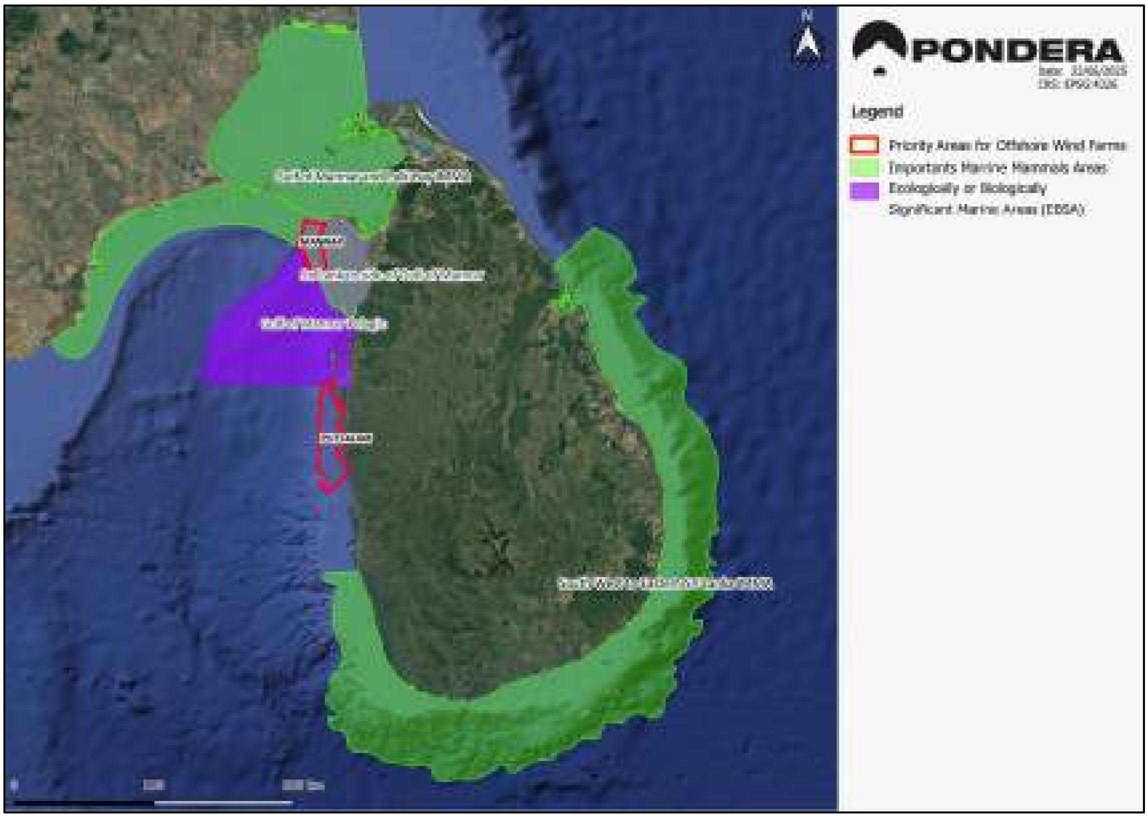
The marine areas of Vankalai Sanctuary, within the GoM, sustain a diverse marine life, including dugongs and marine turtles, facilitated by the presence of seagrasses. Moreover, the shallow brackish water wetlands in this region play a vital role in supporting the life cycle of various harvestable fish species like Milkfish, Trevally, Snappers, and the Spotted Scat. Vankalai Sanctuary encompasses a diverse range of habitats, including arid-zone thorn scrubland, pastures, grasslands, mangroves, sand dunes, and marine regions, along with coastal and marine ecosystems featuring sea-grass beds, lagoons, salt marshes, and coastal scrubland. This is a feeding and breeding ground for numerous waterbird species, serving as a vital stopover for migratory birds including rare to very rare species traveling along the Central Asian Flyway. With over 149 documented bird species and populations exceeding 20,000 during migration seasons, it hosts a diverse array of migratory waders and waterbird species, with notable populations of Greater Flamingo *(Phoenicopterus roseus)*, Eurasian Wigeon *(Anas penelope),* Northern Pintail *(Anas acuta)*, and Black-tailed Godwit *(Limosa limosa)*. Particularly significant is the presence of the nationally critically endangered (CR) Indian Spot-billed Duck *(Anas poecilorhyncha)*, which was previously considered a very rare migrant until a breeding population was recently discovered. Additionally, the site attracts rare migratory waterfowl such as Gadwall *(Anas strepera)* and Comb Duck *(Sarkidiornis melanotos)*. The Red Knot *(Calidris canutus)* is common in this area but rare elsewhere in Sri Lanka, while the Pied Avocet *(Recurvirostra avosetta)* is regular here but very rare in other parts of the country. The sanctuary also supports more than 1% of the relevant population of several waterbird species. The marine avifauna documented within the site are Roseate Tern (*Sterna dougallii*) CR, Common Tern (*Sterna hirundo*) CR, Caspian Tern (*Hydroprogne caspia) CR*, Bridled Tern (*Onychoprion anaethetus*) CR, Little Tern (*Sternula albifrons*) VU.

The Anaiwilundawa wetland serves as a vital sanctuary for water birds. Notably, around 10% of the vertebrate species within Anaiwilundawa are considered nationally threatened by International Union for Conservation of Nature (IUCN) Sri Lanka, with approximately 5% being endemic to Sri Lanka. About 25% of the bird species observed in Annaiwilundawa are annual winter migrants, highlighting its importance as a crucial stopover point along the western migratory route for wintering birds.

Internationally Recognised Areas

Ecologically or Biologically Significant Marine Areas (EBSAs), Important Marine Mammal Areas (IMMAs) and Important Areas for Sharks and Rays (IRSAs) are zones identified for potential marine conservation. EBSAs are special areas in the ocean that support the healthy functioning of oceans and the many services that it provides, based on seven scientific criteria: 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. In contrast, IMMAs are specifically targeted for the conservation of marine mammal habitats, considering factors such as breeding areas and feeding grounds. In general, EBSAs aim for overall marine ecosystem preservation, IMMAs prioritize the protection of habitats crucial for marine mammals. Figure 34 indicates screened EBSAs and IMMAs. The entire Mannar site lies within EBSA and IMMA boundaries, while the north Puttalam site is adjacent to EBSAs. Additionally, Baththalangunduwa ISRA also identified within 50 km vicinity of Mannar site.

Figure 34 Ecologically or Biologically Significant Marine Areas and Important Marine Mammal Areas



The coastal and offshore area of the Gulf of Mannar EBSA covers one of the most biologically diverse coastal regions in the world. It is renowned for its diverse marine ecosystems and is home to globally threatened species such as dugongs, whale sharks and various marine turtle species and whales. It is reported to have 117 species of corals, more than 450 species of fishes, 4 species of sea turtles, 38 species of crabs, 2 species of lobsters, 12 species of sea grasses, 147 species of marine algae, 160 species of birds, 641 species of crustaceans, 108 species of sponges, 731 species of molluscs, 99 species of echinoderms, 4 species of seahorses, 12 species of sea snakes, besides 11 species of mangroves. The Gulf of Mannar is known to be an important foraging site and a migratory route of the olive ridley population inhabiting the South Asian marine region. This region encompasses coastal lagoons, seagrass beds, and coral reefs, providing habitats for a wide array of marine organisms. Due to its high productivity, the Gulf of Mannar serves as a fishing ground for both India and Sri Lanka’s neighbouring exclusive economic areas.

As for IMMAs, the Mannar site is situated within the Gulf of Mannar and Palk Bay IMMA, which overlaps part of the Gulf of Mannar EBSA. Historically, this region supported a larger population of dugongs, but due to fishery entanglements and hunting pressure, their numbers have dwindled, posing a risk of local extirpation. Both Sri Lanka and India, sharing the same population of dugongs, have initiated species recovery programs, offering the highest level of legal protection. Monitoring efforts, including interviews, seagrass bed surveys, and boat-based surveys, are employed to track the population status.

Several species of marine mammals occurring in the area can be seen in Figure 35. Marine mammal watching (see Figure 36) is a very popular tourism activity and is further elaborated in the Section 2.4.4 Social Constraints.

Figure 35 Information sign near Kalpitaya beach about certain species of marine mammals in the area (photo taken by member of the project team)

Figure 36 Photos of whale watching activity during study tour in March 2024 (Spinner Dolphins visible on the right photos)

Gulf of Mannar EBSA, Gulf of Mannar IMMA or Gulf of Mannar in general does not experience oxygen deficiency due to coastal upwelling, ensuring a hospitable environment for marine life. Additionally, the area benefits from ample primary plankton food from adjacent seas, supporting a thriving ecosystem. The clear waters and sandy seafloor further contribute to the growth of diverse corals and sensitive fauna. These findings suggest that the Gulf of Mannar's rich biodiversity is a result of its favourable geographical characteristics, highlighting its importance as a refuge for marine life[28] .

The Baththalangunduwa ISRA overlaps with two Ecologically or Biologically Significant Areas (EBSAs): the Sri Lankan side of Gulf of Mannar EBSA and the coastal and offshore area of the Gulf of Mannar EBSA. This benthopelagic area, delineated from the surface (0 m) to 10 m based on bathymetry, is characterised by the presence of threatened species and reproductive areas, notably for the Winghead Shark (*Eusphyra blochii*).

While there is no clear legal restriction in developing offshore wind in EBSA, IMMA or ISRA, in order to enhance the conservation objectives of Sri Lanka, a recognized biodiversity hotspot, extensive pre-installation measures should be undertaken for offshore wind development in these designated areas (Kraus et al., 2019). Examples of measures include:

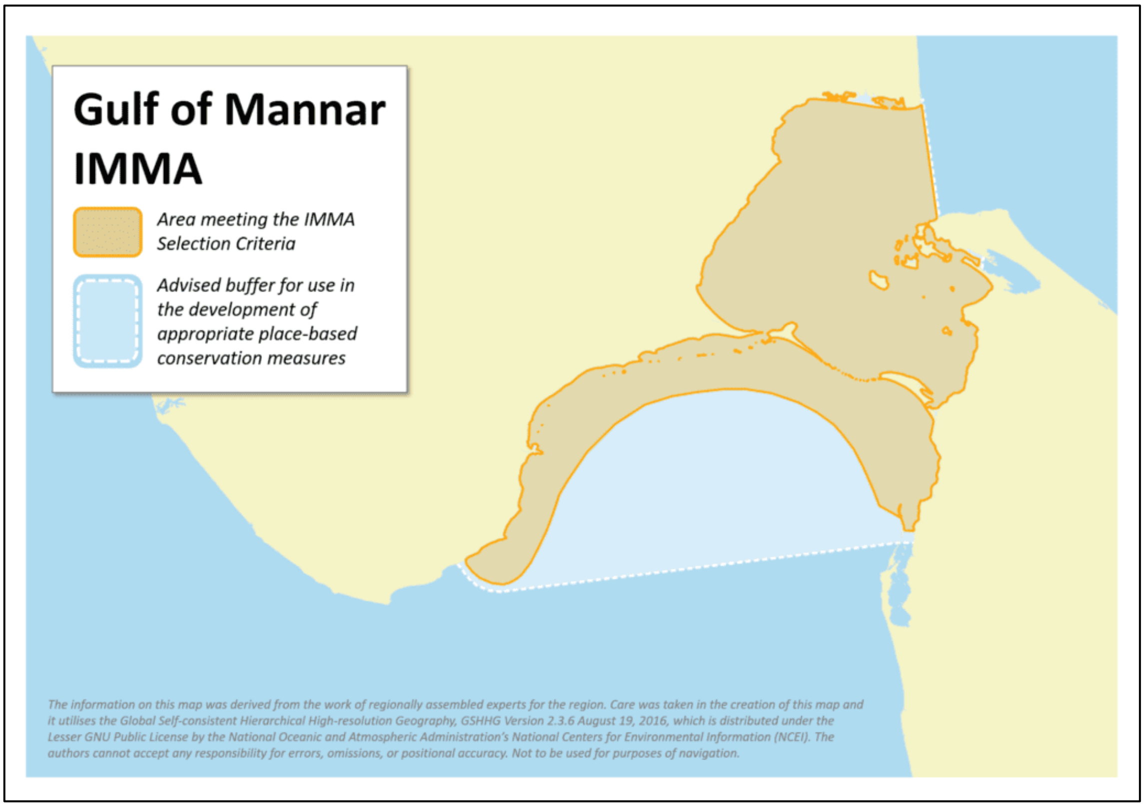
- Developing updated supplementary spatial density models to address potential conflicts with marine mammals;
- Conducting a comprehensive review of the behavioural, physiological, and population effects of impulsive sound sources on marine mammals;
- Collecting empirical data on the effects of impulsive sounds on marine mammal species from offshore construction to validate existing population consequences modelling efforts, and propose suitable mitigation measures whether coming through design or construction/operation-phase mitigation measures;

[28] [Why the Gulf of Mannar is a marine biological paradise? | Environmental Science and Pollution Research]

- Zooplankton modelling to better understand feeding patches for whales, with biological oceanography modelling providing bounds on unknowns and serving as a gap analysis for future work.

Additionally, the IUCN has proposed a buffer zone (which overlaps with the Mannar area), as indicated in Figure 37. Further study is needed to assess what this means for offshore wind development in this buffer zone.

Figure 37 IUCN's IMMA areas and advised buffer



Important ecosystems and natural habitats

Many of the LPAs, KBAs and internationally recognised areas described above include important ecosystems as part of their qualifying features. Figure 38 provides information about the distribution of coral reefs and sea grass. In the northern part of the project areas, coral reefs occur. According to Thilakarathne *et al.*, 2023[29], tropical coral reefs in Mannar are severely threatened due to the elevation of sea surface temperature by global warming and climate variability within the area. Regarding sea grass, the areas shown in Figure 38 represent the main areas that have been studied and mapped. In fact, the distribution of sea grass occurs in the wider region and could also occur within the project areas. It should be noted that the proposed project concept (in Chapter 3) is designed to avoid overlapping with coral reefs but not with seagrass due to its extensive coverage.

[29] Tropical coral reefs in Sri Lanka are threatened due to the fluctuation of seasonal and interannual sea surface temperature | Environmental Monitoring and Assessment

Figure 38 Distribution of sea grass and coral reefs (Source: [Global Distribution of Coral Reefs, Mangroves, and Sea Grass - Overview](#))

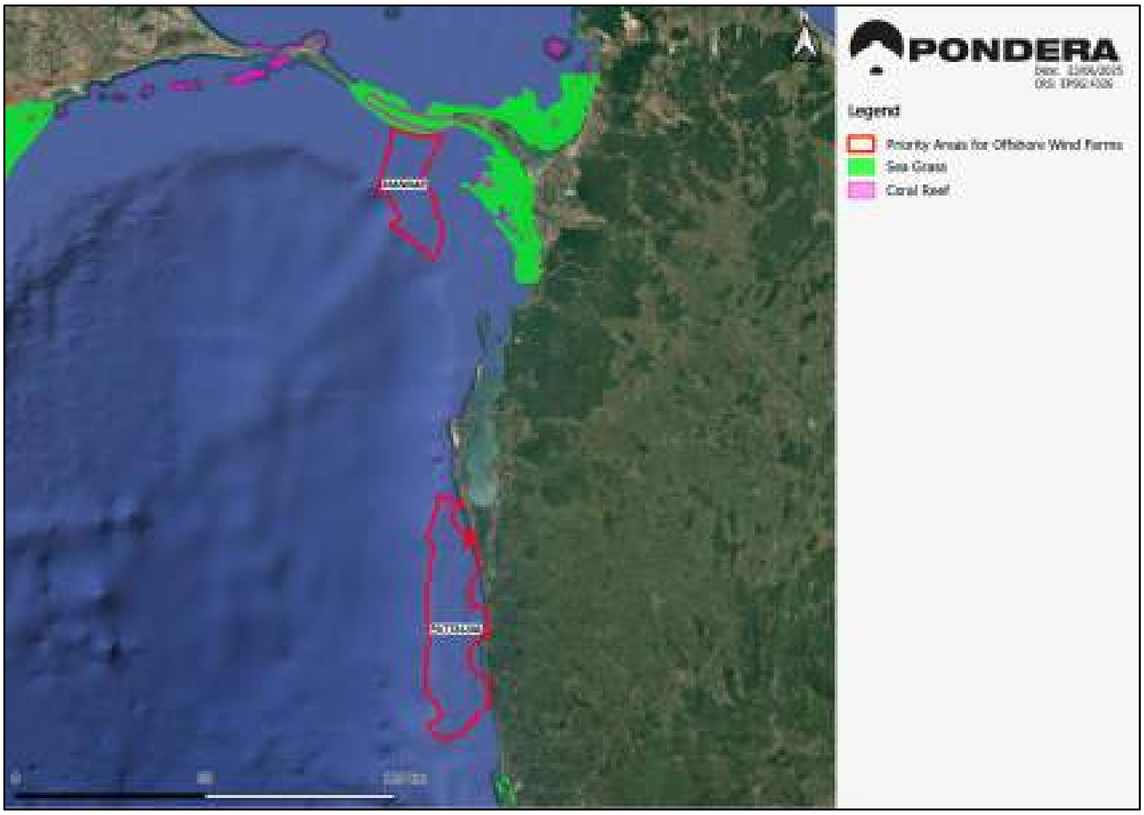


Figure 15, Figure 16 and Figure 38 show locations of coral reefs in the Mannar and Puttalam areas. It can be seen that both sources show overlap in the locations of reefs (especially those located to the east of the Mannar area, such as Bar Reef), however, there are also deviations, such as the reefs across the northern project boundaries for both areas.

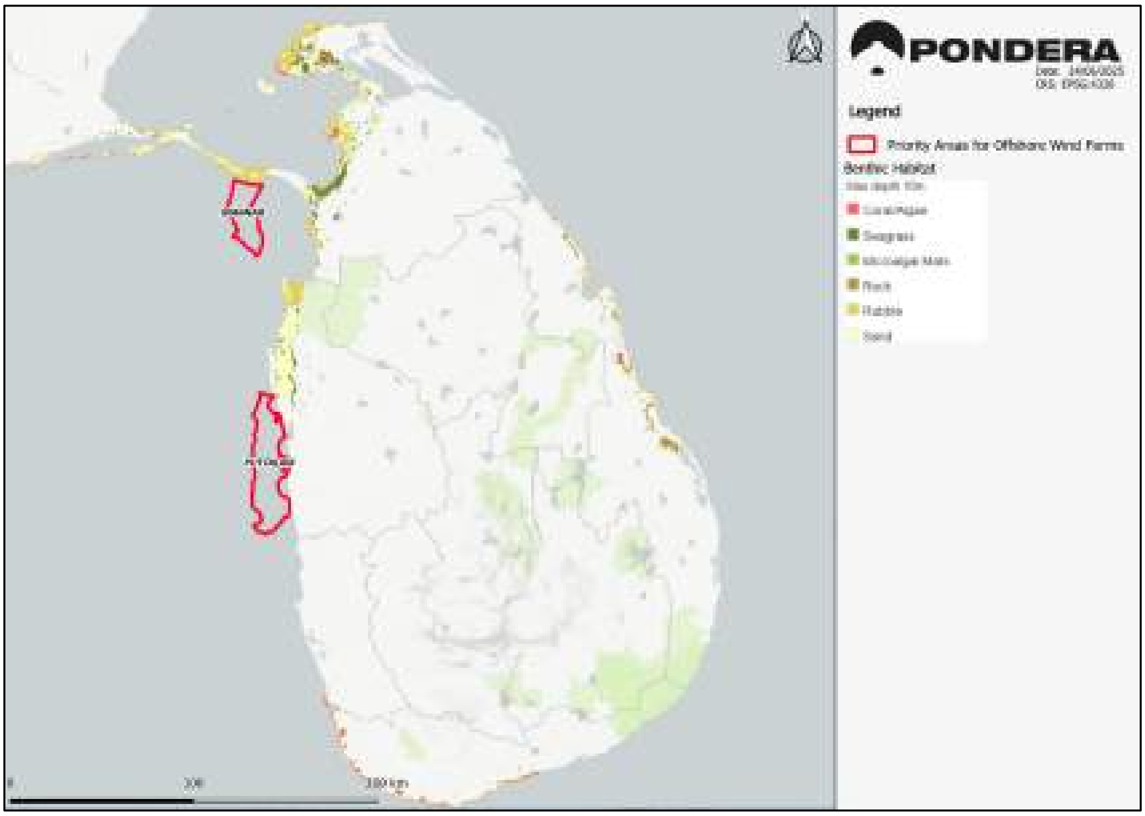
Additionally, Gulf of Mannar was one of the most abundant sources of natural pearls in the world, and the Mannar site overlap with the Aneweoloedaan pearl bed according to the research by Katupotha, 2019[30]. Although specific details about this bed are lacking, and the pearling industry is now essentially extinct, it is still crucial to acknowledge the rich pearl resources of the Indian portion of the Gulf, especially off Thoothukudi, India. Historical records show fertile pearl banks close to shore between Negombo and Muthu Halawatha (Chilaw) in the south, which are anticipated to overlap with the Puttalam site. However, this anticipation lacks supporting GIS or visual data. Consequently, while the historical presence of pearl beds is established, it is uncertain whether viable pearl populations persist or if these beds retain their former richness, although the Gulf of Mannar may still possess the right environmental conditions for pearl oyster survival. Further research is needed to determine the current status of these pearl beds.

Figure 39 illustrates the distribution of benthic habitats. Notably, the extent of seagrass and coral cover appears significantly reduced in the Allen Coral Atlas data compared to UNEP datasets. It should be noted that both datasets are based on satellite image analysis[31] [32], hence, this

[30] (PDF) PEARL FISHERY INDUSTRY IN SRI LANKA
[31] Allen Coral Atlas | Science & Methods
[32] Global Distribution of Coral Reefs, Mangroves, and Sea Grass - Overview

discrepancy may be attributed to differences in data resolution, classification methodologies, or the timing of image acquisition.

Figure 39 Benthic Habitats (Source: Allen Coral Atlas)



Avifauna

Sri Lanka supports a diverse avifauna that includes a number of elements relevant to offshore wind development, including Important Bird Areas (IBAs). This type of area can be considered as a sub-type of KBA due to the significant overlap in the designing criteria. Consequently, the locations identified as IBAs coincide with associated KBAs described in Section 2.4.3 Environmental Constraints.

According to Birdlife data zone, for Mannar site, Periyakalapuwa Mouth, and Giants Tank are identified as IBAs in these areas for Mannar. Designated IBAs within Puttalam region, based on Birdlife data zone, encompass Mundel Lake, Anaiwilundawa complex, and Periyakadawela. Avifauna are also qualifying features of the three Ramsar Sites described in Section Internationally Recognised Areas above.

Small Island III in Adam's Bridge National Park is Sri Lanka's only major seabird breeding area for many seabird species including sooty terns (*Onychoprion fuscatus*), bridled terns (*Sternula anaethetus*), Saunders's terns (Sternula saundersi), roseate terns (Sterna dougallii), common terns (*Sterna hirundo*), brown noddies (*Anous stolidus*), greater crested terns (*Thalasseus bergii*), and little terns (*Sternula albifrons*).

Bird migration in Sri Lanka includes both marine and terrestrial species, with differing characteristics. Of most relevance to offshore wind development is the major seabird migration along the west coast, with up to 400,000 birds flying southwards during daytime. During the southwest monsoon from June/July to October/November a mass migration of Bridled Terns occurs, joined by other species such as Wedge-tailed Shearwater (Puffinus pacificus), Wilson's Storm-petrel (Oceanites oceanicus), Lesser Frigatebird (Fregata ariel), Brown Skua (Catharacta antarctica), Pomarine Skua (Stercorarius pomarinus), Brown Noddy, (Anous stolidus) and Lesser Noddy (Anous tenuirostris). In the inter-monsoonal period (October/November) a large number of Wilson's Storm-petrels (Oceanites oceanicus) arrive in Sri Lanka. This species likely uses the west coast as a staging area before continuing on to breeding areas in Antarctica (De Silva 1997). During this period many winter visitors, such as the Black Tern (Chlidonias niger) also arrive along the west coast. June/July brings the only summer breeding visitor, the Roseate Tern, which nest on the west coast.

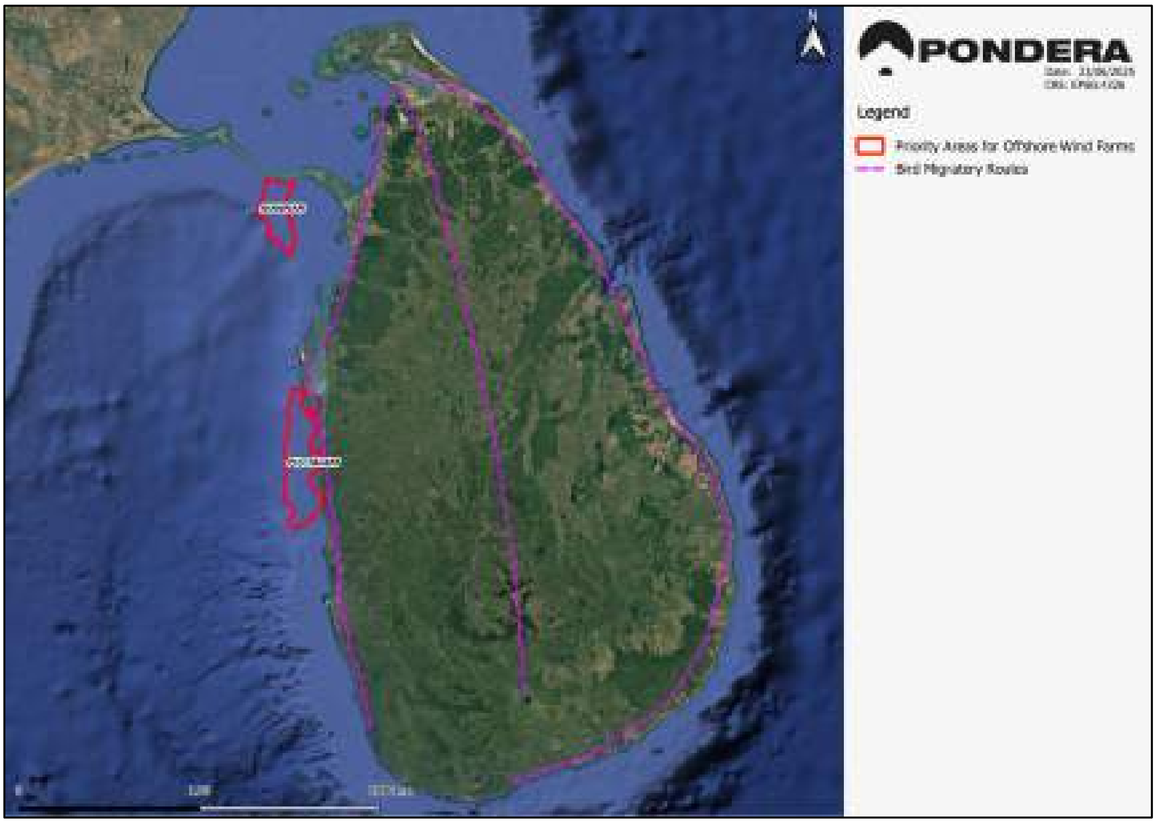
According to the Sri Lanka Aviation Force, there are three major migration routes used by terrestrial bird species[33] (see Figure 40) as follows:

- Northwestern Route: The birds on northwestern route are reaching their destination in the Central Asian Flyway. The birds enter the Island through Jaffna peninsula, and they fly over the following areas (Jaffna > Mannar > Wilpattu > Kalpitiya > Chilaw > Bellanwila > Hikkaduwa)
- Eastern Route: This is the longest migratory route in Sri Lanka. The birds of Indu-Asian fly way enter the island through Jaffna peninsula and take the following route (Jaffna Peninsula > Jaffna Lagoon > Elephant Pass > Chandikulam > Panama > Kumana > Yala > Bundala > Kalametiya > Up to Rekawa).
- Central Route: Some birds take the central route and enter the hilly area, and their final destinations are Udawalawe and Horton Plains. They are mainly forest birds and raptors (birds of prey). The Northwestern Route is adjacent to Puttalam and is expected to overlap with the proposed overhead transmission line connecting the offshore wind farm to the grid connection point (see Chapter 5 for further details).

While detailed information on terrestrial bird species migratory routes in Sri Lanka is limited, it is anticipated that birds will also traverse the Adam's Bridge to migrate from India to Sri Lanka during the migratory season. Consultation with ecologists suggests that the major terrestrial bird species migration routes are focused over Mannar Island and to the north and do not extend much south of Adam's Bridge, thus not overlapping with the Mannar project area.

[33] ENR 5.6-1-3.pdf (airport.lk)

Figure 40 Major Terrestrial Bird Species Migration Routes (source: Sri Lanka Aviation Force)



Most suitable sites within the priority areas
The Gulf of Mannar is recognised as one of the most biologically diverse coastal regions in the world, with many sensitive habitats that support species that could be impacted by offshore wind.

Multiple whale species and other marine mammals are known to occur in both sites, but due to the lack of data, no specific concentrations have been identified that could exclude certain zones or favour other areas. The prime area for marine mammal watching for tourism lies north of the project boundaries in Puttalam and south of the project boundaries in Mannar.

As a precautionary measure, this study has adopted a 5 km buffer zone to the coast and to the boundary of Adam's bridge national park. This 5 km buffer zone will be excluded from the site selection exercise. This will reduce potential impacts on coastal ecological values, including coral reefs. For instance, it is assumed that further offshore the density of bats is lower, and therefore potential impacts to this species group will be reduced as well.

The current data and knowledge gaps regarding the presence and distribution of species do not allow for the selection of areas that are more suitable than others.

Uncertainties and data gaps
Scientific knowledge about the coastal and marine environments of the Sri Lankan side of the Gulf of Mannar is limited, partly due to restricted access for research during the country's internal conflict over the past decades. The majority of ecological studies in the area originate from onshore projects and have been conducted since 2010.

In terms of LPAs, the screening process takes into account the LPAs recognized by the Sri Lanka Government based on national conservation priorities and regulations, as well as international agreements or conventions. It also has included Protected Areas included within the WDPA, noting that whilst these originate from a range of official sources, some may be outdated[34]. Nature reserves managed by the Department of Wildlife Conservation (DWC), including Strict Nature Reserves (SNR), National Parks (NP), Nature Reserves (NR), and Sanctuaries (S), are considered LPAs. However, reserves managed by the Forest Department (FD), such as Conservation Forests (CF), Reserved Forests (RF), Proposed Reserved Forests (PRF), and Other State Forests (OSF), are not classified as LPAs.

Different legal frameworks also govern the conservation of these areas, with nationally recognized LPAs regulated by the Fauna and Flora Protection Ordinance (Amendment) Act of 1993, while forest reserves operate under the Forest Conservation Ordinance (Chapter 451) of 1907. This inconsistency may lead to challenges in ensuring comprehensive conservation efforts, as certain forest reserves with valuable biodiversity may not receive the same level of protection and management as other designated PAs.

The distribution of marine habitats such as seagrass beds, coral reefs, and pearl oyster areas requires further investigation through site surveys, complemented by satellite imagery analysis (e.g., Allen Coral Atlas data).

Additionally, there is a lack of detailed knowledge on onshore and offshore avian migratory patterns and also it is not known to what extent the selected offshore wind areas serve as bird foraging areas. Data on the offshore presence of bats is even less available. There is also a lack of detailed distribution maps of marine mammals. The workshop with NGOs (see Section 7.4.1) confirmed that existing ecological data is scattered and poor quality. Therefore, further stages of offshore wind development will have to involve conducting offshore surveys focused on birds, bats, and marine life to gather more comprehensive data.

2.4.4 Social Constraints

Archaeology

General description

The impact of archaeology on offshore wind energy pertains to the potential presence of archaeological sites or artifacts within the project area. Such sites may include submerged cultural heritage, historical shipwrecks, or other archaeological remains. The development of offshore wind farms can potentially disturb or damage these sites during construction and operation activities, leading to irreversible loss of cultural heritage.

Figure 41 indicates the location of nationally recognized archaeology sites in Sri Lanka, within 10km of the project areas. No sites are screened to be within the project's sites. Within 10km distance from Project's areas, the closest archaeological sites to the Mannar area are Adam's Tomb, Thalaimannar old hospital, Thalaimannar jetty. Adjacent to the Puttalam area are Our Lady of Mount Carmel's Cathedral and St. James church. None of the screened archaeological locations are classified as Archaeology Reserves[35]. According to the National Shipwreck Database of Sri Lanka[36], no submerged cultural heritage, such as historical wrecks, are known in the vicinity of the project areas. This is also confirmed by Figure 42 which also shows the location of wrecks (different colours do not represent different types). However, Figure 16 shows the presence of a shipwreck off the coast of Mundal lake (Puttalam). This shipwreck is located within the 5 km buffer zone from the coast and is not expected to influence offshore wind development

[34] https://www.protectedplanet.net/country/LKA

[35] Archaeology reserves are designated areas holding significant archaeological sites, artifacts, or remains of historical or cultural value. They're set up to safeguard this heritage, promote research, education, and public appreciation.

[36] https://www.archaeology.lk/sri-lanka-dive-sites-historical-shipwreck-sites/

in the priority area. Additionally, no notable archaeological sites or artefacts have been reported to be present in the priority areas during the site visits and stakeholder engagement activities.

Figure 41 Nationally recognized archaeological sites within 10 km of priority areas

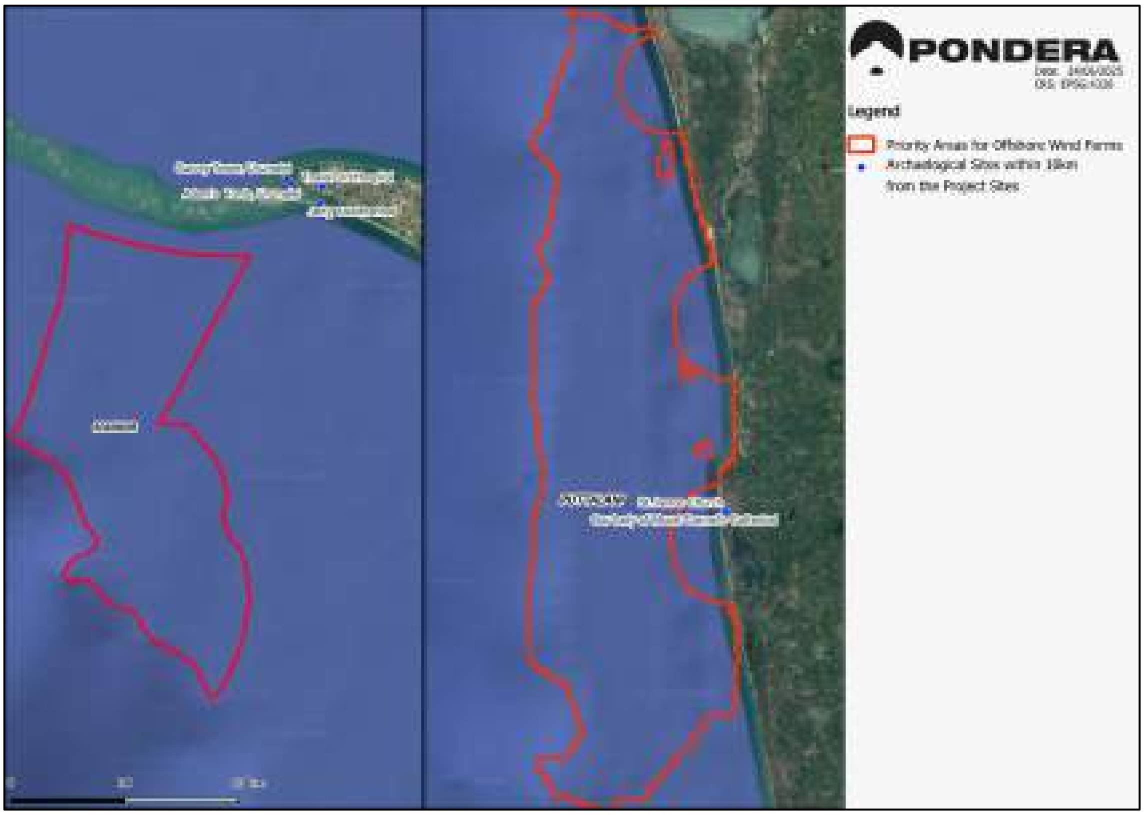
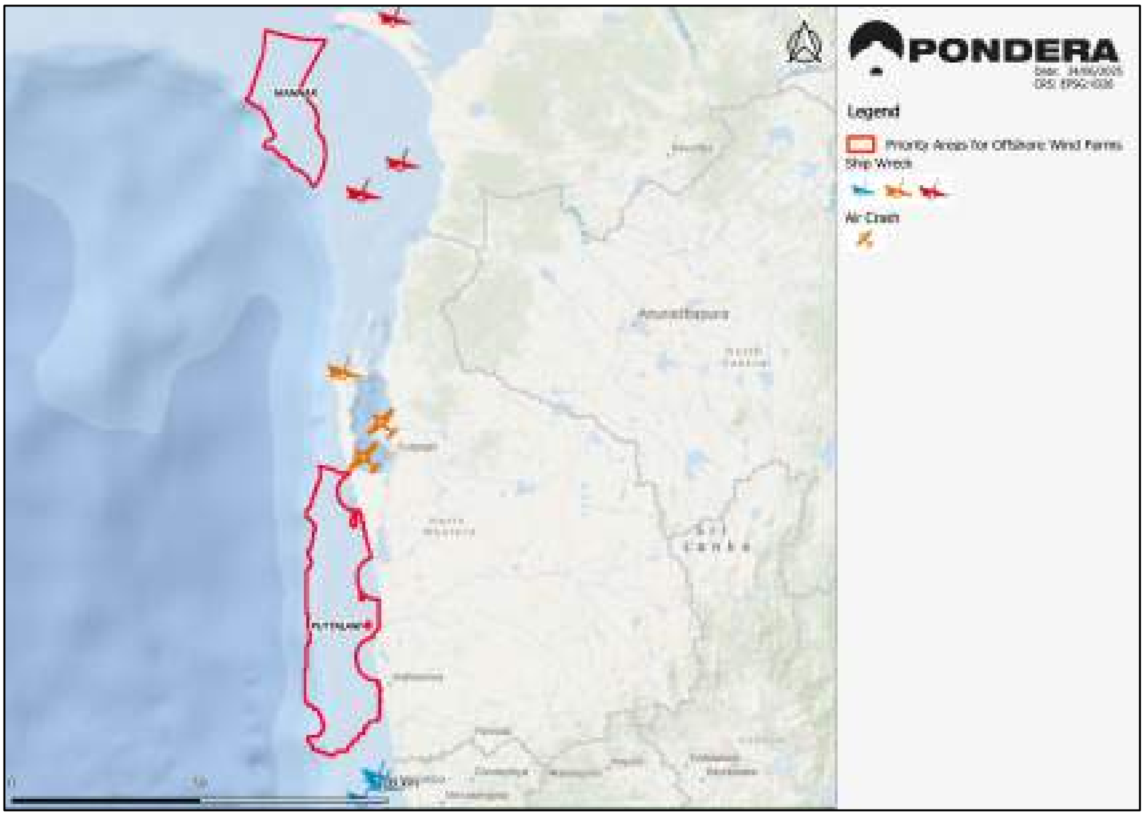


Figure 42 Location of wrecks (source: National Shipwreck Database of Sri Lanka)



Most suitable sites within the priority areas
Aside from the wreck located within the 5 km buffer zone to the coast to mitigate potential impacts on environmental and social aspects, no other archaeological sites or artifacts are known to be in the vicinity of the project areas. Therefore, this is not considered a constraint or influencing factor for the site selection process.

Uncertainties and data gaps
As the data is verified by local experts and site visits, no major uncertainties and data gaps are expected for the onshore part. However, the offshore project areas could contain archaeological artefacts that have not been discovered and mapped. As a post-study activity, on-site archaeological surveys should be carried out.

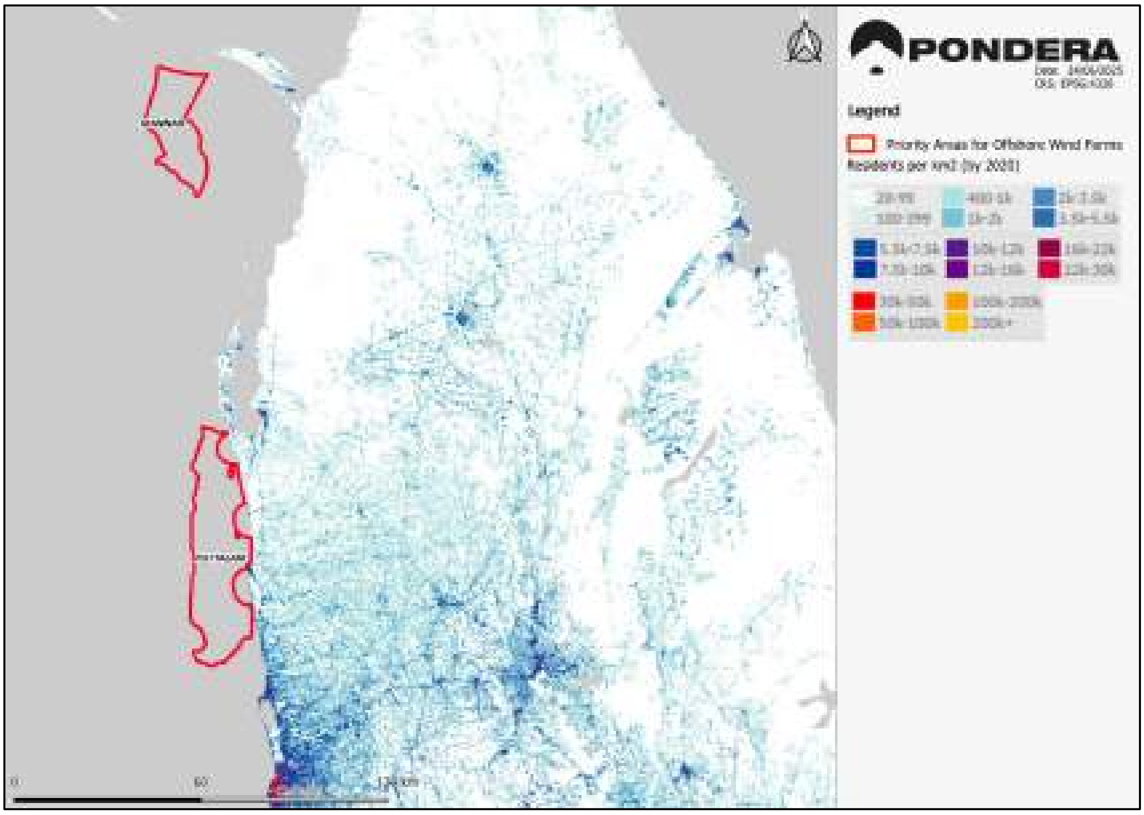
Coastal residents

General description
Offshore wind farms can affect coastal residents in both positive and negative ways. Positive impacts could be job creation, economic benefits, and infrastructure development. Negative impacts could involve concerns about visual, airborne noise during construction and operation phase, and potential safety issues related to required onshore (grid) infrastructure.

Figure 43 indicates the Sri Lankan population density in 2020 from Luminocity. In Puttalam, the coastline adjacent to the site is generally not densely populated, though there are scattered areas with dense populations ranging from 1,000 to 7,500 people per square km.

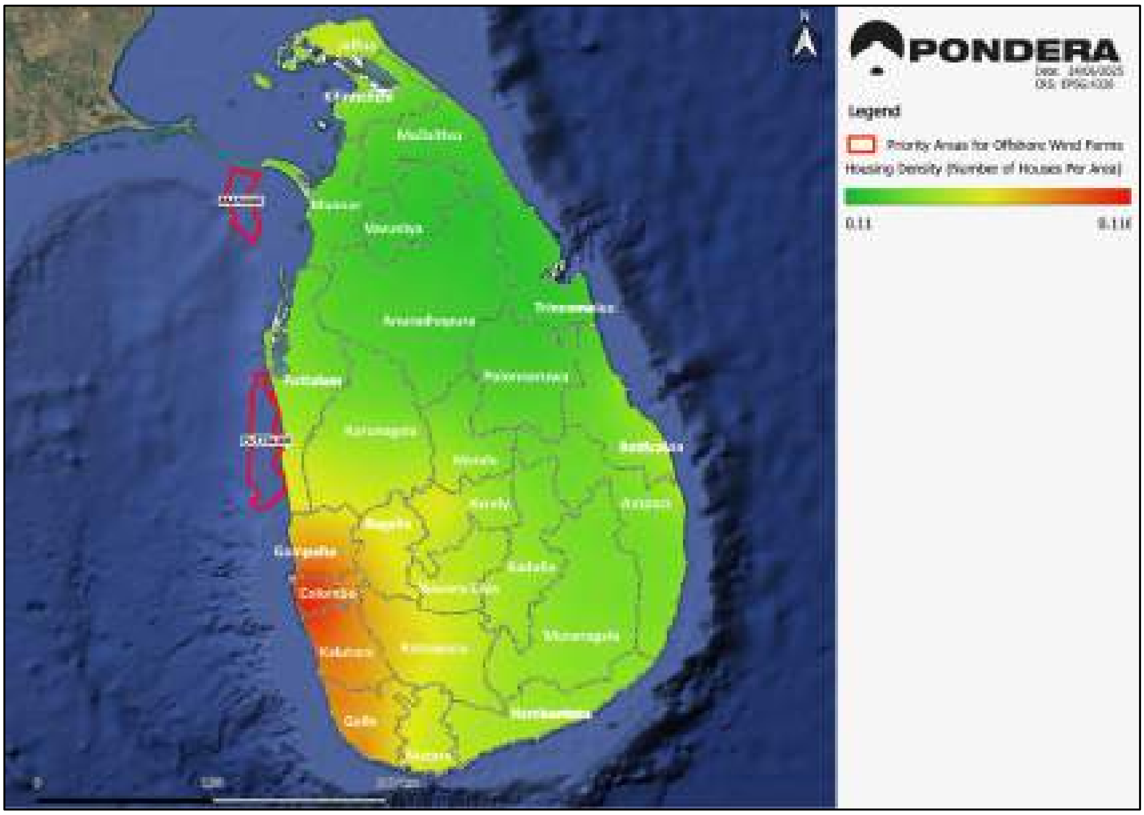
The Mannar district, which contains several natural areas, is even less densely populated. Only a small fraction of the district has dense populations ranging from 3,000 to 10,000 people per square kilometre, while the majority of the district has a population density ranging from 20 to 99 people per square kilometre. To compare, the average population density in 2021 for Sri Lanka was around 331 people per square km.

Figure 43 Housing density (source: Luminocity)



Additionally, Figure 44 shows the density of housing structures in Sri Lanka. It can be seen that the coastal areas of Puttalam and Mannar are much less populated than the southwestern part of the country south from Negombo to Galle.

Figure 44 Housing density (source: National GIS Portal)



Most suitable sites within the priority areas

Generally, it could be argued that the risk of opposition to offshore wind is lower in areas with a lower population and housing density (as is the case with the project areas in Puttalam and Mannar compared to the southwestern part of the country, see Figure 43 and Figure 44). However, even in sparsely populated areas there can be opposition. There are several measures which can help balance the interests of both the offshore wind project and the local community, such as community engagement, offering benefits, and addressing concerns. The 5 km buffer zone used along the coast to reduce potential impacts on environmental and social aspects will mitigate potential negative effects on coastal residents as well, although wind turbines placed more than 5 km away from the coast will be visible. Potential visual effects will decrease the further the wind turbines are placed offshore.

Uncertainties and data gaps

Luminocity data dates from 2020, hence, it is expected that it cannot fully capture the current population density of Sri Lanka. However, the data is verified using housing density data from Sri Lanka GIS data portal, and both datasets witness the same trend. General trends about population densities have also been confirmed during site visits.

Culturally sensitive areas

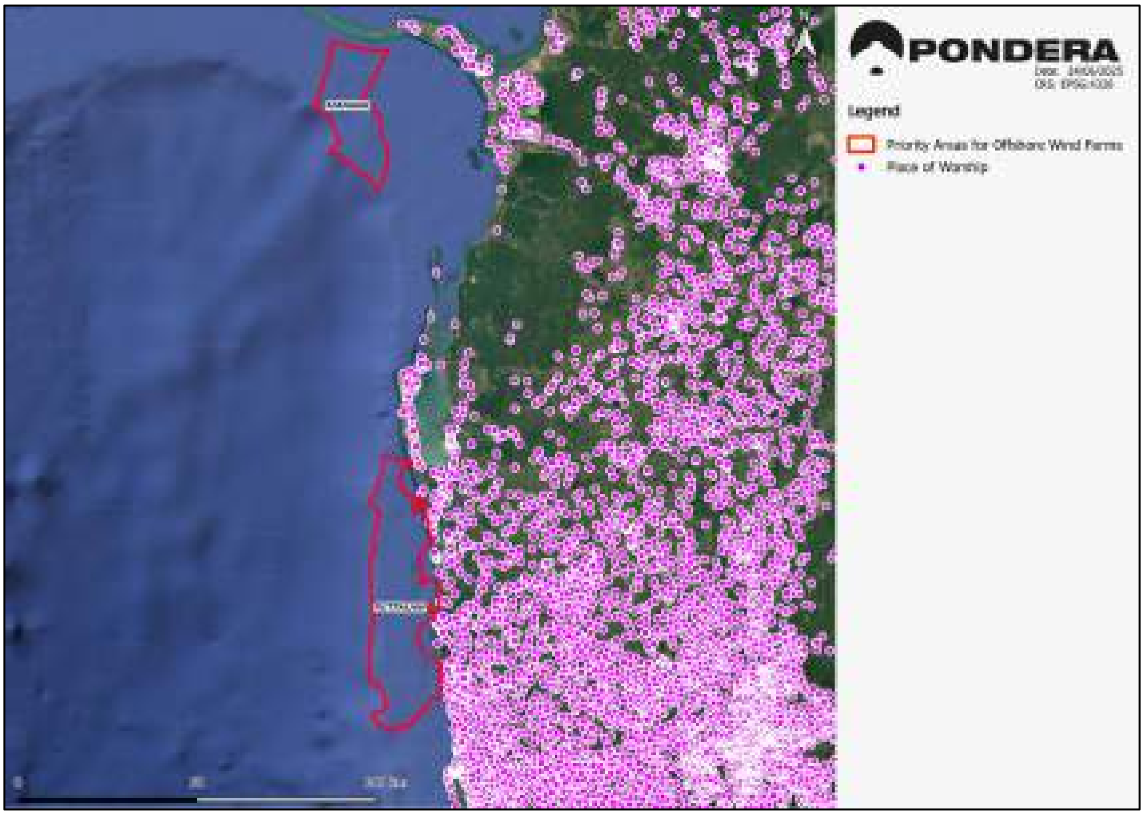
General description

Offshore wind can have significant impacts on culturally sensitive areas. These impacts may include visual, noise, and disturbance to cultural heritage sites. The presence of offshore wind may alter the landscape and seascape of areas, potentially affecting cultural significance and value to local communities. Examples of culturally sensitive areas are places of worship, indigenous communities, cultural landscapes, historical sites (assessed in Section Archaeology), fishing grounds (assessed in Section Fishing and aquaculture) and tourism hotspots (assessed in Section Leisure and tourism).

Figure 45 provides insight into the distribution of places of worship. It can be seen that Sri Lanka boasts an extensive array of places of worship along the coastline, whereas the density is higher along the coast of the Puttalam area compared to Mannar. There are no major concentrations of indigenous communities identified close to the project areas.

Additionally, no other culturally sensitive areas have been reported to be present within or near the priority areas during the site visits and stakeholder engagement activities.

Figure 45 Places of worship (source: National GIS Portal)



Most suitable sites within the priority areas
The establishment of offshore wind farms near culturally sensitive areas can potentially disturb or alter the seascape of these locations. There are several measures which can help balance the interests of both the offshore wind project and culturally sensitive areas, such as community engagement, offering benefits, and addressing concerns. The 5 km buffer zone used along the coast to reduce potential impacts on environmental and social aspects will mitigate potential negative effects on onshore culturally sensitive areas as well, although wind turbines placed more than 5 km away from the coast will be visible. Potential visual effects will decrease the further the wind turbines are placed offshore.

Uncertainties and data gaps
The data is acquired via National GIS Portal and verified using satellite images. Hence, no major data gaps are expected.

Fishing and aquaculture

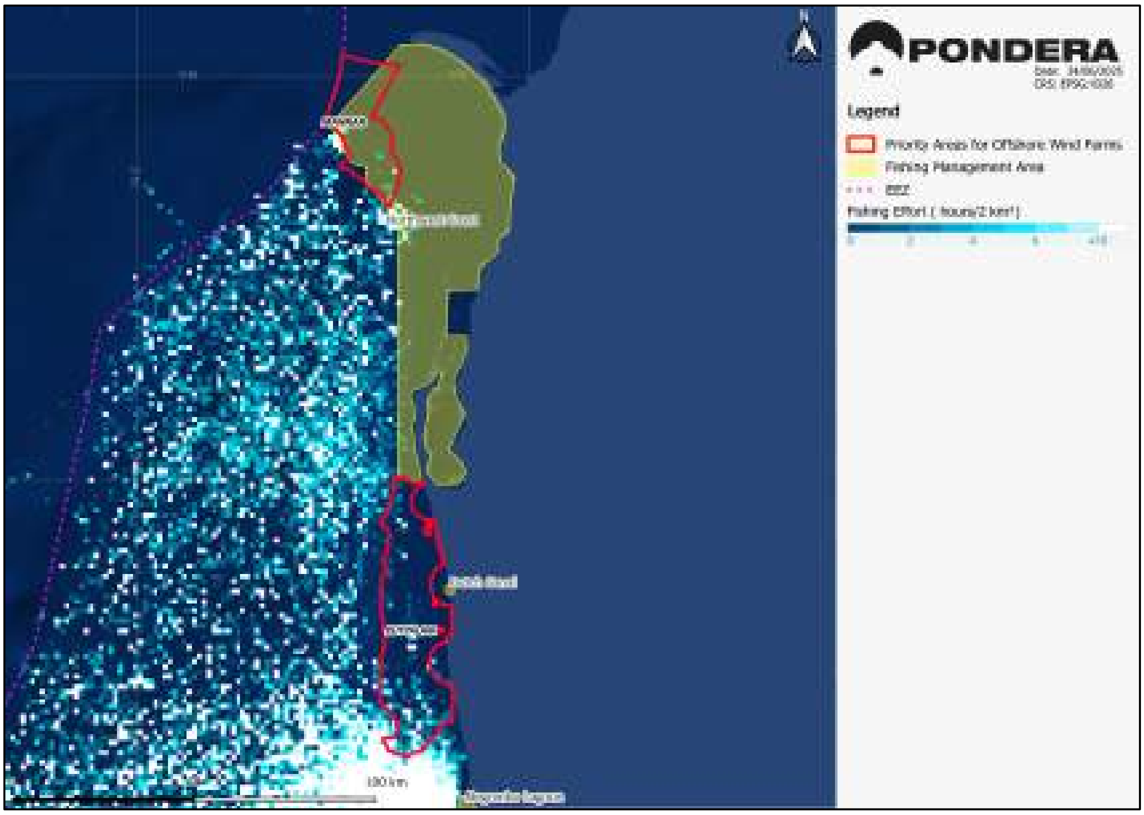
General description

Offshore wind could create conflicts with existing fishing operations, stemming from factors such as spatial competition, gear interference, safety concerns, and economic impacts. Therefore, it is essential to consider these factors during the planning and implementation of offshore wind farm projects to mitigate potential concerns of fishing communities.

Figure 46 indicates Fishing Management Areas (FMAs) adapted from the Sri Lanka Biodiversity action plan and fishing efforts from Global Fish Watch data. One of the criteria for the area to be FMAs is its contribution of the local economy. A significant portion of Mannar falls within the FMA.

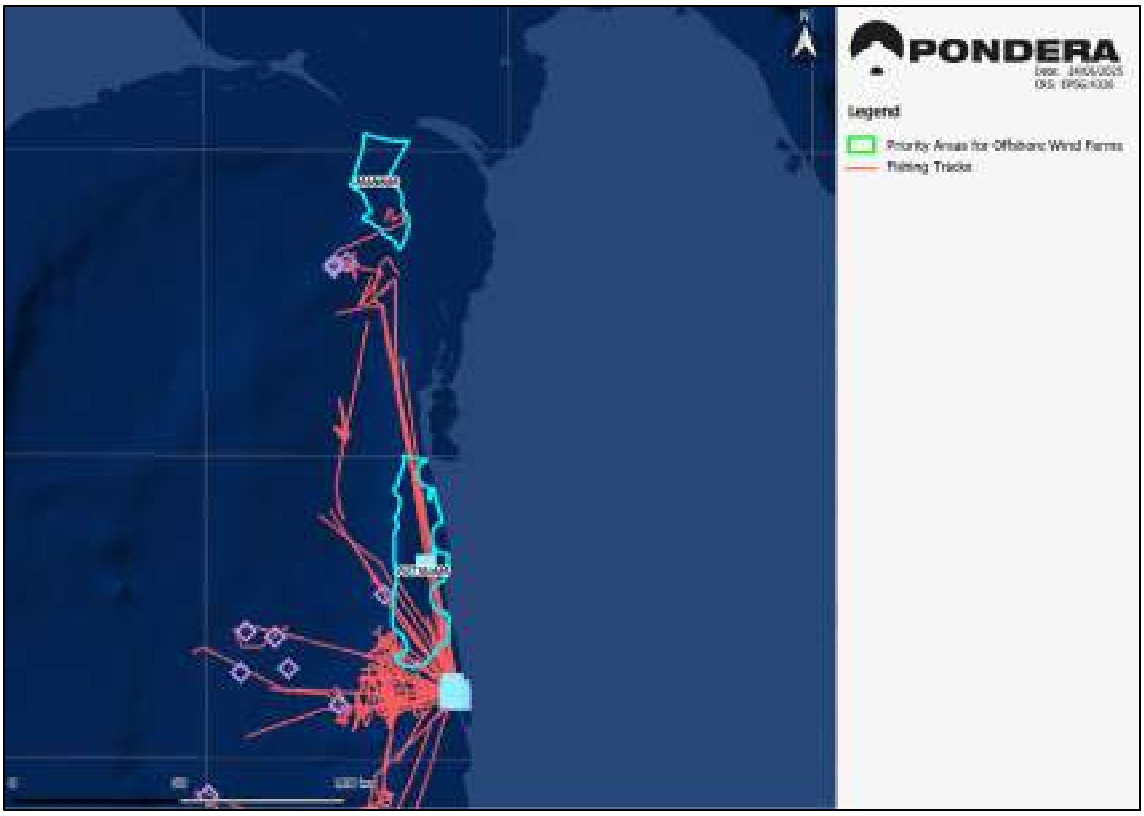
Hence, consultation with the (local) government is proposed to mitigate the impact on the local community. The FMA is also designated for marine conservation, so potential impacts and mitigation measures should be considered in line with conservation objectives.

Figure 46 Official fishing locations (source: Sri Lanka Biodiversity action plan and Global Fish Watch data)



Additionally, Figure 47 shows the fishing tracks according to the Global Fish Watch, indicating fishing activities within and between the two project areas.

Figure 47 Fishing Tracks (Source: Global Fish Watch)



Various data from Global Fish Watch and site visits confirm that the entire coastal area where the projects are located is utilized by local fishers (as illustrated in Figure 48), with fishing activities likely occurring throughout the entire project area. Consultation during site visits and stakeholder engagement learned that fishing in this region is all year round, although many fishermen migrate to other areas (mostly the eastern coast of Sri Lanka) during parts of the monsoon season when weather and sea conditions can be rougher. Some argued that local boats don't fish outside the 10 nm zone, but this was refuted by others. However, the density of local fishing seems to be higher near to the coast.

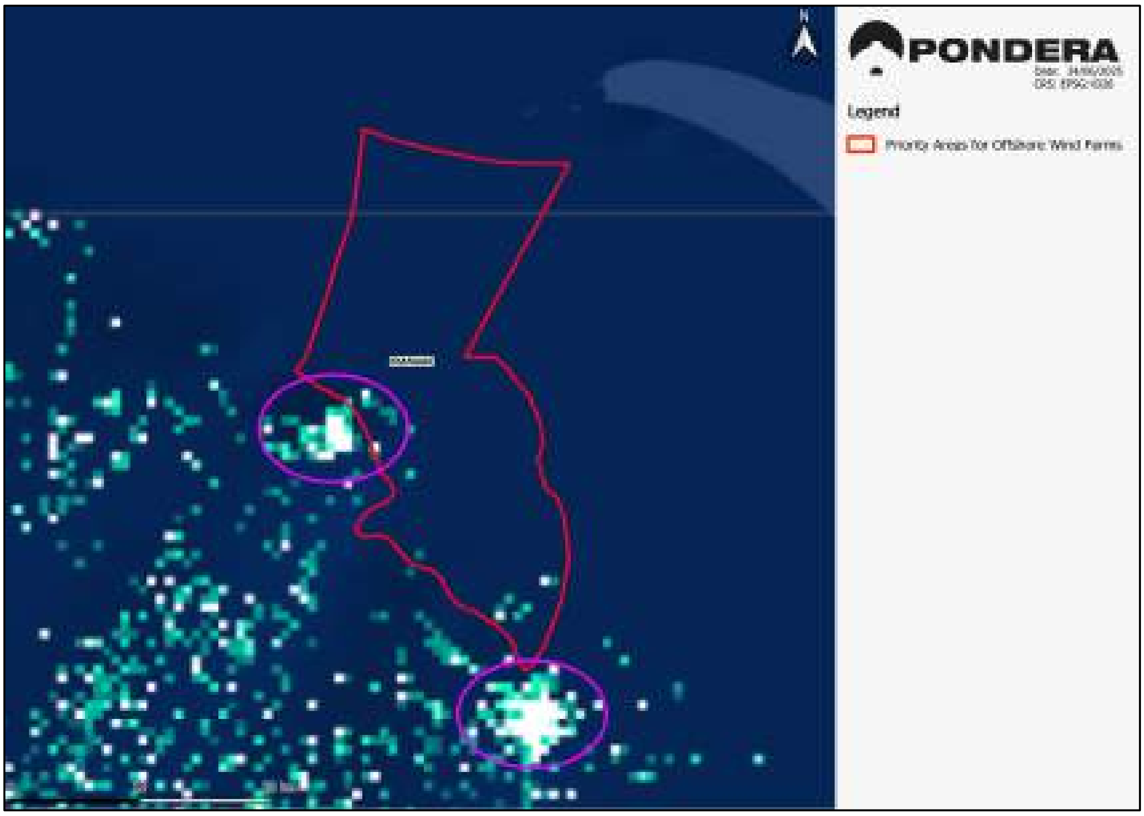
Figure 48 Evidence of coastal fishing activities, left = Mannar, right = Puttalam (photos taken by the project team)

As can be seen in Figure 46, a small fraction of the two project areas has been identified as fishing hotspots (more than 10 hours per km^2), indicating concentrated fishing activity in these specific areas. These fishing hotspots will be described for both Mannar and Puttalam in more detail below, as well as more general information about fishing in these areas. It is worth mentioning that these fishing hotspots do not reflect local fishing by boats without tracking devices.

Mannar

The fishing hotspots in Mannar (circled in Figure 49) are probably characterised by seabed ridges, where the water depth transitions from 40 metres to several hundred meters. This bathymetric feature disrupts ocean currents, leading to nutrient-rich upwellings that support phytoplankton growth. The resulting abundance of phytoplankton attracts small fish and zooplankton, which in turn draw larger predatory fish and marine mammals, creating fish hotspots. These depths also accommodate medium to large fishing vessels.

Figure 49 Fishing Hot Spots (indicated by purple circle) in Mannar (Source: Global Fish Watch)



In Mannar, fishing is a major contributor to the economy, with 38% of its population involved in fishing. As of 2010, 28,852 people in the Mannar District, belonging to 7,813 families, are dependent on the marine fishery sector. Of these, 7,547 are listed as active fishers[37]. According to a report by Mohamad Kasim[38], the average fish-catching rate is 100 kg per hour. In 2018, the Mannar District produced 23,250 metric tons of fisheries products[39] .

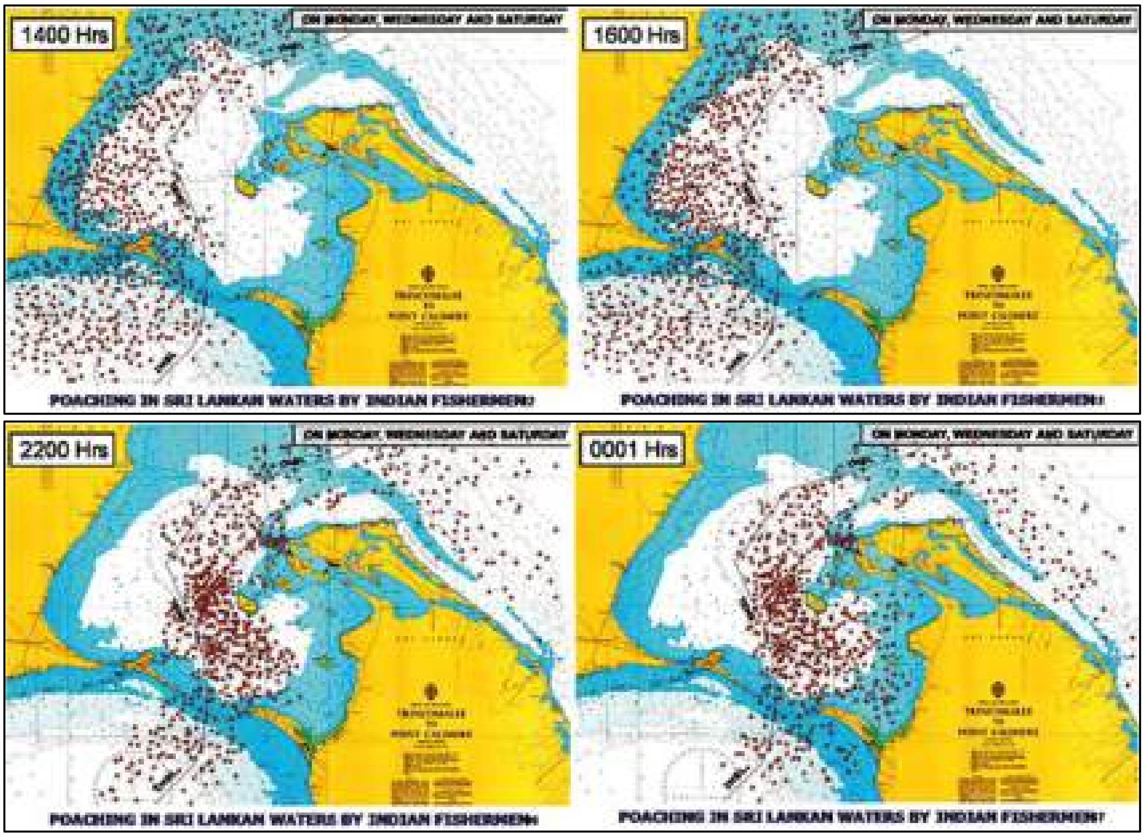
Furthermore, according to data from NARA, as of 2018, Mannar district boasted a total of 4,563 fishing boats, reflecting the varied fishing practices. This diverse fleet includes 41 Inboard Multi-day Boats (IMUL), 208 Inboard Day Boats (IDAY), 3,079 Outboard Fiber Reinforced Plastic Boats (OFRP), 506 Mechanized Trawlers Boats (MTRB), 717 Non-motorized Traditional Boats (NTRB), and 12 Non-motorized Beach Seine Boats (NBSB).

In Mannar, diverse and traditional fishing methods are employed, including the use of Kattamaran boats made from wooden logs and requiring 3 to 5 fishers. Trawl nets with a mesh size of 15 to 20 mm are operated at depths of 10 to 25 meters. Various gill nets, such as bottom set and drift gill nets, range in length from 100 to 200 meters with mesh sizes from 11 to 39 cm. Additionally, hooks and lines, as well as traps made from acacia branches or bamboo, are commonly used. Shore seines like Olavalai and Karavalai are significant in the region, targeting a wide array of marine species. Illegal fishing practices such as dynamite fishing or the use of dangerous or harmful substances are reported within the area[40].

[37] (PDF) Illegal Fishing Activity – A New Threat in Mannar Island Coastal Area (Sri Lanka)
[38] (PDF) The distribution of ecological harm and fisheries potential in Palk Bay
[39] Fisheries Industry Outlook 2018
[40] (PDF) Illegal Fishing Activity – A New Threat in Mannar Island Coastal Area (Sri Lanka)

Local experts have confirmed the presence of illegal fishing activities by foreign fishermen in the Mannar area, deploying bottom trawl fishing gear. Figure 50 illustrates the encroachment in Sri Lankan waters by a significant number of foreign trawlers, indicated by red dots, at various times of the day[41].

Figure 50 Maps of illegal fishing activity in Sri Lankan marine waters (red dots represent foreign fishing boats)[42]



The heavily relied-upon fishing community and illegal fishing by foreign fishermen in the Mannar site are likely due to the highly productive natural conditions of the Gulf of Mannar, which spans 10,500 km². This area is rich in seagrass beds, sand dunes, sandy shores, coastal lagoons, estuaries, mangroves, and coral reefs. These habitats provide excellent breeding grounds for fish and marine fauna, enhancing overall fish productivity. Particularly, the dense seagrass beds and fringing coral reefs serve as essential nurseries for juvenile fish.

Puttalam

For the Puttalam site, a fishing hotspot has developed due to fishing activity in the offshore area of the Negombo district, situated to the south of the site (as shown in Figure 46). This fishing hotspot is likely formed by the ridge morphology of the seabed and the nutrient-rich adjacent inshore area, Negombo Lagoon, which is considered one of the most productive brackish water bodies in Sri Lanka. The lagoon's narrow opening to the sea, the distribution pattern of mangrove vegetation, sea grasses, and varying salinity levels have created a patchwork of diversified

[41] Unregulated and illegal fishing by foreign fishing boats in Sri Lankan waters with special reference to bottom trawling in northern Sri Lanka: A critical analysis of the Sri Lankan legislation - ScienceDirect

[42] Source: Satellite photos catch Indian fishermen in Lankan waters (sundaytimes.lk)

niches, leading to high species diversity. A total of 82 species of fish belonging to 41 families have been recorded.

Negombo's economy relies heavily on fishing, serving as the primary source of livelihood for many residents. In 2018, Negombo reported 30,370 metric tons of fish landings from lagoon and coastal fishing, maintaining its position as a leading contributor to the country's fisheries sector (NARA as of 2018). The district encompasses 143 fishing villages, with 8,065 coastal and lagoon fishing households supporting a total population of 33,116. These households are intricately linked to the region's coastal and lagoon fisheries, highlighting the critical role of fishing in the local economy and community.

The fishing fleet in Negombo comprises a diverse array of vessels, totalling 4,016 boats in 2018 (NARA). This fleet includes various types of boats similar to those mentioned for Mannar. These boats cater to different fishing needs and reflect the versatility required to navigate Negombo's varied marine environments.

Within Negombo Lagoon, a multitude of fishing methods are employed to target various species. Trammel nets are commonly used, especially for shrimp fishing, with mesh sizes tailored to catch specific sizes of shrimp. Other methods include stake nets, cast nets, small-mesh gillnets, brush pile fishing, lagoon seines, bottom-set gillnets for crabs, cross nets for shrimp, and drive-in nets for small shrimp. Coastal fishing in Negombo utilizes a range of gear types, including small mesh gillnets, trammel nets, large mesh gillnets, and bottom set gillnets, each tailored to target specific species and optimize catch efficiency.

To conclude, given the significance of these marine ecosystems and the reliance of local communities on fishing activities, extensive stakeholder engagement is imperative during the execution of offshore wind projects to minimize potential controversy.

Most suitable sites within the areas

Although fishing activities occur throughout both project areas, local stakeholder engagement has confirmed that fishing density, particularly that of local fishing boats, is higher closer to the coast. Therefore, this study assumes a 5 km buffer zone from the coast to mitigate potential impacts on coastal fishing. This 5 km buffer zone will be excluded from the site selection process. During the site selection exercise, the location of key fishing hotspots in the southern part of the priority areas will be considered. In general, fishing is an important factor that should be addressed in subsequent stages of project planning.

Uncertainties and data gaps

The Global Fish Watch dataset may have certain limitations or data gaps that could affect its reliability and completeness, and local fishing is often not represented as boats do not use tracking devices. Hence, it is important to rely on a broad range of data sources, including local consultation, government data and NGO’s intelligence to assess the fishing activities in the priority areas.

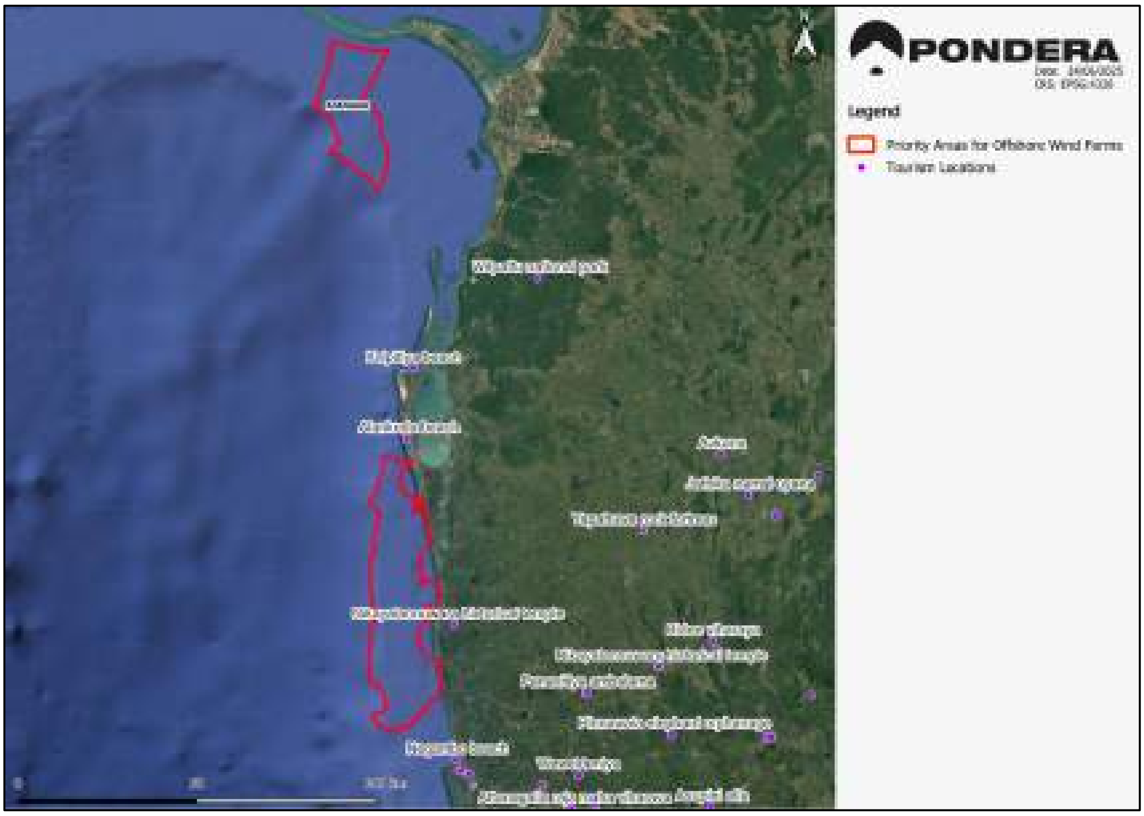
Leisure and tourism

General description

Offshore wind can provide recreational opportunities for leisure and tourism activities like sightseeing and photography. However, their installation may alter the visual aesthetics of coastal regions. This change in landscape and seascape could impact the appeal of coastal areas for visitors who appreciate open sea views. The coastal areas of Puttalam and Mannar are not considered to be Sri Lanka’s major tourism destinations. Key tourist spots which draw the highest visitors are located elsewhere on the island. Nevertheless, there is tourism activity, and almost the entire coastal strip offers tourist accommodation.

Figure 51 indicates nationally recognized tourism locations. The nearest major tourism location is Alankuda beach, located approximately 6km north of the Puttalam site. Further to the north of the Puttalam area lies Kalpitiya beach, which is a popular kite surfing spot. Other popular tourism activities are marine mammal watching (carried out by the project team, see previous section about marine mammals), fishing, snorkelling and scuba diving. These are mostly centred north of Puttalam around the Kalpitiya area. Additionally, no other major tourism attractions have been reported to be present near the project areas during the site visits and stakeholder engagement activities.

Figure 51 Major tourism locations (source: Sri Lanka GIS Portal)



Most suitable sites within the priority areas

The 5 km buffer zone used along the coast to reduce potential impacts on environmental and social aspects will also support reducing potential impacts on tourism. However, even at a distance of 5 km from the coast, wind turbines will be visible from land. Potential visual effects will decrease the further the wind turbines are placed offshore. Potential impacts should be considered in the planning stage.

Uncertainties and data gaps
Risk of uncertainties and data gaps related to leisure and tourism is considered to be low, as information is verified during site trips and local consultations.

2.5 Tentative available areas for offshore wind

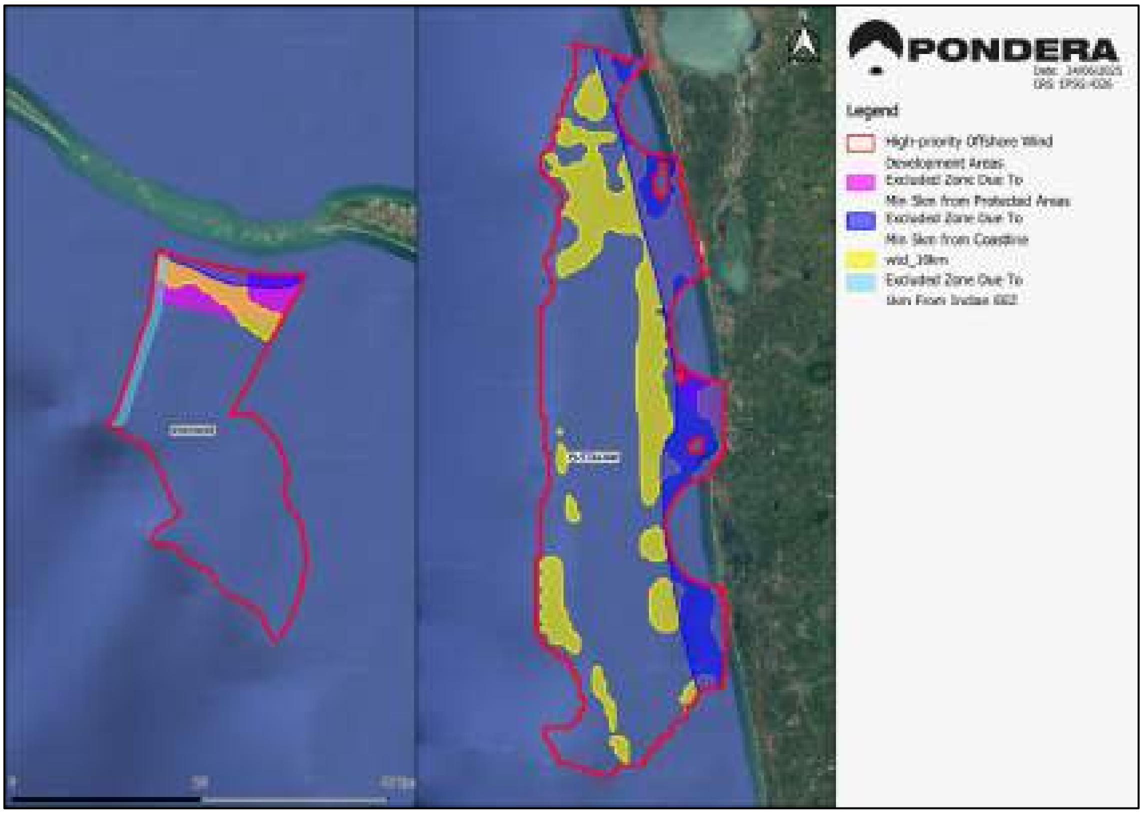
This section summarizes the main findings from the site assessment in terms of suggested exclusion zones and tentative available areas offshore wind within the project areas.

The following exclusion zones have been proposed:
- Water depths shallower than 10 meters and deeper than 50 meters to enable cost-effective foundation structures and installation methods;
- A 5-kilometer safety / precautionary buffer zone from Adam's Bridge National Park is proposed to minimize potential negative effects on ecological values;
- A 5-kilometer distance from the coastline is proposed to minimize potential negative effects on ecological values, coastal activities, and people;
- A 1-kilometer distance from the marine border (EEZ) with India is proposed to avoid any potential border issues.

It is worth emphasizing that although these exclusion zones are proposed, no direct showstoppers have been identified within the project areas at this stage that would constitute a direct exclusion and prevent offshore wind development.

The suggested exclusion zones and tentative available areas for offshore wind are indicated in Figure 52. Based on current study findings, it can be seen that relatively large areas are potentially available for offshore wind, areas that in theory could accommodate multi-GW projects in both areas.

Figure 52 Suggested exclusion zones and tentative available areas for offshore wind within the project areas



The information in this chapter, such as the tentative available areas for offshore wind, will be used as inputs to the project concepts considered in Chapter 3.

2.6 Qualitative assessment of risks and mitigation strategies

Based on the site assessment in this chapter and the evaluation criteria as presented Table 6, Table 12 provides a summary of the risk levels of various constraint items within the project areas. The risk is related to potential barriers (influencing overall feasibility and site selection) for offshore wind development and is an updated version of the general influence of these factors on offshore wind as previously described in Table 8. It is worth mentioning that the two project areas in Mannar and Puttalam are the outcome of the initial scouting exercise in the Roadmap, which utilized exclusion and restriction zones, already reducing potential risks to some extent. For each constraint, potential mitigation strategies are presented. As a general mitigation strategy extensive stakeholder engagement with involved parties is needed during project development. Moreover, all constraint items will be assessed in detail during subsequent project development activities, including the FS and ESIA. This should also include the constraint and impact assessment for onshore infrastructure required for the offshore wind farm, which is currently not included.

Table 12 Risk level of various constraint items in relation to offshore wind in the project areas (* *Based on current study findings)*

Constraint item	Risk Level*	Explanation	Mitigation strategies
Wind resources	Medium / High	Local wind conditions seem viable for offshore wind development in both areas, although for Puttalam the suitable area seems restricted to the northern part. The risk level for Mannar is considered medium (due to more homogeneous wind speeds) and high for Puttalam (due to the strong gradient). This gradient introduces uncertainty and emphasizes the importance of siting the wind farm in the windiest area.	To reduce uncertainties in the wind climate and estimated gradient (in Puttalam), local measurements and further analyses are required. These measurements should include on-site data collection, which can be conducted using various instruments, such as floating LiDAR, met masts, and scanning LiDAR. This is the main focus of a parallel study being conducted by the WB. The recommended option in this parallel study, at the time of writing this report, is to use dual scanning LiDAR technology, which provides highly accurate wind speed data with an expected accuracy level similar to traditional met mast approaches as well as greater prediction of turbulence intensity.
Water depths	Medium/ High	Overall, the water depths in most of the project areas appear viable for offshore wind development. However, there is some uncertainty regarding these depths, as this study has primarily relied on model data. Due to these uncertainties, the risk level for Mannar is classified as medium. Additionally, in the northern part of Puttalam (which also seems to be the windiest area), the water depths are relatively shallow, and even a difference of a few meters could determine a go or no-go decision for wind turbine positioning, as installation vessels require a minimum depth for deployment. Furthermore, water depths in this area appear to be subject to significant	A mitigation strategy for addressing water depth challenges in offshore wind projects involves conducting comprehensive bathymetric surveys to map the seabed, identify depth variations and reduce uncertainties. These surveys help in understanding the seabed topography and in selecting suitable locations for offshore wind development. As water depth is an important factor for offshore wind, it is one of the focus areas of follow-up activities under Phase 3 TA.

Constraint item	Risk Level*	Explanation	Mitigation strategies
		fluctuations due to shifting sandbanks. The risk level for Puttalam is therefore considered high.	
Seabed characteristics	Medium	Based on current knowledge, no significant seabed structures are present that could pose a significant threat to the design and construction of offshore wind structures. However, the available data on this subject is limited, particularly regarding spatial variation. Good insight into seabed characteristics is also important because these determine the design of the foundations and thus determine a significant part of the costs of offshore wind.	Mitigation strategies for reducing the uncertainty and risk level of seabed characteristics include geotechnical and geophysical surveys. These surveys help identify suitable locations by assessing soil properties, sediment types, and potential hazards. As seabed characteristics are an important factor for offshore wind, this is one of the focus areas of follow-up activities under Phase 3 TA.
Ecology – areas	High	The northern boundary of the Mannar project area has been altered during this study to prevent overlap with Adam’s Bridge National Park. However, some of the ecological features of the Protected Area (e.g. foraging birds) may extend more than 5 km from the boundary of the Protected Area. The entire Mannar project area lies within EBSA and IMMA boundaries, while the northern boundary of the Puttalam area is adjacent to EBSA. These areas are recognized as containing important ecosystems and high diversity of species.	To reduce uncertainties related to ecological areas, conducting thorough ESIAs to Good International Industry Practice (GIIP) is essential for identifying potential impacts on local ecosystems. Employing high-resolution habitat mapping can provide valuable data on habitat conditions, including pearl beds, seagrass and coral reefs. Based on findings, an assessment can determine whether the overlap with EBSAs and IMMA is acceptable.

Constraint item	Risk Level*	Explanation	Mitigation strategies
		Furthermore, coral reefs and seagrass areas overlap with the project areas. It is worth noting that the coverage of these habitats in models might not be comprehensive. The proposed project concept (in Chapter 3) is designed to avoid overlapping with (known) coral reefs but not with seagrass due to its extensive coverage.	
Ecology – avifauna	High	The area is known to support globally significant migratory populations of seabirds and wetland birds. LPAS and IBAS have been identified for the latter. However, there is a high level of uncertainty regarding the abundance, distribution and behaviour of seabirds within the project areas due to a lack of offshore surveys. There is also insufficient information about the extent to which terrestrial bird migration routes traverse the project areas, although their migration does cross the proposed grid connection (overhead lines) for Puttalam. As the wider region supports numerous species (some in large numbers), avifauna poses a significant potential risk for offshore wind development	To increase understanding of avifauna in the project areas and region more generally, on-site baseline surveys should be conducted as part of the ESIA to gather data on the abundance, distribution and behaviour patterns. Additional surveys to inform the baseline in terms of migratory species is also required. This information can be used to inform site selection and project design to minimize and mitigate potential impacts. As avifauna is an important factor for offshore wind, this is one of the focus areas of follow-up activities under Phase 3 TA.

Constraint item	Risk Level*	Explanation	Mitigation strategies
Ecology – marine mammals	High	The construction of offshore wind farms can have a significant impact on marine mammals, and the measures to limit this impact can have a major influence on the location and construction possibilities of wind farms. As a result, marine mammals pose a significant potential risk for offshore wind in the project areas, as the wider marine region is renowned for its rich biodiversity and known to host many species of marine mammals. This includes endangered species such as the Dugong. This risk is difficult to assess at present due to the lack of data regarding the distribution, density, and behaviour of marine mammal species in the project areas.	To increase understanding of marine mammals in the project areas, on-site baseline studies should be conducted as part of the ESIA, including both acoustic and visual surveys. This information can be used to inform the project to minimize and mitigate potential impacts. As marine mammals are an important factor for offshore wind, this is one of the focus areas of follow-up activities under Phase 3 TA.
Aviation and radar	Low	Based on current knowledge, there are no nearby airports, height restrictions, or radars that could pose a threat to offshore wind development in the project areas. There are suggestions to extend flight operations at an airstrip 12 kilometres inland of the Puttalam area, but these plans have not been confirmed and are unlikely to impact the project areas.	If future aviation plans pose restrictions to the project areas, early engagement with relevant stakeholders should be initiated to ensure that various interests can coexist. Potential measures include creating designated flight paths and avoiding turbine placement in height restriction zones.
Military zones	Medium	The project areas are outside main military areas. However, military activities, like the	A continuous dialogue should be maintained with the government of Sri Lanka (in particular Ministry of Defence

Constraint item	Risk Level*	Explanation	Mitigation strategies
		Navy patrolling marine waters, presumably take place within the entire Sri Lankan marine space, including the project areas. This is therefore a potential risk to consider.	and the Navy) to identify potential conflicts, and, if conflicts arise, determine how they should be prevented or mitigated to ensure both interests can co-exist.
Mining activities	Medium	Based on current knowledge, no mining activities take place within the project areas. However, the project areas are available for hydrocarbon surveys and investigation, which form a potential risk when permission for surveys are granted.	A continuous dialogue should be maintained with the government of Sri Lanka (in particular MoPE, and PDA) to identify potential conflicts, and, if conflicts arise, how they should be prevented or mitigated to ensure both interests can co-exist.
Natural hazards	Low	The project areas are vulnerable to typhoons, and to a lesser extend earthquakes. However, potential negative impacts from these kinds of natural hazards can usually be mitigated through technical solutions to enhance the overall stability of the structures.	A mitigation strategy is to increase knowledge of natural hazards to inform project design and implementation. The metocean, geophysical, and geotechnical surveys during the feasibility study include assessments of natural hazards.
Offshore infrastructure	Low	Based on current knowledge, there is no offshore infrastructure present in the project areas that could pose a threat to offshore wind development.	Further engagement with government agencies should be conducted to verify the absence of offshore infrastructure. Any potential offshore infrastructure in the project areas will also be identified during geophysical investigations.
Unexploded ordnance	Low	Based on current knowledge, there is no unexploded ordnance present in the project areas that could pose a threat to offshore wind development.	Further engagement with government agencies should be conducted to verify the absence of unexploded ordnance. Any potential unexploded ordnance in the project areas will also potentially be identified during geophysical investigations during Phase 3 TA (depending on survey method used).

Constraint item	Risk Level*	Explanation	Mitigation strategies
Shipping & anchorage	Medium	Compared to other regions in Sri Lanka, the shipping density in the project areas is low, but this accounts for vessels with tracking devices. Moreover, there are no known protected shipping lanes or anchorage areas within the project areas. However, local shipping (such as fishing, tourism, transport, coal supply, and Navy activities) is present throughout the project areas and requires attention.	It is essential to conduct additional mapping of the frequency and characteristics of local maritime activity during the ESIA. Potential mitigation measures to avoid conflicts include establishing special vessel traffic zones and management, and by incorporating collision avoidance measures (for instance by marking and lighting systems).
Other wind projects	Medium	Several onshore wind projects are located along the coast, near the project areas. The currently applied exclusion zone to the coast provides a minimum distance of 5 km, though some wake effects may still be present. Wake effects may lead to reduced energy yield and increased fatigue for downwind turbines.	Wind resource modelling should include and assess potential wake effects. This could help inform potential mitigation strategies, such as the siting (wake effects usually decrease over distance) and design of offshore wind projects (better capable to withstand wake effects).
Archaeology	Low	There is an identified shipwreck off the coast in Puttalam (source Navionics), but it is located within the 5 kilometre buffer zone from the coast and not expected to affect offshore wind development. Furthermore, according to current knowledge, there are no other archaeological values in the project areas that could pose a threat to offshore wind development.	On-site archaeological surveys should be conducted during the ESIA, and identified artifacts should be preserved through proper project planning and implementation, such as adjusting the project layout and incorporating protective measures during construction and operation.

Constraint item	Risk Level*	Explanation	Mitigation strategies
Coastal residents	Medium	Although not the most densely populated areas of the country, coastal residents are present along most of the coastline adjacent to the project areas. There could be opposition from (some of the) coastal residents, as the wind farm will likely be visible from the shore.	Coastal residents should be actively engaged throughout the process, including educating them about the project and addressing their concerns. Proper impact assessment should be conducted during the ESIA. Public awareness campaigns can foster a positive perception of offshore wind energy.
Culturally sensitive areas	Medium	According to current knowledge, there are no culturally sensitive areas in the project areas that could pose a threat to offshore wind development. However, there are culturally sensitive areas along the coast, and potential interference is a point of attention, as the offshore wind farm will be visible from shore.	Stakeholders of culturally sensitive areas should be actively engaged throughout the process, including educating them about the project and addressing their concerns. Proper impact assessment should be conducted during the ESIA. Public awareness campaigns can foster a positive perception of offshore wind energy.
Fishing & aquaculture	High	Fishing is a potential risk for offshore wind development, as there is extensive local fishing within the project areas. Additionally, fishing is a significant source of income for the local economy and an important cultural aspect for many local communities.	To mitigate potential risks regarding to fishing, it is crucial to engage local fishing communities during future development activities and conduct a thorough ESIA. This could include monitoring fishing populations and activities to assess impacts. Establishing buffer zones around important fishing grounds can help minimize disturbances, while compensation can offset potential negative impacts.
Leisure and tourism	Medium	Although not the country’s prime tourist destination, tourism does occur along the entire coast adjacent to the project areas and warrants attention.	Mitigation strategies to reduce risks from tourism include engaging relevant stakeholders in the planning process and conducting thorough assessments in the ESIA. This could lead to reconsider site selection (possibly creating buffer zones around key tourist areas) which can minimize (visual) disturbances. Public awareness campaigns can foster a positive perception of offshore wind energy.

3.1 Preamble

The development of wind farm projects demands a delicate balance between minimising potential impacts on the surroundings, while maximising energy yield and cost-effectiveness. In this chapter, we investigate the potential of wind energy at the Mannar and Puttalam project areas by building project concepts for both sites. The project concept is a formulation of the reference wind farm layout, which considers insights from the constraints assessment, technology options for wind farms, and electrical layouts, to provide input for Levelized Cost of Energy (LCoE) calculations.

First, the wind climate for both areas will be described. Then, project concepts will be formulated, including foundation, wind turbine model, layout, and electrical system. An Energy Yield Assessment is conducted for the project concepts for both sites. Several variations of the project concept are explored, scrutinizing different wind farm layouts and scenarios. This will provide input to the LCoE to assess the financial feasibility of the project concept variations. A sensitivity analysis is conducted to understand the robustness of our proposed solutions in the face of varying parameters. A qualitative assessment at the end of this chapter puts the results into perspective by looking at electricity price forecasting, uncertainties, data gaps, and mitigation strategies.

3.2 Review of previous work

This section aims to provide a condensed summary of previous work on the contents of this chapter. Table 13 summarizes what we know from other studies, providing clarity about the starting point and preventing risk of duplication. Where this study deviates from previous work, it is described in the table as well.

Table 13 Main findings from previous studies

Item of chapter	Name of previous study	Main findings
Wind Climate	Everoze[43]	In Mannar, mean wind speeds range from 8.4 to 8.5 m/s at 125m and 8.3 to 8.4 m/s at 150m above Mean Sea Level (MSL). In the Puttalam area, slightly lower mean wind speeds are observed, ranging from 7.8 to 8.2 m/s at 125m and 7.9 to 8.2 m/s at 150m MSL. Everoze recommends conducting a wind measurement campaign in both Mannar and Puttalam areas to provide accurate wind data for assessing energy production potential, aligning with best practices for financing purposes in the future.
Wind Climate	World Bank[44]	The desktop study conducted by the World Bank aimed to assess wind resource measurement risks and opportunities in Sri Lanka, focusing on two zones: Mannar and Puttalam. The study found that using GWA and ERA5 models outside of Europe, where high-quality wind measurements are readily available, results in a high level of uncertainty. Therefore, a 30% baseline uncertainty has been indicated for the offshore areas of interest in Sri Lanka. No specific wind climate values are mentioned for both sites,

[43] Everoze Partners Limited (2023). 'Sri Lanka offshore wind – Wind resource and mapping' VORTEX017-R-01-B
[44] World Bank (2025) Desktop Wind Resource Study – Measurement, Risks and Opportunities Sri Lanka

Item of chapter	Name of previous study	Main findings
		given the high level of aforementioned models' uncertainty, a measurement programme is highly recommended.
Wind Climate	Roadmap	Indicated in Chapter 3.
Project concept	Roadmap	Considered a 500 MW pathfinder project with 42x 12 MW WTG model with a rotor diameter of 220m and a hub height of 150 m.
Project concept	Everoze	Everoze conducted preliminary energy production assessments for 500MW wind farms in Mannar, Puttalam, Northeast, and South Areas. In Mannar, mean wind speeds of 8.4-8.5 m/s could generate a capacity of 498.8 MW with 58 WB-8.6-200 turbines (at 125 m MSL hub height). At 150 m MSL hub height, the estimated capacity is 504 MW with 28 WB-18.0-250 turbines (at 8.3-8.4 m/s). In Puttalam, where mean wind speeds are slightly lower (7.8-8.2 m/s and 7.9-8.2 m/s for 125 m and 150 m MSL, respectively), the total capacity remains the same at both hub heights. The estimation is performed using virtual wind turbine WB-8.6-200 IEC Class II and WB-18.0-250 IEC Class I.
Energy Yield modelling	Everoze	Everoze has undertaken preliminary high-level energy production assessments at the Mannar, Puttalam, Northeast and South Areas, considering a 500MW wind farm
Energy Yield modelling	Roadmap	Roadmap has undertaken preliminary high-level energy production assessments at the Mannar site, considering a 500MW wind farm
LCoE	Roadmap	In Roadmap the LCOE was calculated. Following Figure 9.1, one of the major findings was that considering a weighted average cost of capital (WACC) of 8%, and average wind measurements, a LCoE of 101 USD / MWh was calculated. Following Figure 9.2, this value will drop roughly by 20 to 30 percent between the years 2030 and 2050, due to costs advantages.
LCoE	LCOE study India (FIMIO version 2)	The LCoE was calculated for several price levels. The study shows a bandwidth of 142 and 198 USD / MWh, under the assumption that cost reduction due to local supply in the APAC region is still limited.

3.3 Wind climate

3.3.1 Description of wind climate

For establishing a wind climate this study will use findings from the Everoze report and the World Bank report. Main findings from both reports are described in more details below.

Everoze report
The wind climate description for this study is based on the findings of the Everoze report. Everoze performed a wind resource mapping study for future offshore wind development in Sri Lanka in which it investigated the GWA and Vortex models for four potential sites, including Puttalam and Mannar. Wind speed maps were based on a Vortex MAP (5-year timeseries on a 1 km resolution grid) coupled with a calibration factor derived from on-site met masts which were deemed representative of the offshore site. The process of extracting Vortex-Everoze data and used in this energy yield assessment details as below:

- Choosing nearest reference (NR) points: To improve the representation of the climatology of the project sites, the nearest points to the initiation points of the models within the project areas will be selected.
- Choosing points to create time series: In this step, the data is divided into four quantiles, for each site, 5-6 points are selected from each quantile to ensure that the wind speed gradient is fully captured.
- Figure 53 illustrates the locations of the initiation points, nearest reference points, and chosen points.
- At the chosen points, a time series was created based on the provided timeseries at the NR points and consecutively, a simple single-factor correction was applied based on the wind speed gradient provided in the Everoze report.

Figure 53 Locations of the initiation points, nearest reference points, and chosen points

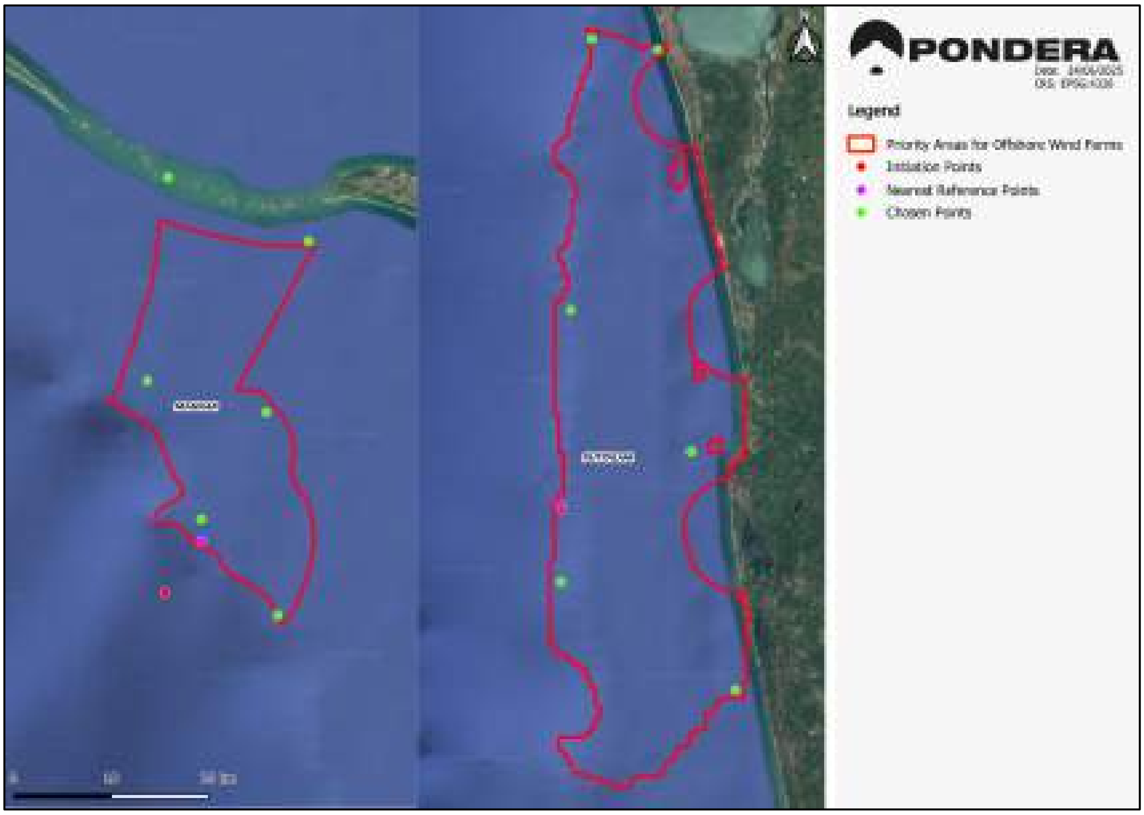
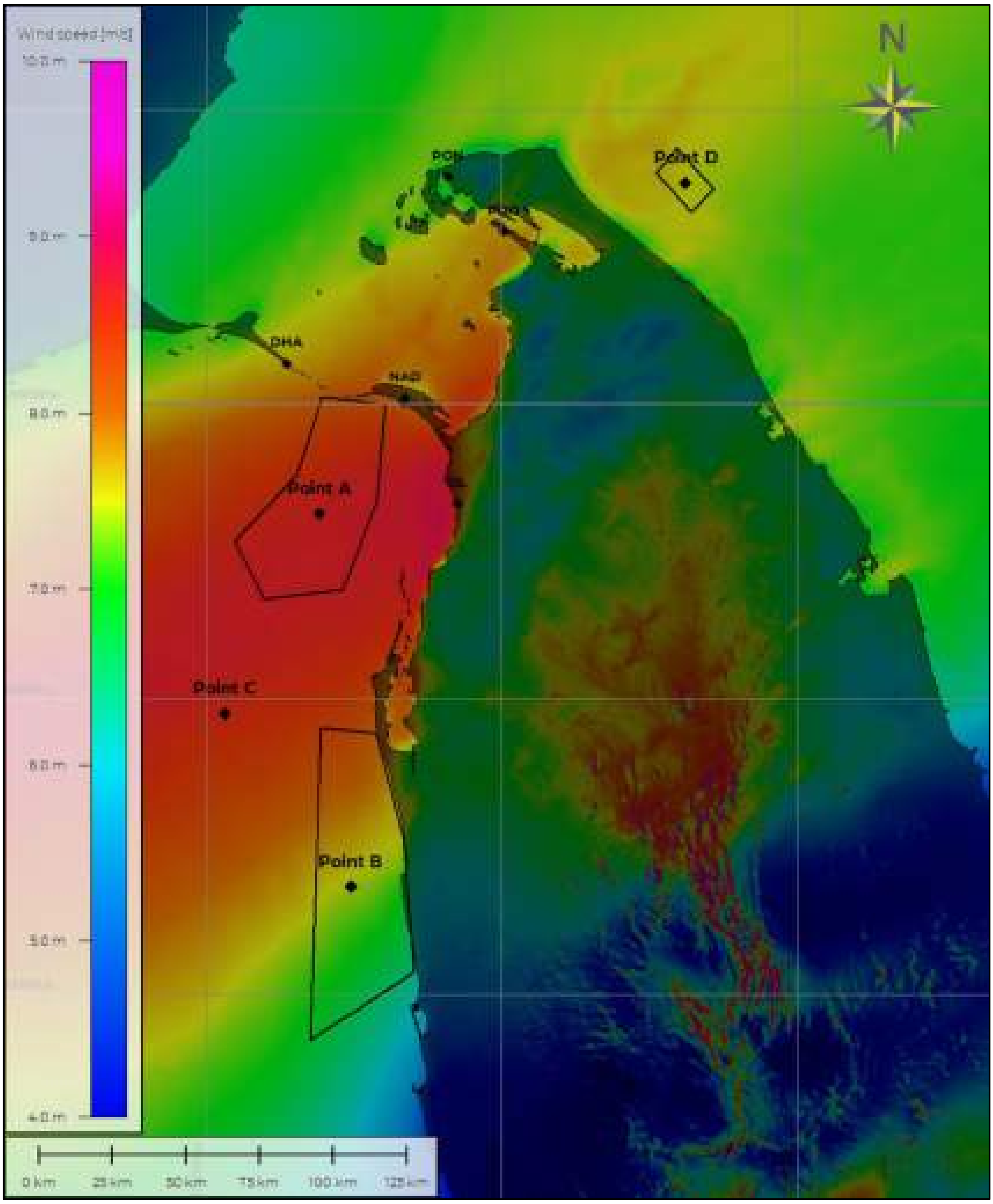


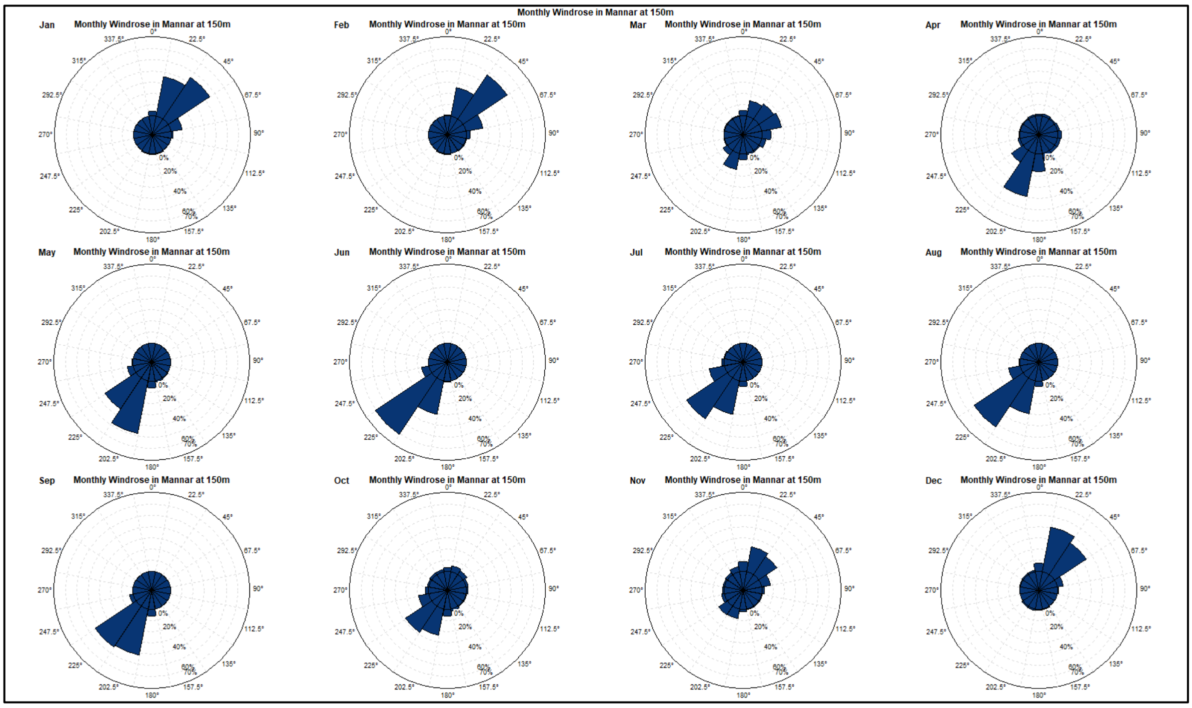
Figure 54 shows the Vortex wind speed map at 100 meters. In the centre of the Mannar site, mean wind speeds were found to be 8.37 m/s at 125 m and 8.43 m/s at 150 m MSL (mean sea level) hub height. The wind speed is fairly consistent over the entire site, denoting a low wind speed gradient. The wind speeds in Puttalam are lower compared to the Mannar site. In the centre of the Puttalam site, mean wind speeds were found to be 7.3 m/s at 125 m and 7.7 m/s at 150 m MSL hub height. The Vortex map points towards a strong wind speed gradient from North-West (8.1 m/s) to South-East (6.6 m/s), which suggests that establishing wind farms in the northern region of Puttalam would be more viable. Given the absence of near-site measurements, the uncertainty of the wind speed gradient can be considered high and should be evaluated through a wind measurement campaign.

Figure 54 Vortex wind speed map at 100 m MSL showing the Mannar area (with Point A in centre) and the Puttalam area (with point B in centre). Source: Everoze



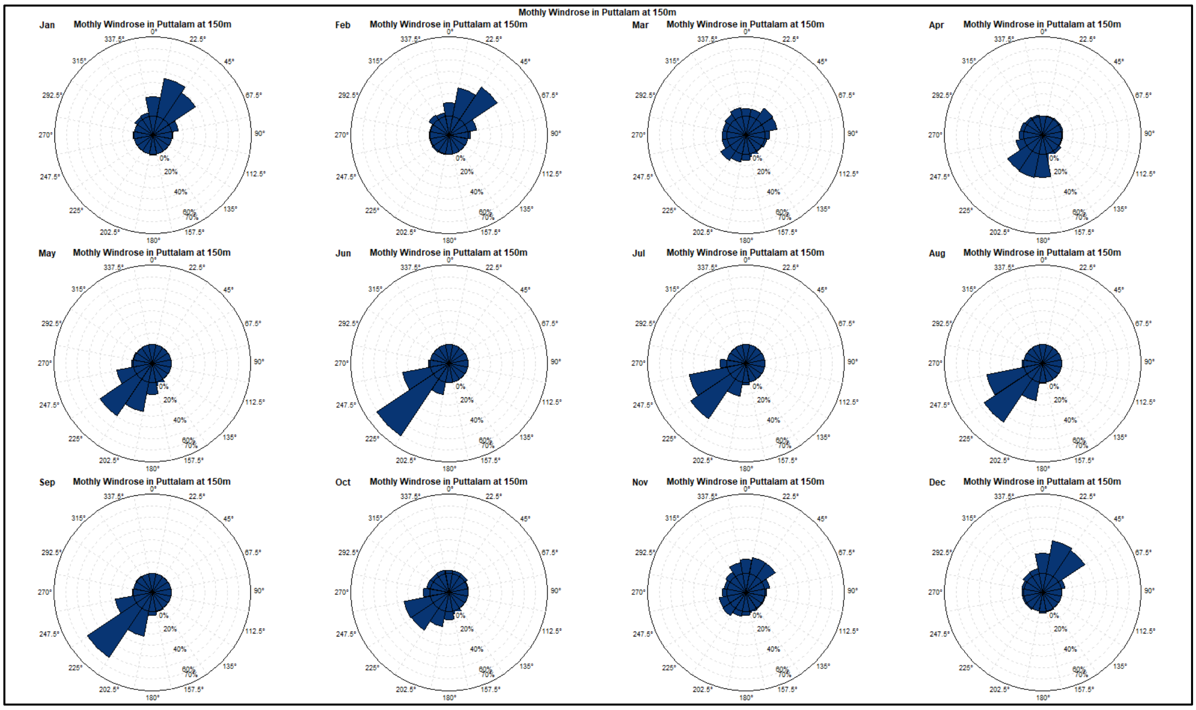
The monthly wind rose for the Mannar site is provided in Figure 55. It is based on Everoze's Vortex wind speed map. As such it shows South-West (SW) as the prevailing wind direction from April to October, and North-East (NE) as the prevailing wind direction from November to March.

Figure 55 Monthly wind roses at the Mannar site (at 150 m)



The monthly wind rose for the Puttalam site is provided in Figure 56. Similar to Mannar, SW and NE are the prevailing wind directions. SW is the prevailing wind direction from April to October, and NE is the prevailing wind direction from November to March.

Figure 56 Monthly wind roses at the Puttalam site (at 150 m)



World Bank report
The desktop study on wind resource measurement risks and opportunities in Sri Lanka by the World Bank focused on evaluating the potential wind resources in two areas in Mannar and Puttalam. The assessment relied on numerically modelled data to understand the advantages of conducting wind measurement campaigns and address uncertainties present in the current predicted data, including ERA5 and GWA data. The study concluded that both datasets pose a high level of uncertainty. This is the case for specific regions within global reanalysis models where there are few sources for data assimilation. Given the high level of model uncertainty, a measurement campaign is highly recommended. Examples of potential measurement campaigns are explained in Table 14.

Table 14 Various options (non-exhaustive) for offshore wind measurement campaigns

Measurement Campaign	Description	Advantage	Disadvantage
Meteorological Masts	Tall masts with sensors to measure wind speed, direction, temperature, humidity, and pressure at different heights	Provides direct measurements of wind characteristics	Expensive and complex to install and maintain
LiDAR Measurements	Deployment of LiDAR systems on fixed platforms or buoys to remotely measure wind speed and direction	Remote sensing capability for offshore locations. Relatively easy to deploy and maintain.	Limited by line-of-sight obstruction, accuracy affected by atmospheric conditions
Data Buoy Arrays	Deployment of buoys equipped with sensors to collect data on wind, wave, and ocean conditions	Mobile and versatile, suitable for short-term and long-term monitoring	Limited coverage, vulnerable to damage and loss in harsh offshore environments

3.3.2 Data evaluation

A data validation was carried out to assess the accuracy and reliability of the Everoze-Vortex data, especially for energy yield calculations. The validation process involves comparing the wind speed data obtained from the Everoze report with the corresponding data from the ERA5 dataset. To conduct this validation, the Everoze-Vortex data was reassessed by generating time series data from initiation points, specifically designated as point A for Mannar and point B for Puttalam. Multiple points within the wind farm (approximately 5-6 points for each site) were selected for analysis.

To check whether the selected time period of the Everoze dataset is representative for the long term, a comparison was made with ERA5 wind data since the ERA5 model contains data from a longer period. Generally, a 15 year period is seen as representative for the long-term mean wind speed. Table 15 shows that the ERA5 mean wind speed in the period 2018-2022 was lower than the period 2008-2022. This is 2.2% and 1.2% for Mannar and Puttalam, respectively. This suggests that the produced Everoze time series might lead to a slight underprediction of the long-term mean wind speed.

Table 15 Wind speed comparison

Location	Source	Mean wind speed 2018-2022 (5 years)	Mean wind speed 2008 – 2022 (15 years)	Difference
Mannar	Everoze-Vortex	8.37 m/s		
	ERA5	8.09 m/s	8.27 m/s	-2.2%
Puttalam	Everoze-Vortex	7.34 m/s		
	ERA5	6.39 m/s	6.47 m/s	-1.3%

The scatter plots in Figure 57 and Figure 58 show the relation of concurrent ERA5 and Everoze-Vortex wind speed data. With a correlation coefficient (R2) of 0.75 and 0.64 for Mannar and Puttalam respectively, there is a decent relationship between the ERA5 and Everoze-Vortex data, although significant scatter is visible. The slope values mentioned in Figure 57 and Figure 58 are not close to unity, which suggest that the performance of the Everoze-Vortex or the ERA5 data in the Sri Lanka region is not sufficiently validated. The scatter plots show the need for accurate and local wind measurement campaigns to further ascertain the wind climate.

Figure 57 Comparison ERA5 with Everoze for Mannar. R2 = 0.75, slope = 0.90, intercept = 1.45

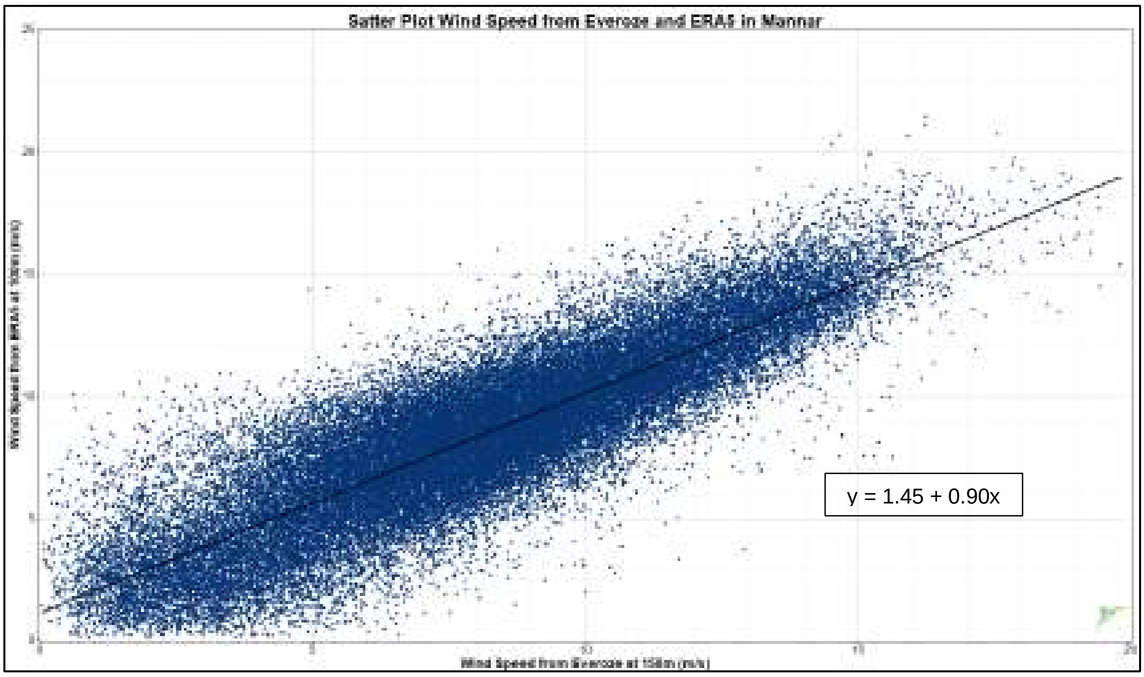
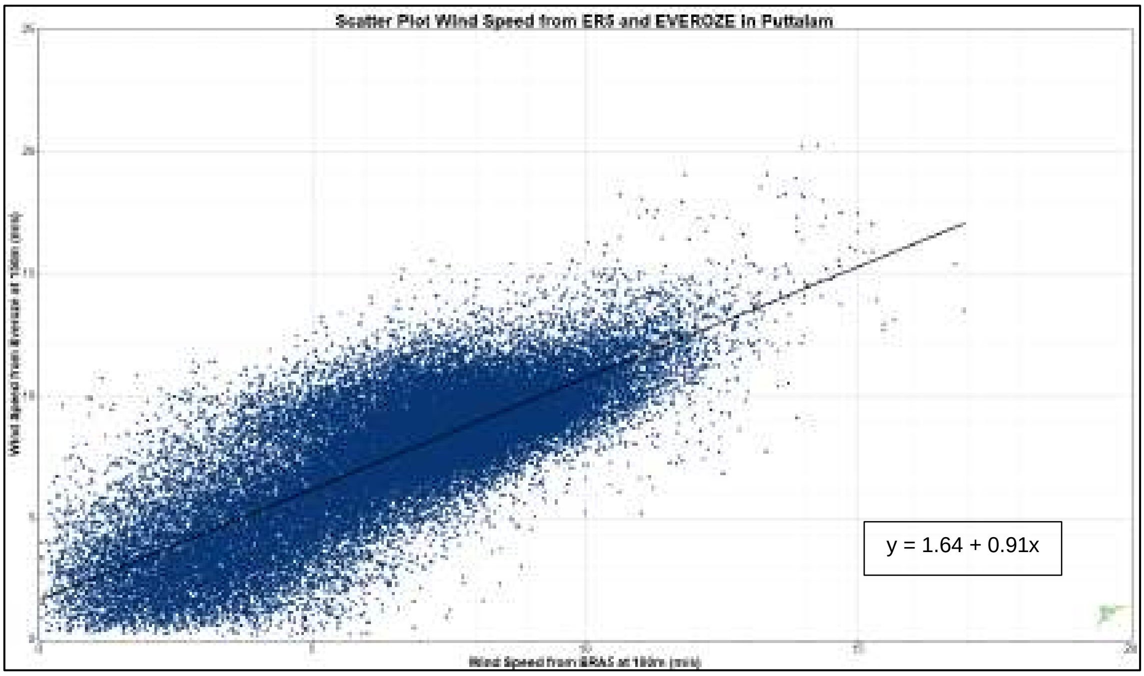


Figure 58 Comparison ERA5 with Everoze for Puttalam. R2 = 0.64, slope = 0.63, intercept = 1.64



3.4 Project concept description

This section describes the principles that have been applied for the project concept. The design of a wind farm depends on many parameters. The purpose of developing a project concept is to determine how these parameters affect the success of an offshore wind farm in Mannar and Puttalam. The designed wind farms are explicitly not fully optimized scenarios, as this exceeds the scope of this study. The design parameters have been kept consistent between Mannar and Puttalam as much as possible. This was done to be able to compare the results at both sites. However, different parameters have been chosen where necessary.

The project concept results from an iterative process (in consultation with the World Bank) in which various relevant elements for energy yield and LCoE have been considered. The following sections describe the choices made regarding foundations, wind turbine sizing, layout, and offshore grid plan.

It's worth mentioning that the standard project concept will be referred to as the "reference project concept." Later, various variants of the project concept (such as different wind turbine generator models or layouts) will be introduced for each site for comparison purposes.

3.4.1 Foundation

The selection of the optimal wind turbine foundation type (e.g., monopile, jacket, gravity-based) for each wind farm site depends upon data pertaining to variables such as water depth, seabed conditions, supply chain feasibility, and international installation methodologies. This study assumes the use of a monopile to allow for better comparison with the LCoE study in India, and as monopiles seem the most logical option based on the current understanding of local site conditions (shallow water depths and the top layer of the seabed mostly consisting of unconsolidated sediments). The most suitable foundation type should be confirmed in future studies by assessing the variables in more detail.

However, it is worth mentioning that there are high uncertainties associated with the available bathymetry data, and the seabed composition cannot be stated with certainty.

Geophysical and geotechnical surveys are strongly recommended for a detailed understanding of on-site conditions. A general description of various types of surveys is given in Table 16.

Table 16 General description of geophysical and geotechnical surveys

Survey Type	Description	Advantage	Disadvantage
Seismic Surveys	Utilizes seismic waves to image subsurface geological structures, typically used to identify potential hydrocarbon reserves or geological hazards at great depth.	- Provides detailed information about subsurface geological structures.	- Expensive and time-consuming.
Bathymetric Surveys	Measures water depths and seabed topography using echo sounders, important for navigation safety and understanding seabed features.	- Essential for identifying suitable locations for wind turbine installation.	- Limited in providing information about seabed composition.
Side-Scan Sonar Surveys	Deploys sonar systems to produce detailed images of the seafloor, identifying objects and geological features, and assessing seabed composition.	- Can detect submerged obstacles and geological features.	- May have limited resolution in shallow or high-energy areas.
Magnetometer Surveys	Measures variations in the Earth's magnetic field to detect magnetic anomalies, useful for identifying buried geological structures or archaeological artifacts.	- Non-intrusive method for identifying potential hazards or resources.	- May be affected by magnetic interference from offshore structures.
Gravity Surveys	Measures variations in gravitational pull to map subsurface density variations, aiding in geological mapping and identifying potential mineral deposits.	- Provides information on subsurface density variations.	- Requires sophisticated equipment and data processing.
Sub-Bottom Profiling	Uses seismic or sonar techniques to penetrate the seafloor and image geological layers beneath the seabed, providing insight into sediment composition and geological history.	- Helps assess seabed stability and foundation design.	- Limited penetration depth in certain geological conditions.

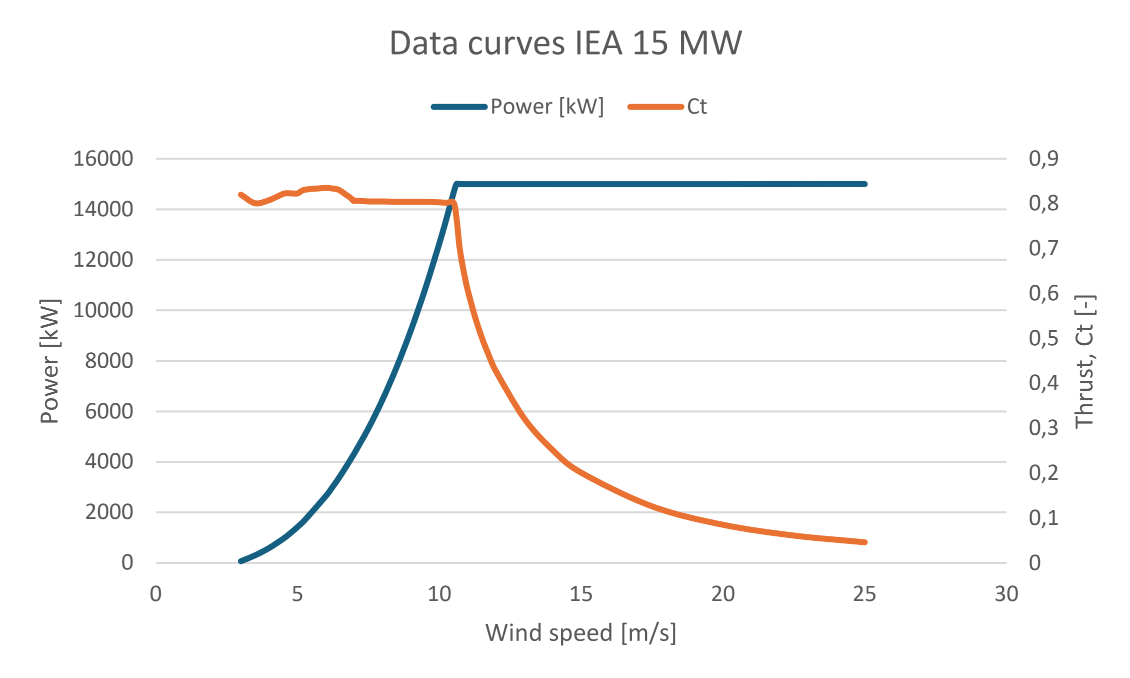
Survey Type	Description	Advantage	Disadvantage
Cone Penetration Testing (CPT)	Involves pushing a cone-shaped probe into the seabed to measure soil properties such as strength, density, and stratigraphy, essential for offshore foundation design.	- Provides direct measurements of seabed soil properties.	- Limited spatial coverage compared to other methods.
Seabed Sampling and Coring	Retrieves sediment and rock samples from the seafloor using coring equipment, allowing for laboratory analysis of sediment composition, age, and properties.	- Provides direct evidence of seabed composition and stratigraphy.	- Can be costly and time-consuming, especially in deep water.
Soil Resistivity Testing	Measures the electrical resistivity of seabed soils to assess their moisture content, salinity, and other properties, aiding in foundation design and cable burial assessments.	- Helps assess soil corrosion potential and cable burial suitability.	- Limited effectiveness in highly conductive marine environments.
Multibeam Echo Sounder Surveys	Uses multiple sonar beams to generate detailed three-dimensional maps of the seafloor and subsurface features, crucial for offshore construction planning and habitat mapping.	- Provides high-resolution maps of seabed topography and features.	- Equipment costs and data processing requirements can be high.

3.4.2 Wind turbine

This study uses the specifications of the 15 MW research wind turbine model developed by NREL for the International Energy Agency (IEA) Wind TCP Task 37[45]. This reference wind turbine is a Class IB direct-drive machine, with a rotor diameter of 240 m and a hub height of 150 m. The power curve and thrust (Ct) curve are shown in Figure 59.

[45] NREL (2020) Definition of the IEA15-Megawatt Offshore Reference Wind. Golden, CO: National Renewable Energy Laboratory. NREL/TP-5000-75698. https://www.nrel.gov/docs/fy20osti/75698.pd

Figure 59 Data curves of IEA 15 MW wind turbine model



The IEA wind turbine model was selected since its conceptual design is open source with transparency in design parameters. This means that the energy yield calculations can be reproduced without requiring access to information that is usually under NDA. The IEA wind turbine model is a widely used as a reference model for offshore pre-feasibility wind studies, hence this model serves as a suitable benchmark to allow for comparison with other studies. A disadvantage for this model is an abrupt transition in the power curve between ramp-up and achieving rated power. This region, shown in Figure 59 around the 10 m/s mark, is usually where the turbine produces the most energy. This does not reflect power curves of actual wind turbines. This disadvantage needs to be considered as an uncertainty in the energy yield output.

3.4.3 Layout

The basis of the wind farm layout is a regular, rectangular grid of wind turbines that is oriented northwest to southeast, which is perpendicular to the prevailing wind directions (SW and NE). Due to the strongly prevailing wind conditions the minimum distance between wind turbines (or wind turbine spacing) is 8 times the rotor diameter (RD) in the prevailing and 4 times RD in the non-prevailing wind directions. A 0.5 RD offset is applied for every second row to reduce wake effects.

All layouts assume a project size of 500 MW in terms of installed capacity for each area. This project size is large enough to be attractive for project developers (who will benefit from economies of scale) and possible in terms of the absorption capacity of the Sri Lankan grid (which will be further assessed in Chapter 5). Moreover, a similar project size was assumed in the Roadmap and therefore allows comparison between both studies. A 500 MW project leads to a layout of 34 wind turbines for each site. As such, the total wind farm capacity is 510 MW, which means that 10 MW is overplanted[46].

[46] Installing a (small) number of extra wind turbines compared to the grid connection capacity limit to increase the wind farm efficiency

The project concept layout presented in this study should be considered indicative and is not optimized for the lowest wake losses. The highest energy yield losses occur in the wind farm centre, where turbines are exposed to higher wakes. A more tailored wind farm layout in future studies would show more wind turbines at the outer borders and fewer wind turbines at the centre.

3.4.4 Electrical layout

The electrical design considers the connection of every individual wind turbine to the existing electrical infrastructure. Array cables connect multiple wind turbines on one string, which is connected to a transformer station (could be onshore, offshore or both), which is then connected through export cables to the existing electrical grid. This section outlines selections regarding elements in the grid connection system. More detailed information about the electrical system will be provided in Chapter 5.

Array cables

In current practice, wind turbines within offshore wind farms are connected through strings of 66 kV cables. As a rough rule of thumb, the required cable voltage is approximately 1 kV per MW of transmitted power. Therefore, as the rated power of individual wind turbines increases, the number of turbines that can be connected in a single-array-string decreases, assuming the cable capacity remains constant. The upcoming generation of wind turbines will have 15 to 20 MW rated power. Because of this, market players are preparing the supply of 132 kV cables, which are assumed for this study. These cables can connect up to 9 wind turbines of 15 MW each on a single string. Four array cables can connect the entire 500 MW wind farm. Upon leaving the wind farm, the cables are arranged into a single corridor to reduce ecological impacts to the seabed. The cable length is determined by taking the shortest distance between the wind farm and the onshore grid point and multiplying it by a 1.2 "inefficiency factor" which accounts for inefficient routing due to site constraints such as (for instance, coral reefs.). This factor is empirically found based on the ratio between actual cable length and the shortest route in many existing wind farms.

Transformer substation

Array cables usually connect to a transformer station in which the voltage level is stepped up to 220 kV to minimise energy losses. The electrical design of the Mannar and Puttalam project concepts differ in the position of the substation.

At Mannar, the distance between the shore and the nearest wind turbine to the shore is approx. 30 km. There is an economic trade-off between the (relatively high) production cost of an offshore substation versus the increased cable length and associated energy losses of connecting array cables directly to land. This trade-off is further complicated by low production capacity and long lead times for producing such offshore substations. The project concept for Mannar will therefore not have an offshore substation. Four array cables will connect to an onshore substation in close proximity to the grid connection. As these array cables are relatively long with moderately high energy losses, a variation to the project concept will be researched which includes an offshore substation in the layout.

The shortest distance between the nearest wind turbine at Puttalam and shore is approx. 7.5 km. As a consequence, an onshore substation will be positioned behind the Puttalam shoreline. There will be no offshore substation variation.

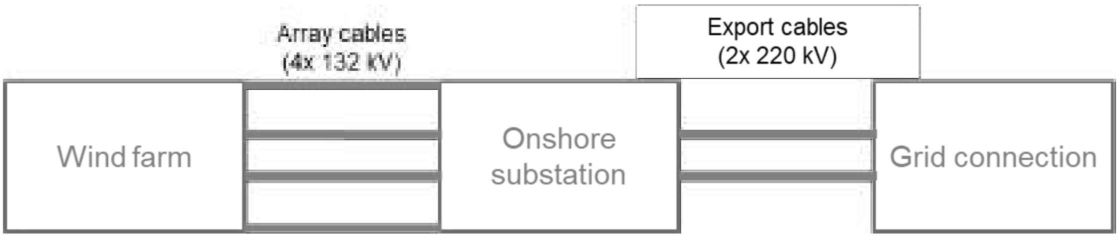
Export cables

The export cables transmit electricity from the substation (if any) to the grid connection point. The nearest viable grid connection point at Mannar is relatively close to the shore, whereas for Puttalam, this is approximately 50 km inland. The export cable length at Mannar is assumed to be zero, as the array cables will be connected to the grid connection point immediately after the step-up transformers. Whereas at Puttalam, a 50 km 220 kV overhead line is required for grid connection. Connecting a 500 MW offshore wind project in Puttalam to the nearby coal-fired power station was investigated as an alternative connection option but did not immediately lead to a feasible solution. The main reason for this is the lack of capacity on the existing grid network and the crucial role the coal-fired power plant currently plays in stabilizing the Sri Lankan grid (further elaborated in Chapter 5)[47]. Similar to the array cables, an inefficiency factor of 1.2 is applied to account for inefficient routing.

In summary, the electrical layouts at Mannar and Puttalam are shown in Figure 60 and Figure 61 respectively.

Figure 60 Electrical layout at Mannar

Figure 61 Electrical layout at Puttalam



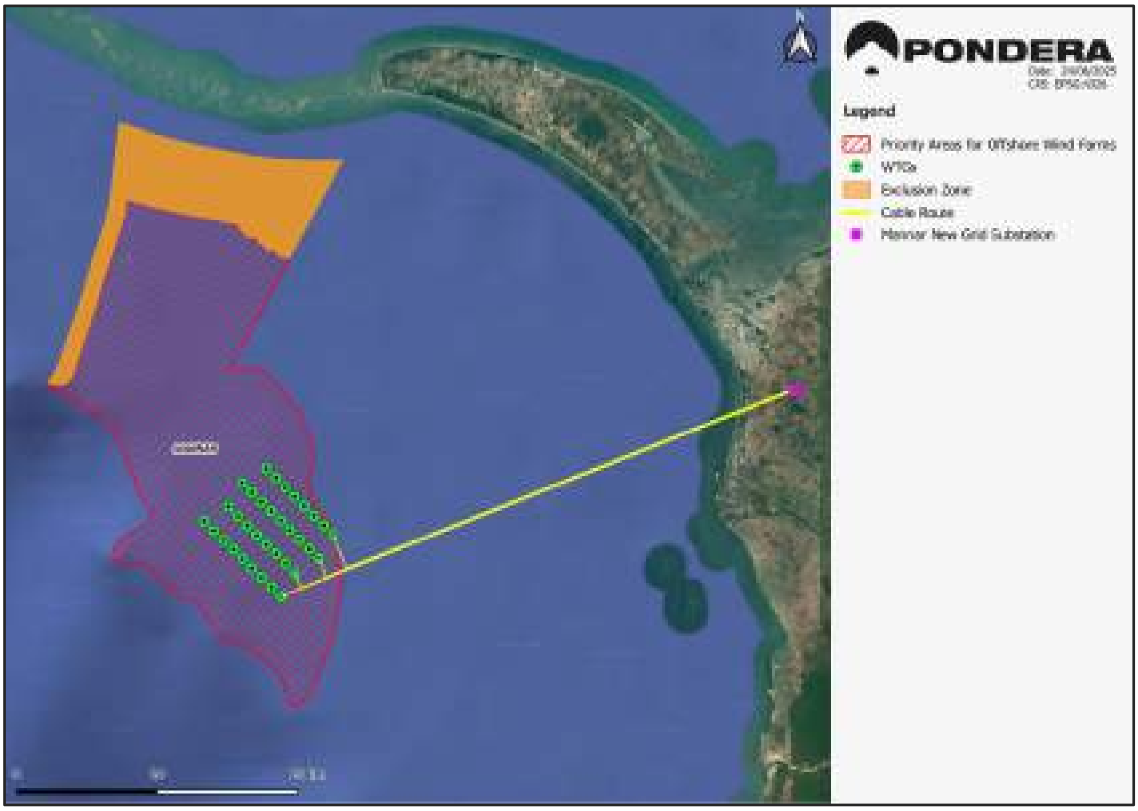
3.4.5 Reference project concepts

The full reference project concepts are visible in Figure 62 and Figure 63 Mannar and Puttalam, respectively. The choices for foundation, wind turbine, layout, and electrical system have been described previously. The location selections for each project are set out below. As concluded in Chapter 2, a relatively large area within the project boundaries of the Mannar area is tentatively available for offshore wind (with no direct showstoppers). The main reasoning behind the proposed location of the reference project concept in Mannar (in Figure 62) can be explained by:

- Relatively close to the grid connection point at the Mannar substation;
- Favourable wind speeds and water depths;
- Further offshore to minimize potential coastal impacts on people and ecology;
- Outside the key fishing hotspots in the southern part of the project area as visible in Figure 49.

[47] The approved LTGP shows the coal power plant to be fully operational throughout the 20-year planning window 2023-2042. Presently it transfers 810 MW of coal power to the grid.

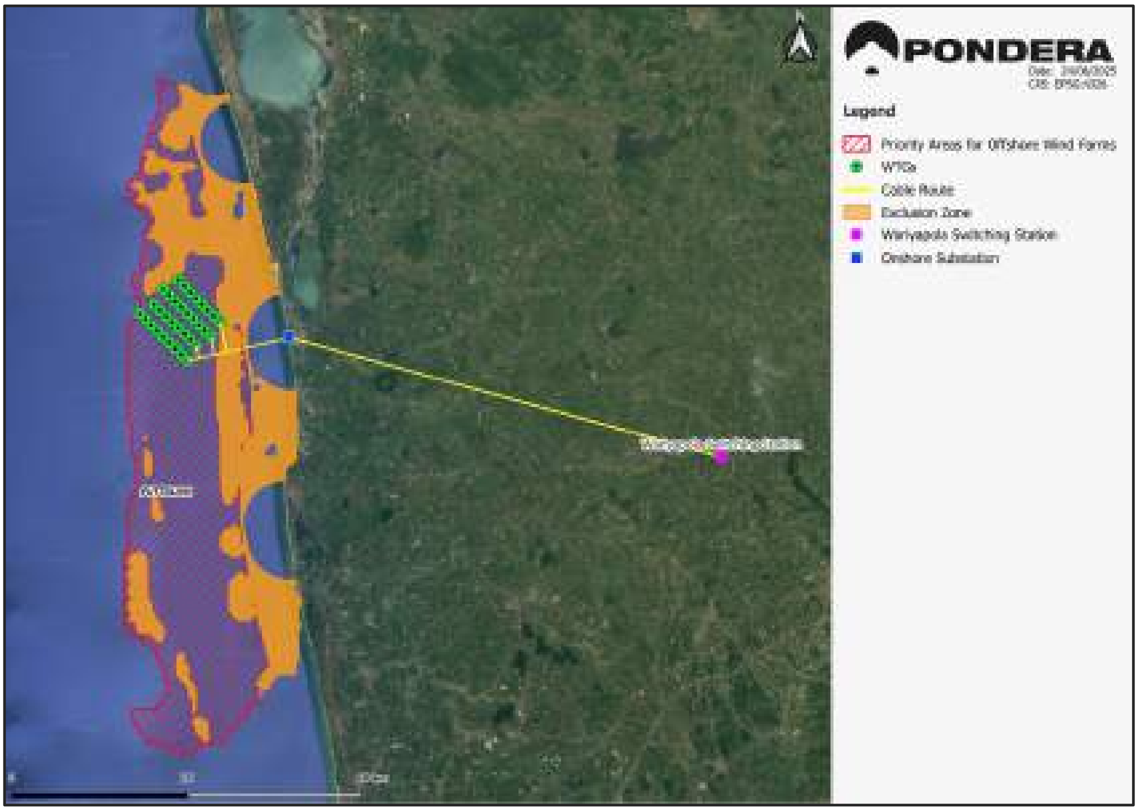
Figure 62 Reference project concept at Mannar



Section 2.5 Tentative available areas for offshore wind also concluded that a relatively large area within the project boundaries of the Puttalam area is tentatively available for offshore wind (with no direct showstoppers). The main reasoning behind the proposed location of the reference project concept in Puttalam (in Figure 63) can be explained by:

- Avoiding the northern area with water depths regularly below 10 meters;
- Shifted as much as possible to the north to harness the higher wind speeds found in the northern region;
- Positioned as far offshore as possible to minimize potential coastal impacts on people and ecology (also no interference with the identified shipwreck as visible in Figure 16).

Figure 63 Reference project concept at Puttalam



3.5 Energy yield modelling

Based on the proposed layouts in the previous section, energy yield modelling was conducted to assess the energy feasibility of each layout. The section on energy yield modelling is divided into three parts:

- Input model parameters and assumptions, including wake effect, calculation type, and losses.
- The result of the model runs.
- Various project concept variations to assess sensitivity to key parameters such as wind turbine types, layout, and electrical configurations.

3.5.1 Model parameters and assumptions.

The model parameters and calculation settings are provided in Table 17.

Table 17 Used model parameters and calculation settings

Model parameter	Input
Modelling software	WindPRO 4.0
Flow model	WAsP 12
Calculation type	Time-varying PARK calculation
Used wind data	Vortex MAP calibrated by Everoze
Used period	01/01/2018 – 01/01/2023

Model parameter	Input
Wake model	TurbOPark
Blockage model	Self Similar Model (Forsting 2017)
Electrical losses	Calculated through Pondera Cable Loss tool
Other losses (losses other than wake and electrical losses)	10%
Ambient turbulence level	8.0% (estimated)
Horizontal interpolation	Distance weighted with meteo objects

3.5.2 Results

The results of the energy yield modelling of the reference project concepts in both areas are compared in Table 18 and graphically in Figure 64. The mean wind speed at Mannar is +0.7 m/s higher (9.1%) than Puttalam. The difference in wind speed is the largest contributing factor to the 16.3% difference in the net Annual Energy Production (P50 AEP) between Puttalam and Mannar. This effect is amplified by the difference in wake losses. Table 18 shows a 7.4%-point higher wake loss at Puttalam. At lower wind speeds, wind turbines often have a higher thrust coefficient (Ct). This is because turbines are designed to maximize energy extraction at these speeds, which results in higher thrust forces and consequently larger wakes.

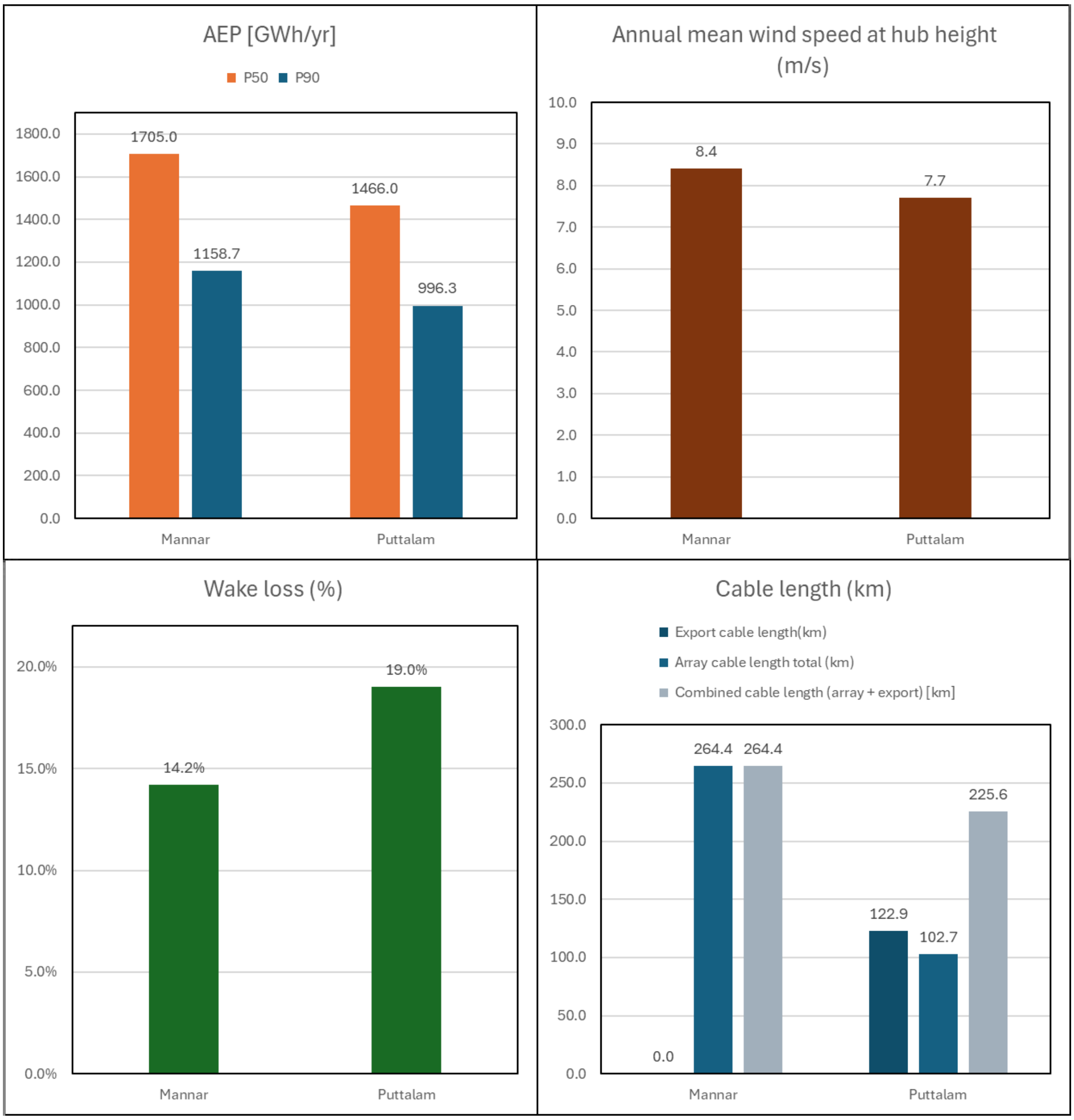
The P90 AEP is calculated by incorporating a 25% uncertainty factor for using generalized models which require on-site validation. Please be advised that the results in the table below must be treated as preliminary. The estimation of the wind climatology and the wake modelling are based on single models. Wind flow is complex in large offshore wind farms and as such, a more in-depth wake assessment is advised, in which a multi-model approach is advised to understand the range.

Table 18 Overview and comparison of energy yield modelling inputs and results for Mannar and Puttalam

WTG input	Mannar	Puttalam
WTG type	IEA-15MW	IEA-15MW
Wind farm crosswind WTGs (max in row)	9	9
Wind farm downwind WTGs (max in row)	4	4
Rotor diameter (m)	240	240
Hub height (m)	150	150
WTG rated capacity (MW)	15	15
Wind farm input	**Mannar**	**Puttalam**
Wind farm - total capacity [MW]	510	510
# of WTGs	34	34
WTG power to rotor ratio [W/m2]	331.6	331.6
Rotor swept area of wind farm (km2)	1.54	1.54
#WTGs on 1 string (132kV)	9	9
Array cable length total (km)	264.4	102.7

Export cable length (km)	0	122.9
Combined cable length (array + export) [km]	264.4	225.6
Average water depth (m)	18.0	18.7
Energy yield output	**Mannar**	**Puttalam**
Annual mean wind speed at hub height (m/s)	8.4	7.7
Gross AEP wind farm [GWh/yr]	2306.2	2081.1
PARK AEP wind farm [GWh/yr]	1979.2	1685.7
Wake losses (1-x%)	85.8%	78.4%
Electrical losses (1-x%)	95.7%	96.6%
Other losses (1-x%)	90.0%	90.0%
P50 Net annual yield [GWh/y]	1705.0	1466.0
P50 Full load hours [hr/yr]	3343.2	2874.4
P50 AEP per m2 swept area [GWh/km2(/yr)]	1108.5	953.1
Uncertainty	25%	25%
P90 Net annual yield [GWh/y]	1158.7	996.3
P90 Full load hours [hr/yr]	2272.0	1953.5

Figure 64 Visual comparison of energy yield modelling results between reference project concepts of Mannar and Puttalam



3.5.3 Project concept variants

Several variations of the reference project concepts were introduced to determine the sensitivity of the results to specific project parameters, which are believed to have a significant impact. This includes variations in wind turbine types, wind farm layout, and electrical layouts. It should be noted that there is asymmetry in the number of project concept variations between Mannar and Puttalam. The project variation at Puttalam aims to find a wind turbine model at which the LCoE is expected to be significantly reduced. Additionally, the site at Puttalam has fewer options for wind farm layout optimization to reduce wakes, nor did investigations for connecting a wind farm to a nearby coal-fired power plant lead to feasible alternatives for the present inland connection at Puttalam.

Mannar – WTG variants

The wind turbine model selection, especially the combination of rated power and rotor diameter, has an impact on the energy yield and LCoE. The wind turbine models of the Everoze report were used to compare wind farm layouts, energy yield and LCoE results. An overview of selected wind turbine models is presented in Table 19. The variations for WTG a and WTG b are visible in Figure 65.

Table 19 Design assumptions WTG a and b variants in relation to project concept Mannar

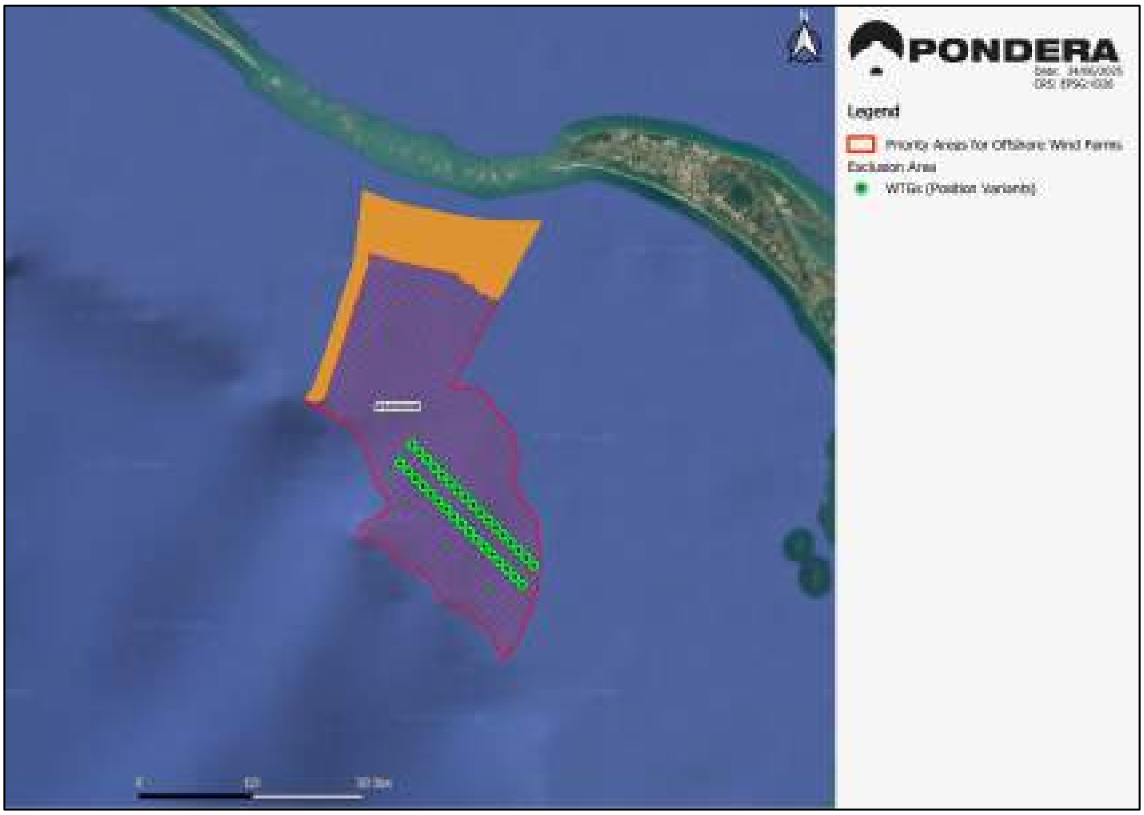
Scenario	Project concept	WTG a	WTG b
WTG dimensions			
WTG type	IEA-15MW	WB-8.6-200	WB-18-250
Rotor diameter (m)	240	200	250
Hub height (m)	150	125	150
WTG rated capacity (MW)	15	8.6	18
Wind farm dimensions			
# of WTGs	34	59	28
Wind farm - total capacity [MW]	510	507.4	504
Wind farm crosswind WTGs (max in row)	9	12	7
Wind farm downwind WTGs (max in row)	4	5	4
#WTGs on 1 string (132kV)	9	16	8
Rotor swept area of wind farm (m2)	1,538,124	1,853,540	1,374,447
Rotor swept area of wind farm (W/m2)	331.6	273.7	366.7

Figure 65 WTG a and b variants for Mannar

Mannar – positioning variant

All previous layouts consider a rectangular shaped grid of wind turbines with 4 and 5 rows in the downwind direction. With this regular grid, it is expected that wind turbines at the wind farm centre suffer the highest wake losses. The proposed variation considers a reduced wake loss layout, which contains two longer rows of wind turbines, as shown in Figure 66. It is acknowledged that there is room for further optimising wind farm layouts to reduce wake losses (such as a smaller spacing at the wind farm border and a larger spacing at the wind farm centre), which could be subject for further study. Please note that the 2-row solution provides limited space and reduced efficiency for the exploitation of three or more 500 MW projects within the priority area.

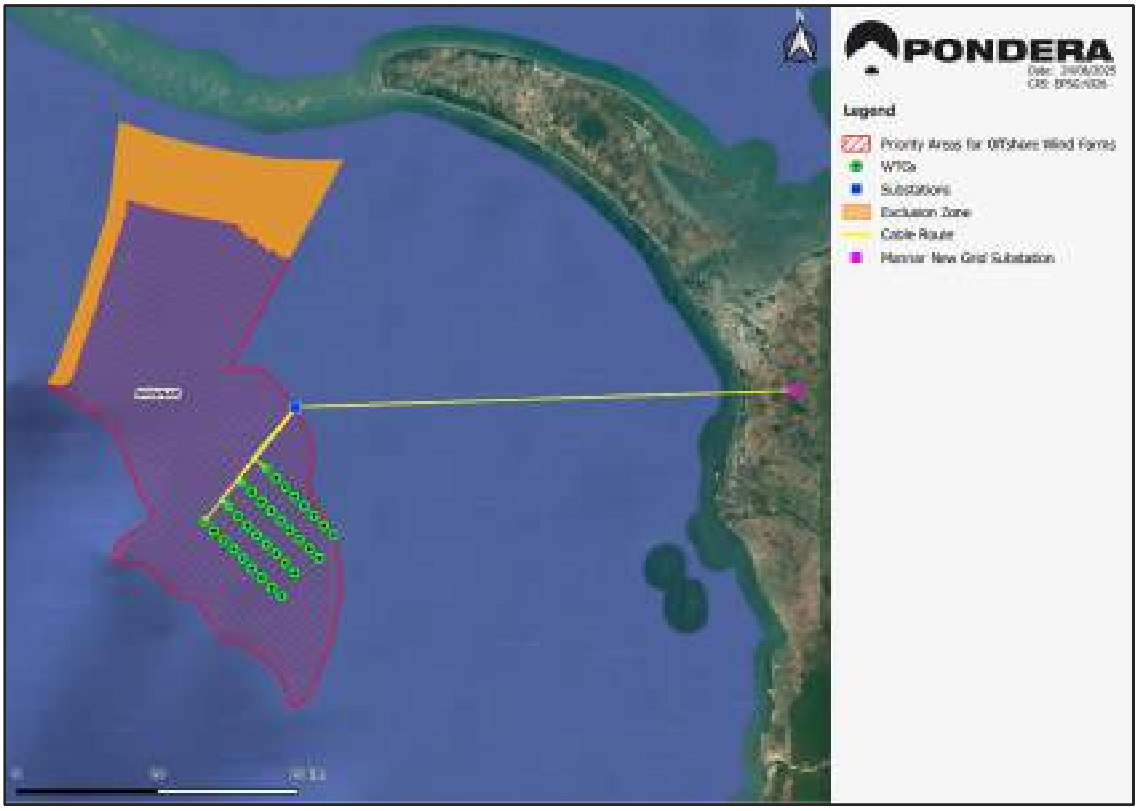
Figure 66 Positioning variant for Mannar



Mannar – electrical variant

This variant explores the possibility that multiple wind farms will be connected through a single offshore substation. The variant considers a 1 GW offshore substation which connects two 500 MW wind farms to mainland Sri Lanka. This variant, as shown in Figure 67, considers one of the two 500 MW wind farms to allow comparison with other variants. The capital cost for an offshore substation and export cabling is distributed over two wind farm projects.

Figure 67 Mannar – electrical variant

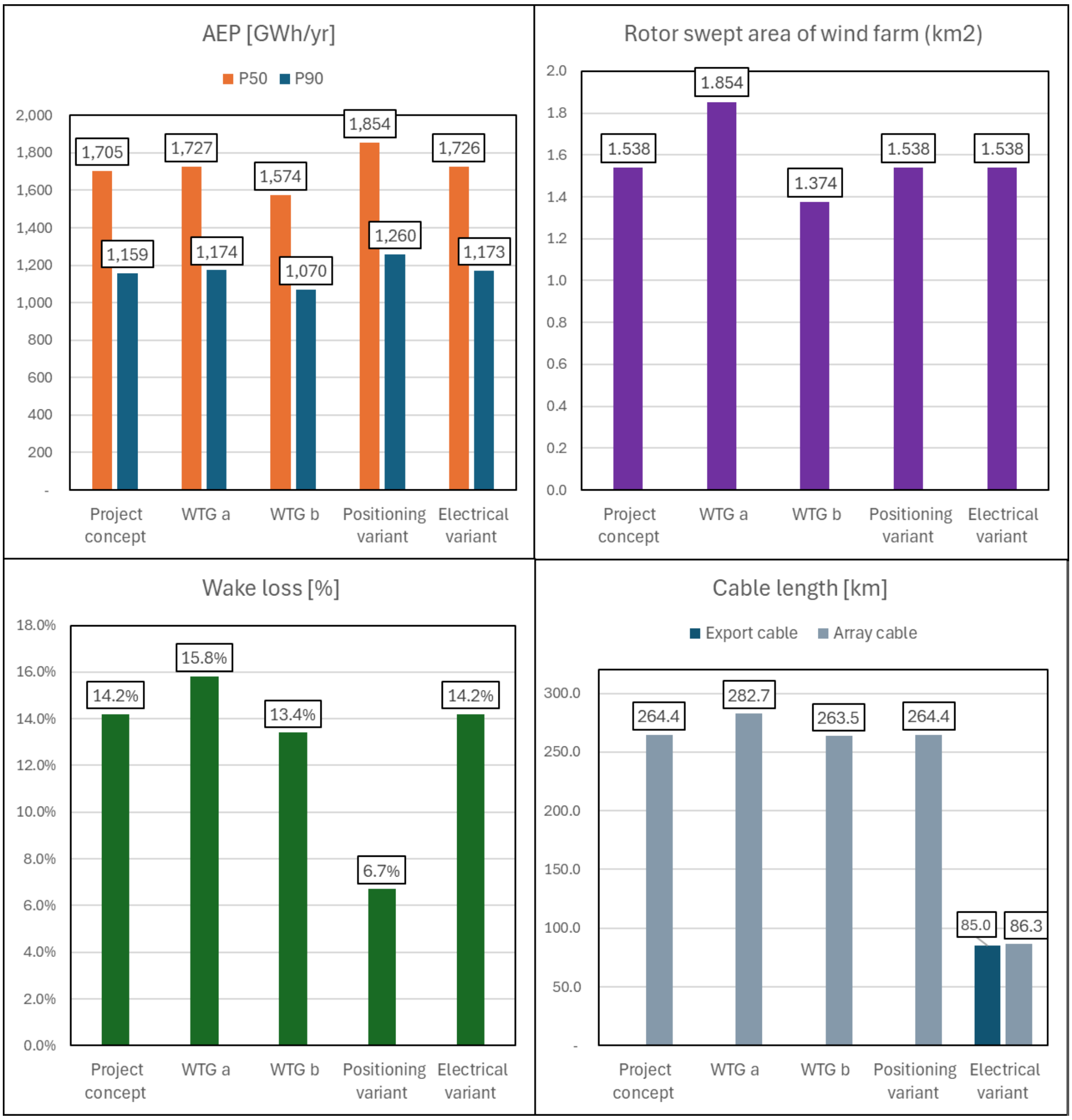


Mannar – variants results

The results of the Mannar variants are compared against the reference project concept and are shown graphically in Figure 68. The results show the following:

- The highest energy yield was calculated for the positioning (layout) variant. Compared to the reference project concept, the wake loss is sharply reduced from 14.2% to 6.7%. Although the positioning variant is not an optimised wind farm layout, the results show that the wake effect significantly affects the wind farm performance.
- A large WTG model, such as in variant WTG b (using WB-18-250 as WTG model), does not lead to higher production. The results show a 7.6% AEP decrease compared to the reference project concept. This is likely due to the low cumulative swept area of all rotors of the wind farm as this turbine is optimised for higher wind speeds.
- The reference project concept and the 'variant WTG a' (using WB-8.6-200 as WTG model) have similar energy yield values. The LCoE cost model, as described in Section 3.6, should determine whether the slightly higher energy yield in 'variant WTG a' is offset by the higher capital costs of more wind turbines.
- The electrical variant has a slightly higher energy yield (+1.2%), since the cable length is significantly reduced by +35.2%, uses a different cable type and electricity is transported at high voltage for longer.

Figure 68 Comparison between reference project concept and variants for Mannar



Puttalam – WTG variants

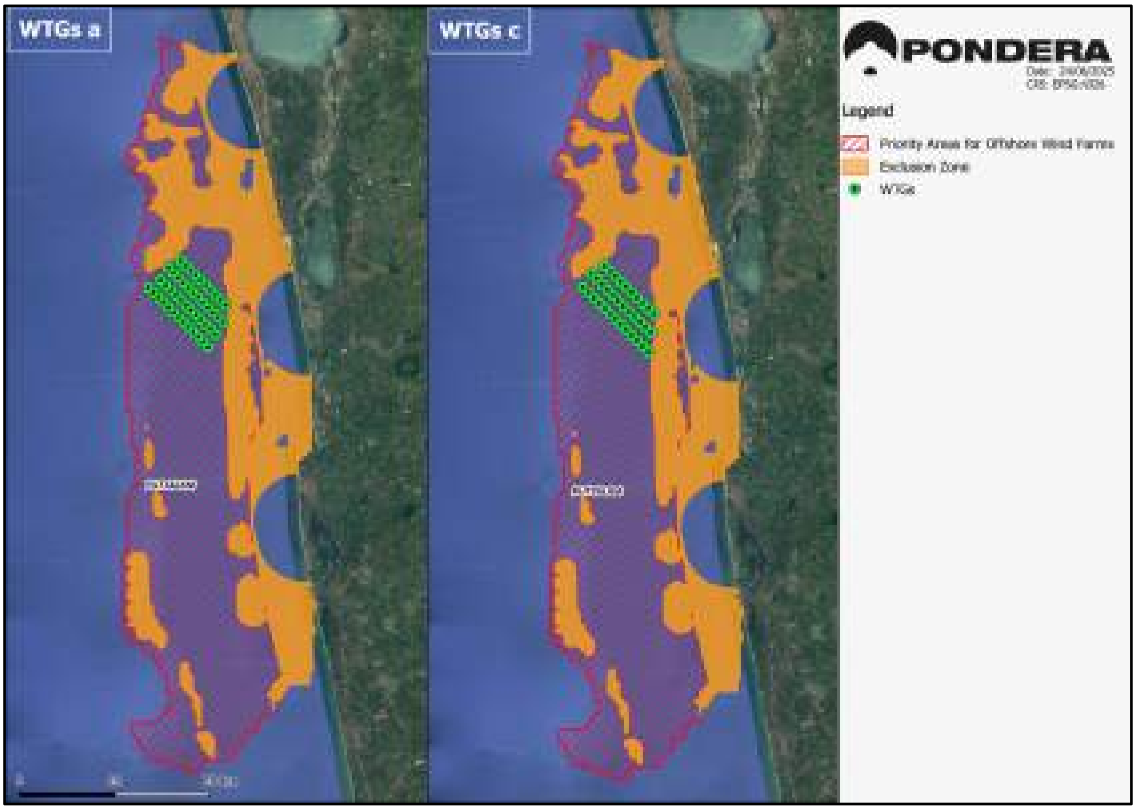
The present 15 MW IEA model is classified as an IEC Class I wind turbine, which is designed for higher wind speed than was found at the project site. The wind turbine model selection, especially the combination of rated power and rotor diameter, has an impact on the energy yield and LCoE. Two variations have been scrutinized for Puttalam and are selected based on a low power-to-rotor ratio (W/m^2). Variant ‘WTG c’ uses the WTG model Goldwind GW184/6.45MW, and ‘WTG a’ is the Everoze WTG model ‘WB-8.6-200’[48]. Due to the high power-to-rotor ratio the Everoze WTG model ‘WB-18-250’ has not been included as a variant, as this IEC I class wind turbine model is not deemed suitable for this location. An overview of selected wind turbine models is presented in Table 20. The variations for WTG a and WTG c are shown in Figure 69.

[48] For both Mannar and Puttalam, the following ‘WTG variants’ are used: ‘WTG a’ = 8.6 MW, ‘WTG b’ = 18 MW, ‘WTG c’ = 6.45 MW

Table 20 Design assumptions WTG c and a variant in relation to project concept Puttalam

Component	Project concept	WTG c	WTG a
WTG dimensions			
WTG type	IEA-15MW	GW184/6.45MW	WB-8.6-200
Rotor diameter (m)	240	184	200
Hub height (m)	150	150	125
WTG rated capacity (MW)	15	6.45	8.6
Power-to-rotor ratio (W/m^2)	331.6	242.6	273.7
Wind farm dimensions			
# of WTGs	34	78	59
Wind farm - total capacity [MW]	510	503.1	507.4
Wind farm crosswind WTGs (max in row)	9	14	15
Wind farm downwind WTGs (max in row)	4	6	5
#WTGs on 1 string (132kV)	9	21	16
Rotor swept area of wind farm (m2)	1,538,124	2,074,054	1,853,540
Rotor swept area of wind farm (m2/MW)	3,016	4,123	3,653

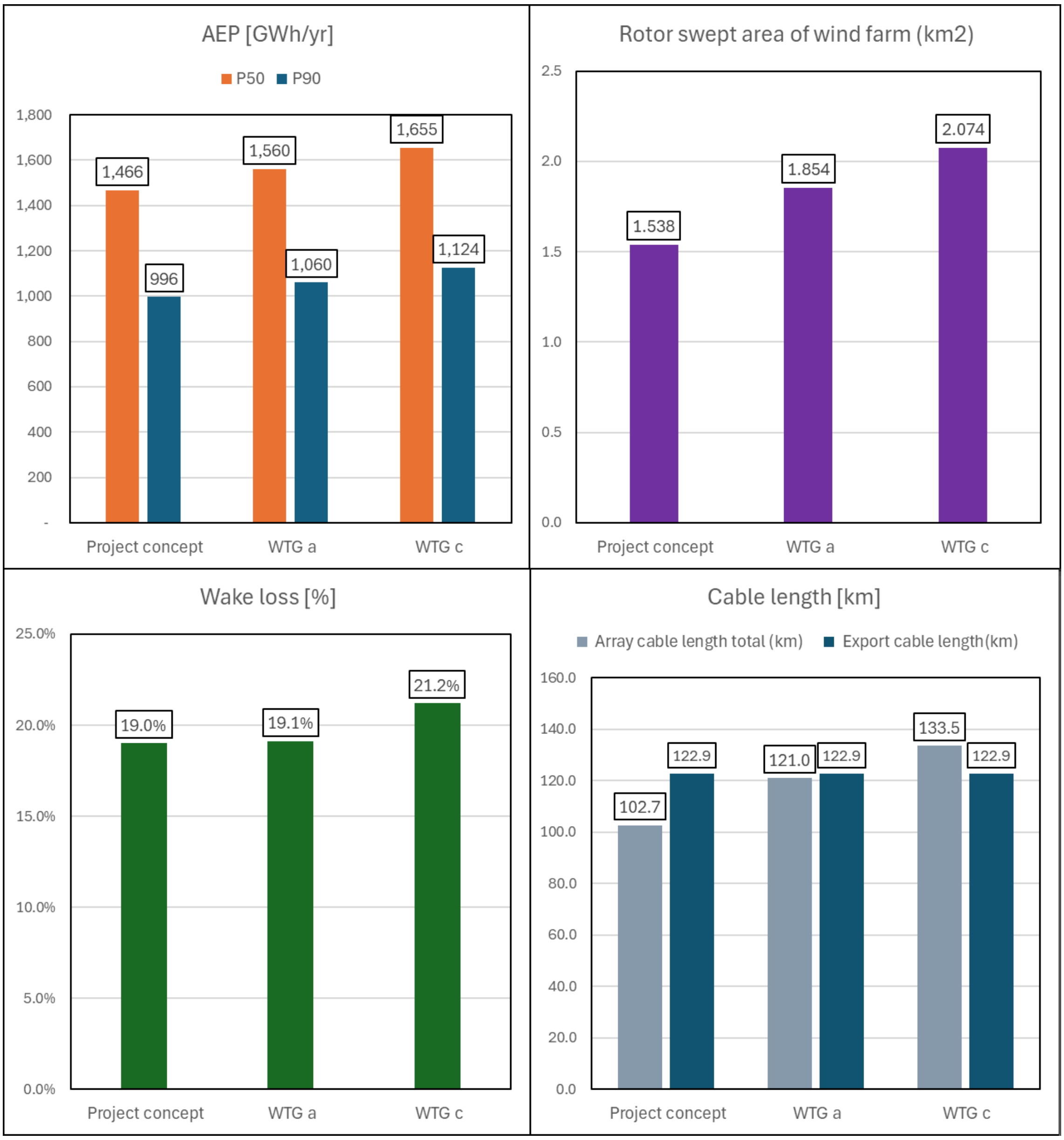
Figure 69 WTG a and c variations for Puttalam



The results of the Puttalam variants are compared against the reference project concept and are shown graphically in Figure 70. The results show the following:

- The highest energy yield is calculated for 'variant WTG a' with the Goldwind GW184/6.45MW as the selected WTG model. This is explained by the low power-to-rotor ratio as well as the high rotor swept area of the wind farm. The LCOE cost model, as described in Section 3.6, should determine whether the higher energy yield in 'variant WTG a' is offset by the higher capital costs of adding more wind turbines.
- The wake effects and cable lengths of all variants are relatively similar, with slightly higher wake losses at 'variant WTG a'.

Figure 70 Comparison between the reference project concept and variants for Puttalam



3.6 Levelised cost of energy (LCoE)

This section describes the LCoE analysis that is executed to test the financial feasibility of the project concept variants introduced in the energy yield modelling part. First, the cost parameters, scenarios, and assumptions will be elaborated, followed by the results, sensitivity analyses, and discussion.

3.6.1 Costs parameters, scenarios and assumptions

General introduction and method

Similar to other energy-generating facilities, building and exploiting an offshore wind farm requires major investments. Capital is needed to construct all required infrastructure and to maintain and insure all assets on an annual basis. In order to analyse whether an offshore wind farm can be financially feasible, the total costs are often calculated and compared with the amount of energy generated. The cost per unit of energy, is a useful metric that can be compared with the cost of electricity in the region and the costs of other methods of generating electricity.

The following formula from the was used to calculate the LCoE:

$$LCoE = \frac{I_0 + \sum_{t=0}^{n} \frac{M_t}{(1+r)^t}}{\sum_{t=0}^{n} \frac{E_t}{(1+r)^t}}$$

I_0: total investment costs in year 0 (that is: during the two-year construction period)
M_t: Operation & Maintenance (O&M) costs in year t
E_t: energy generation in year t
r: discount rate. The discount rate is the Weighted Average Cost of Capital (WACC).
n: project lifetime
t: year

The LCoE was calculated for the project concepts within the two project areas in Mannar and Puttalam. Moreover, to what extent the LCoE varies, was calculated if:

- a different price level comes into effect (based on cost scenarios);
- the layout choice is varied, other turbines are used, or the electrical system is altered (based on project concept variants);
- certain cost items become more or less expensive (based on a sensitivity analysis).

Review cost parameters

General principles and references

The costs of offshore wind depend strongly on the chosen price level of inputs. Prices have risen sharply in recent years. This has been taken into account in this LCoE study. As a start, values are presented for cost parameters, assuming that the current prices (2024) will remain the same until the moment of procurement (in 2028) and no indexation takes place. From 2028 onwards, indexation will be applied to both CAPEX and OPEX. The Section Cost scenarios elaborates on the two other cost scenarios used: a) the price level of some years ago, and b) the price level when a local supply chain is used.

Input for this study originates from a desk study, as well as various national and international industry experts. This includes experts who have been involved in various recent offshore wind projects across the world. From this, intelligence has been obtained about current market information that is hard to find in publicly available sources. Furthermore, information was used from a recent LCoE study of offshore wind in India (LCOE study of India (FIMOI version 2, April 2022)) to crosscheck assumptions and outcomes.

In order to calculate the LCoE for the different cost scenarios and project concept variants, insight is required for:

- Project lifetime;
- Investment costs (hereinafter CAPEX);
- Annual O&M costs (hereinafter OPEX);
- Discount rate or WACC;
- Annual amount of energy produced (from Section 3.5).

Each component is described in more detail below.

Project lifetime

The wind farm is assumed to become operational in 2032 and run for 30 years. This period of operation is common in the current offshore wind industry. Assumptions on project lifetime are provided in Table 21.

Table 21 Assumptions on project lifetime

Aspect	Value	Unit
Starting date operations	1-1-2032	date
Starting date construction	1-1-2030	date
Total period of construction	24	months
Number of operational years	30	years
Procurement start / Price level	2028	year
Indexation on CAPEX	3.0	%

Capital Expenditures (CAPEX)
The CAPEX includes all investment costs, such as the cost of wind turbines, foundations, electricity cables, substations, construction supervision costs and development costs. Table 22 provides information on various CAPEX cost items as used in this study. The CAPEX will be indexed by 3.0 percent from 2028 onwards (regardless the cost scenario).

Table 22 Substantiation of CAPEX cost items

Item	Value	Unit
Wind turbine	22	M USD per turbine
Foundation	11	M USD per turbine
Inter array cables	1.2	M USD per km
Onshore export cables - overhead lines	0.75	M USD per km
Onshore substation and grid connection	55	M USD per wind farm
Construction costs and guidance (insurance, project management)	125	M USD per wind farm
Financing costs	1.5	% on financing share
Development Expenditures (Devex)	75	M USD per windfarm
Decommissioning wind farm and infrastructure	-	M USD per windfarm

Based on typical European offshore projects, foundation transportation and installation are assumed to be 3 days on average per foundation (including weather delay) and WTG installation 2 days on average.

Table 23 and Table 24 indicate the CAPEX for the reference project concepts for Mannar and Puttalam, respectively. The tables show that the total investment costs for Mannar are almost 1.8 billion USD. Per installed MW this is 3.6 million USD. For Puttalam – reference project concept the CAPEX is 3.5 million USD per installed MW. The difference between Mannar and Puttalam lies in the distance to the shore and to the grid.

Table 23 CAPEX Mannar - reference project concept

Item	Total wind farm	Per MW	Unit
Wind turbine	758	1.5	M USD
Foundation	364	0.7	M USD

Inter array cables	317	0.6	M USD
Grid connection	10	0.0	M USD
Construction costs and guidance (insurance, project management)	125	0.3	M USD
Financing costs	18	0.0	M USD
Development Expenditures (DevEx)	75	0.2	M USD
Unforeseen (8%)	127	0.3	M USD
Total CAPEX investment	1,794	3.6	M USD

Table 24 CAPEX Puttalam – reference project concept

Item	Total wind farm	Per MW	Unit
Wind turbine	758	1.5	M USD
Foundation	364	0.7	M USD
Inter array cables	123	0.2	M USD
Export cable onshore - overhead lines	92	0.2	M USD
Onshore substation and grid connection	55	0.1	M USD
Construction costs and guidance (insurance, project management)	125	0.3	M USD
Financing costs	17	0.0	M USD
Development Expenditures (DevEx)	75	0.2	M USD
Unforeseen (8%)	123	0.2	M USD
Total CAPEX investment	1,732	3.5	M USD

Operational Expenditures (OPEX)

The OPEX includes the annual recurring costs such as maintenance, operational costs (wind farm management) and the property tax on the assets. Table 25 provides information on OPEX cost items as used in this study. The OPEX will be indexed by 5.0 percent from 2028 onwards (depending on the cost scenario). This corresponds to the inflation value as used in the recent LCoE study for offshore wind in India.

The operational costs are higher for Mannar than for Puttalam (55 million USD versus 45 million USD). This has to do with the distance of the wind farms to the coast. The Mannar project is more than 30 km from the coast, which means maintenance will take more time and incur higher costs. The Puttalam project is located a few kilometres from the coast, which means maintenance can be carried out more quickly.

Table 25 Substantiation of OPEX cost items

Item	Mannar – reference project concept	Puttalam - reference project concept	Unit
Operational management, insurance and maintenance	55	45	M USD per windfarm per year
Property tax	0.3	0.3	%

Discount rate and WACC calculation

Cost of capital is relevant for both the financing and the equity share. In order to determine the cost of capital, common interest rates that financiers are likely to charge have been investigated, as well as a common rate for cost of equity. Table 26 provides the input for the WACC calculation.

Table 26 Input for the WACC calculation

Item	Share / interest
Financing share	75%
Interest rate	8%
Equity share	25%
Cost of equity	10%

The WACC can be calculated from these parameters. A WACC of 8.5% applies to the above parameters. The WACC varies between the cost scenarios.

Cost scenarios

In this LCoE study, the following three cost scenarios are considered:

- Cost scenario 1: The relatively high price levels of 2024 will remain unchanged in the coming years;
- Cost scenario 2: Current prices will drop back to the 2019 price levels (before the Covid outbreak and the war in Ukraine, which both resulted in an increase in costs due to inflation, higher interest rates and commodity price increases);
- Cost scenario 3: The Price level of 2028 with a local supply chain (assuming that the APAC region's offshore wind market experiences strong growth in the coming years, causing the prices to drop, both because of economies of scale and relatively cheap local labour).

Each cost scenarios is explained in more detail below.

Cost scenario 1: current price level

In recent years, the cost of global offshore wind has increased significantly. While it was common in the late 2010s to construct offshore wind farms at 2.5 to 3 million USD per MW, today it is often the case that the price is 4 million USD per MW. This holds for offshore wind farms all around the world. The sharp increase was initiated when COVID-19 broke out and put significant pressure on supply chains. Commodity prices and interest rates have also risen due to the war in Ukraine and other macroeconomic factors.

For cost scenario 1, it is assumed that today's prices stabilize until the moment of procurement (in 2028). Costs will not be indexed between 2024 and 2028.

Cost scenario 2: price level before COVID19 and war in Ukraine
Before the war in Ukraine and before COVID-19, prices were relatively stable for several years. Costs at the time were approximately 20% lower than the current price level.

For this cost scenario, it is assumed that in 2028, today's prices will have been reduced to the price level of approximately 5 years ago (will be further described below).

Cost scenario 3: price level when using a well-developed local supply chain
In recent years, the market in the APAC region for offshore wind farm components has grown. Wind farms are being / have been developed in China, Japan, Korea, Taiwan and India. If the development of the supply chain continues to grow, particularly in China, it is likely that Sri Lanka can make (partial) use of this local supply chain by the time 2028 is reached. This could result in a cost advantage compared to prices of a Western supply chain.

For cost scenario 3, it is assumed that in 2028 the costs will be lower than today due to cost advantages in the local supply chain in the APAC region. This is implemented by reducing today's prices (see next section) and by not applying indexation until the moment of procurement in 2028.

Implementation of the cost price scenarios in the LCoE
The current price level (cost scenario 1) is treated as 100%. A falling price level (cost scenario 2) reduces all CAPEX, OPEX and interest on financing by 20% (which impacts the WACC). For a price level based on a strongly grown, local supply chain in the APAC region (cost scenario 3), a reduction of 30% applies. This creates a bandwidth of 70 to 100% of the prices of 2024. We show this bandwidth in all results.

Interpretation of results
With this approach to various cost price levels, the results of the LCoE study provide a first glance at the actual costs of offshore wind. In practice, certain cost items may be estimated fairly well, while other cost items may be over- or underestimated. For example, the Asian market can develop enormously in the coming years, making it competitive and enabling cheap O&M services, as well as local supply chains with turbines and foundations cheaper than estimated. If so, the LCoE moves towards the lower end of the bandwidth (70%). It may also be that the local supply chain partly reduces costs, but that steel prices continue to rise, so that the LCoE does not change in practice.

Disclaimer: The fact that the above cost scenarios are included in the LCoE calculation and analysis does not say anything about the likelihood that a certain cost scenario will actually arise. All cost scenarios are considered to be hypothetical.

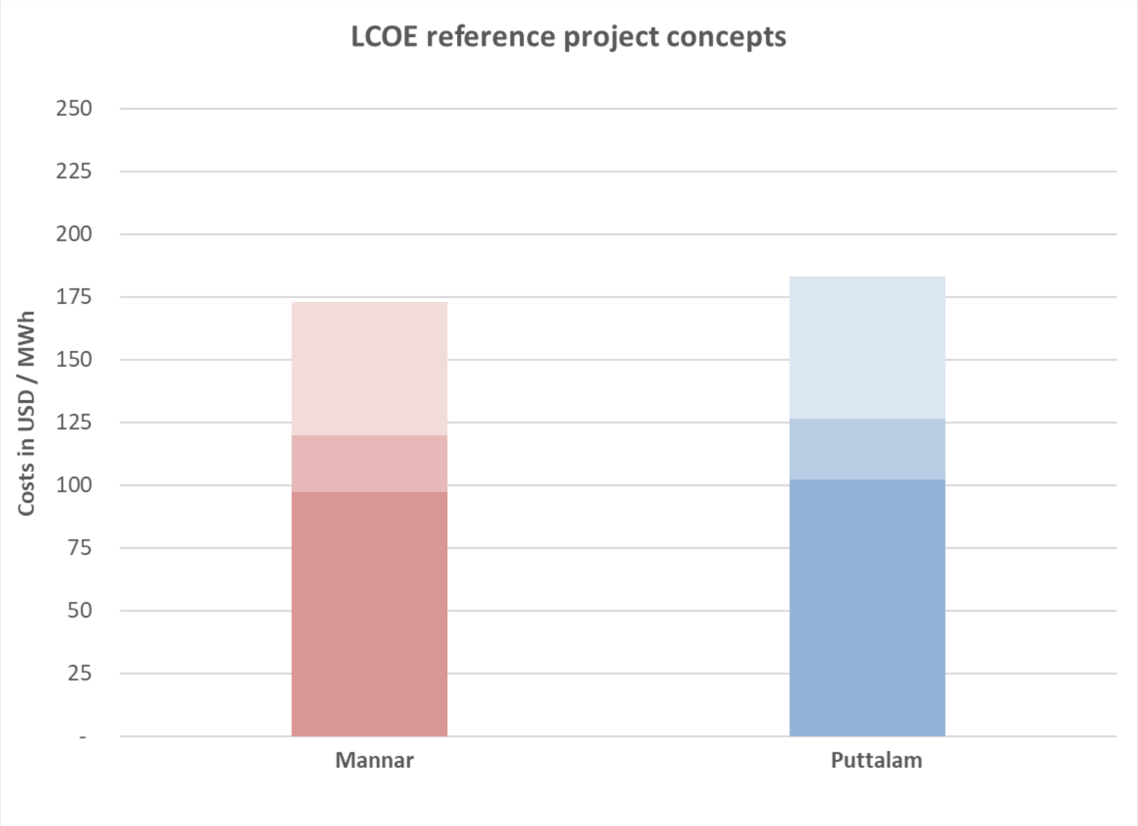
3.6.2 Results

This section provides the results of the LCoE analysis for the reference project concepts and the variants.

Results reference project concepts

The LCoE for the Mannar reference project varies between 97 USD / MWh and 173 USD / MWh. For the Puttalam reference project concept, the LCoE for different cost scenarios varies between 102 USD / MWh and 183 USD / MWh. This is shown in Figure 71.

Figure 71 LCOE for reference project concepts. Darker colours being the lower cost bound (i.e. 70%) and lighter colours being the surplus for the 80% and 100% cost bounds



When further analysing this LCoE, it turns out that the CAPEX has more effect on the LCOE's magnitude than the OPEX. This is listed in Table 27 for both Mannar and Puttalam.

Table 27 Subdivision of CAPEX and OPEX for both reference project concepts

Cost item	Local prices (70%)	Lower prices (80%)	Current prices (100%)	Unit
Mannar – reference project concept				
CAPEX	57	72	105	USD / MWh
OPEX	40	48	68	USD / MWh
Total LCoE	97	120	173	USD / MWh
Puttalam – reference project concept				
CAPEX	64	80	118	USD / MWh
OPEX	38	46	65	USD / MWh

Cost item	Local prices (70%)	Lower prices (80%)	Current prices (100%)	Unit
Total LCoE	102	127	183	USD / MWh

Results variants

Mannar

The CAPEX and OPEX values for the variants at Mannar are provided in Table 28 and Table 29 respectively. The CAPEX differs between the variants. For variant 'WTG a' and 'WTG b' the amount of wind turbines is different and for variant 'Electrical' an expensive offshore substation is included. The differences in OPEX are related to the number of wind turbines and for variant 'Electrical' to the fact that maintenance of the offshore substation is needed. The values are based on cost scenario 1 (current prices).

Table 28 CAPEX for variants at Mannar

Variant	Total wind farm	Per MW	Unit
Reference project concept	1,794	3.6	M USD
WTG a	2,151	4.2	M USD
WTG b	1,696	3.4	M USD
Positioning	1,794*	3.6	M USD
Electrical	1,883	3.7	M USD

** Additional costs for extra infrastructure in the variant positioning (such as longer cables) are negligible.*

Table 29 OPEX for variants at Mannar

Variant	Total wind farm	Unit
Reference project concept	55	M USD / year
WTG a	60	M USD / year
WTG b	50	M USD / year
Positioning	55	M USD / year
Electrical	60	M USD / year

The calculation of the LCoE is based on the current price level (100%), a lower price level (80%) and local prices (70%). The calculated LCoE for the variants are provided in Table 30 and graphically in Figure 72.

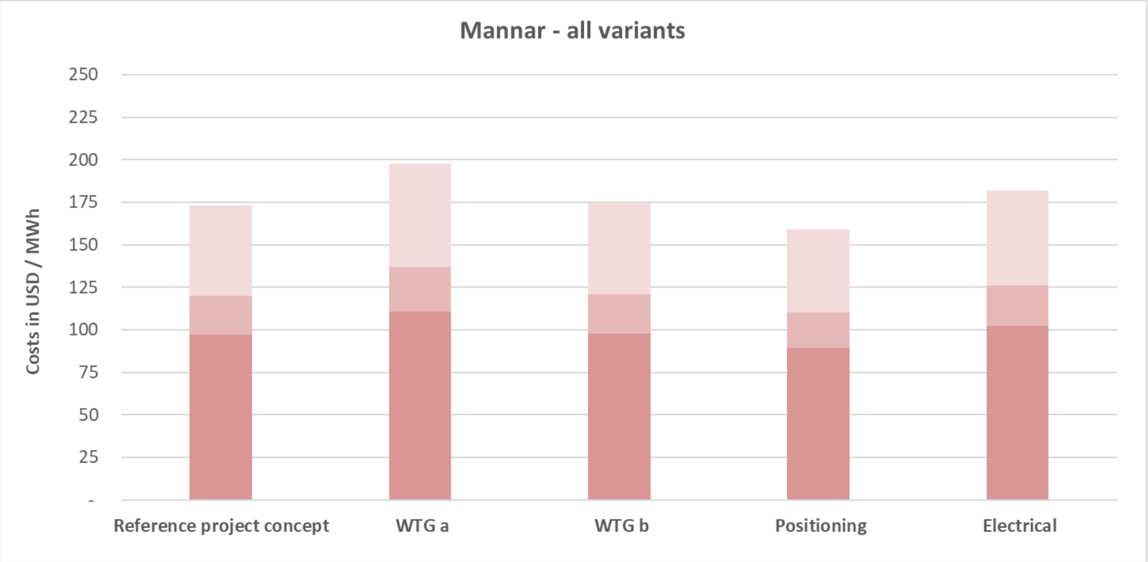
The results below show a range in the LCoE between the variants. It can be observed that:

- the variant with an alternative layout setup (Mannar – positioning) has the lowest cost price between 89 USD/MWh and 159 USD/MWh.
- the energy costs do not decrease when a different wind turbine type is chosen (variants WTG a and b).

Table 30 LCoE results for variants at the Mannar site

Cost item / Cost scenario	Local prices (70%)	Lower prices (80%)	Current prices (100%)	Unit
Reference project concept	97	120	173	USD / MWh
WTG a	111	137	198	USD / MWh
WTG b	98	121	175	USD / MWh
Positioning	89	110	159	USD / MWh
Electrical	102	126	182	USD / MWh

Figure 72 LCoE results for variants at the Mannar site. Darker colours being the lower cost bound (i.e. 70%) and lighter colours being the surplus for the 80% and 100% cost bounds



Puttalam

The CAPEX and OPEX values for the variants at Puttalam are provided in Table 31 and Table 32 respectively. The CAPEX differs between the variants as the amount of wind turbines is different. The same holds for the differences in OPEX. Values are based on cost scenario 1 (current prices).

Table 31 CAPEX for variants at Puttalam

Variant	Total wind farm	Per MW	Unit
Reference project concept	1,732	3.5	M USD
WTG a	2,369	4.7	M USD
WTG b	2,089	4.1	M USD

Table 32 OPEX for variants at Puttalam

Variant	Total wind farm	Unit
Reference project concept	45	M USD / year
WTG a	57.5	M USD / year
WTG b	50	M USD / year

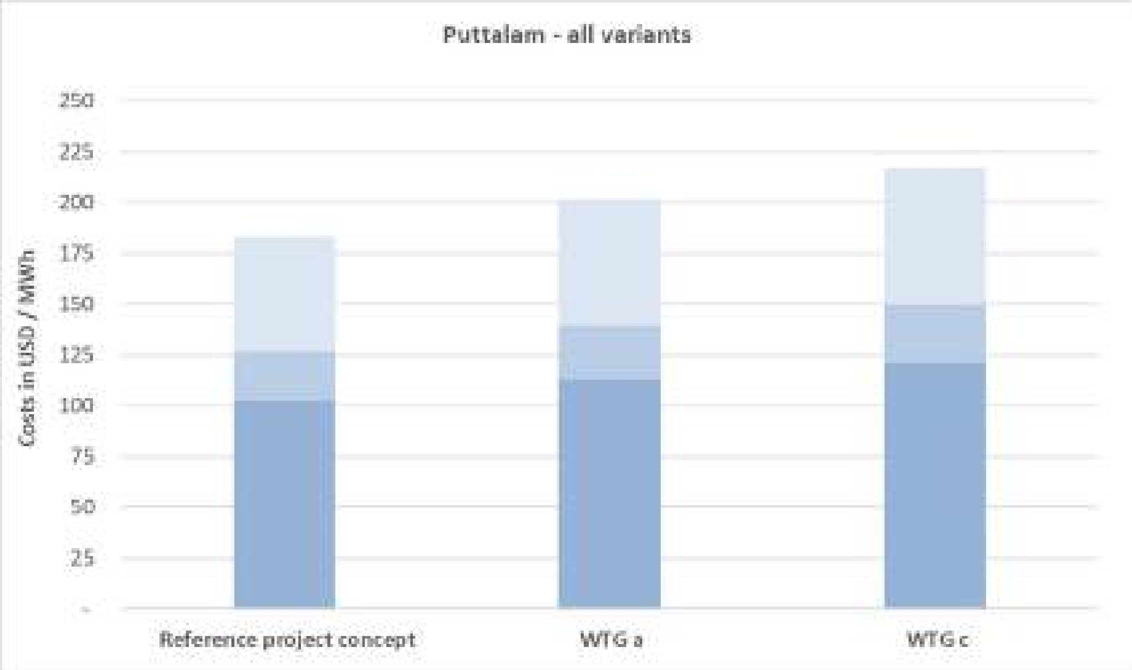
The calculation of the LCoE is based on the current price level (100%), a lower price level (80%) and local prices (70%). The calculated LCoE for the variants are provided in Table 33 and graphically in Figure 73.

The results show a range in the LCoE between the variants. The calculation shows that Puttalam – reference project concept has the lowest cost price from 102 USD / MWh to 183 USD / MWh. Furthermore, it appears that the energy costs do not decrease when a different wind turbine type is chosen (variants WTG a and b). This is mainly because the CAPEX for those variants (with more wind turbines) is a lot higher.

Table 33 LCoE results for variants at the Puttalam site

Cost item / Cost scenario	Local prices (70%)	Lower prices (80%)	Current prices (100%)	Unit
Reference project concept	102	127	183	USD / MWh
WTG a	121	150	217	USD / MWh
WTG b	113	140	202	USD / MWh

Figure 73 LCoE results for variants at the Puttalam site. Darker colours being the lower cost bound (i.e. 70%) and lighter colours being the surplus for the 80% and 100% cost bounds



3.6.3 Sensitivity analysis

A sensitivity analysis was conducted to evaluate the impact of the following parameters on the LCoE outcomes:

- Operational and Capital Expenditures;
- Indexation (e.g. inflation) on the OPEX and WACC;
- Price level.

The sensitivity analysis was carried out for the reference project concept of Mannar.

Operational and Capital Expenditures

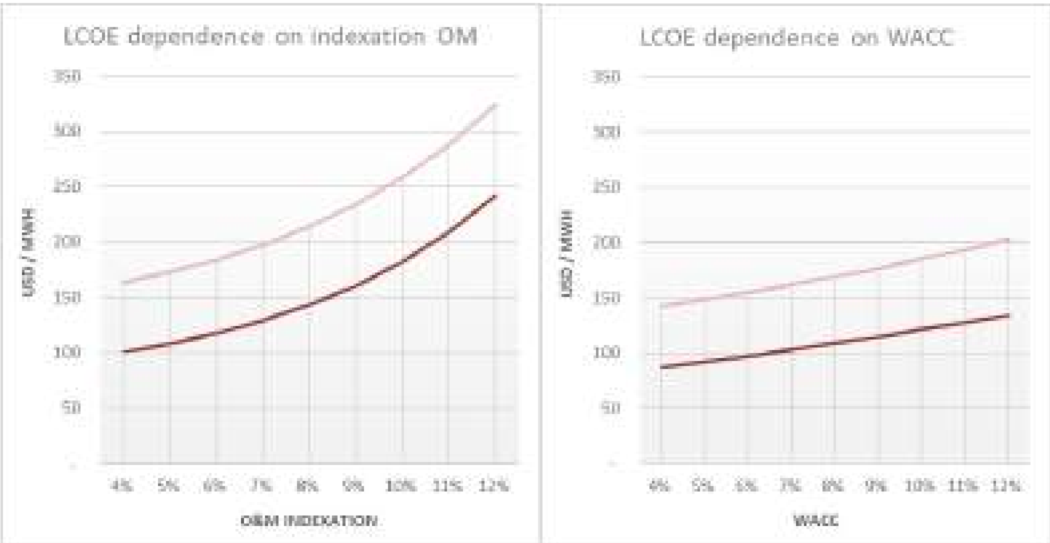
Figure 74 (left) shows the alteration of the LCOE if the Operation and maintenance costs would vary between 40 and 80 million USD per year. Figure 74 (right) shows the alteration of the LCOE if the Capital investments would vary between 2.5 M USD / MW and 5.0 M USD / MW.

Figure 74 LCoE results in case of changing Indexation on OPEX (left) and WACC (right). Darker colour being the local prices (70%) and lighter colour representing the current prices (100%)

Indexation on OPEX and WACC

Figure 75 (left) shows the alteration of the LCOE if the indexation on OPEX would vary between 4% and 12%. Figure 75 (right) shows the alteration of the LCOE if the WACC would vary between 4% and 12%.

Figure 75 Impact of OPEX Indexation and WACC Variation on LCoE. Darker colour being the local prices (70%) and lighter colour representing the current prices (100%)



Price level

Figure 76 shows the alteration of the LCOE if the price level would vary between 60% and 140% relative to current prices.

Figure 76 LCoE results in case of changing price level

3.6.4 Discussion results

The results show that with current prices (cost scenario 1) the LCoE varies between 159 (most favourable variant for Mannar) and 183 (most favourable variant for Puttalam) USD per MWh. The study shows that the LCoE for Mannar is on average lower (i.e. more favourable) than the LCoE for Puttalam. This is mostly due to the higher wind speeds found at the Mannar site. As Puttalam's proximity to shore offers benefits by way of lower costs, the difference in LCoE between the two sites is not that large. The lowest identified LCoE for Mannar is achieved at 89 USD per MWh, assuming a 30 percent cost reduction scenario and employing a layout with reduced wake losses compared to the reference project concept.

We compare the results with the previous report prepared for Sri Lanka (Roadmap) and a recent LCoE study carried out for offshore wind for India (FIMOI).

Roadmap

The Roadmap indicates that with a WACC of 8 percent, the LCoE was calculated to be 101 USD/MWh. At a WACC of 10 percent, the LCoE is 116 USD/MWh. These figures are lower than those found in this study. The primary reason for this discrepancy lies in the Roadmap's assumption of a very low CAPEX: it assumes a mere 2.5 million USD per MW. However, this is no longer considered realistic given current market conditions. In contrast, this study adopts an approximate figure of USD 3.5 million per MW for the reference project concepts (excluding decommissioning costs), and more than USD 4 million per MW for certain variants.

LCoE study India

The LCoE study of India (FIMOI version 2, April 2022) shows a bandwidth of 142 and 198 USD / MWh[49], depending on the chosen site. Considering the assumptions of the report, they are partly comparable to the assumptions in this study. This explains the similarity in the order of magnitude of the LCoE.

3.6.5 Electricity costs and prices in Sri Lanka

This section will delve into the topic of electricity costs and prices in Sri Lanka to gain a better understanding of future offtake scenarios. Initially, more context will be provided about the current landscape of costs and prices, comparing them with those in the region. Following this, an outlook of generation costs will be presented, with a brief discussion on the potential impact of the interconnector. Finally, an explanation will be provided on why a simple comparison between LCoE, and cost/price forecasts is insufficient for assessing offtake scenarios.

Current prices and costs

Table 34 presents an overview of the average selling price and average cost of electricity in Sri Lanka in recent years. Generally, the country's electricity industry encounters numerous challenges, including the high cost of generation, and inadequate investment in modernization of transmission and distribution infrastructure. The significant reliance on imported liquid fossil fuels poses substantial risks to energy security and sustainability. For a considerable period, Sri Lanka did not enforce a cost recovery tariff in the electricity sector due to non-implementation of provisions in the electricity act and the tariff methodology. This situation resulted in the financial insolvency of CEB[50], as costs where higher than prices (see Table 34). To address these negative impacts, prices were increased starting in late 2022.

Table 34 Sri Lanka: Average Selling Price and Average Cost 2012-2023[51]

Year	Unit	2012	2013	2014	2015	2016	2017
Average cost at selling point	(LKR/kWh)	23.66	16.94	20.00	15.07	18.08	20.34
	USD/MWh	185.4	131.2	153.2	110.9	124.1	133.3
Average selling price	(LKR/kWh)	15.56	17.93	18.50	16.00	16.18	16.26
	USD/MWh	121.9	138.9	141.7	117.7	111.1	106.6
Year	**Unit**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023***
Average cost at selling point	(LKR/kWh)	19.12	24.12	21.67	19.42	33.65	-
	USD/MWh	117.6	134.9	116.8	97.6	103.6	-
Average selling price	(LKR/kWh)	16.29	16.63	16.72	16.37	21.24	47.23
	USD/MWh	100.2	93.0	90.1	82.3	65.4	144.2

[49] In the LCoE study for India, the LCoE was calculated for several price levels. The report assumes that the costs of wind energy will decrease in the coming years because the local supply chain will grow, and that costs in 2025 will already be ~25% lower than costs in 2020. In practice, however, the supply chain in the APAC region has grown less than predicted in that report. Therefore, it is considered more realistic to use the 2020 LCoE values (rather than the 2025 values) as a benchmark for the LCOE values in this study.

[50] Discussions are ongoing for a new electricity law to restructure the CEB, separating its functions into distinct corporations. This law, to be implemented in stages, includes reforms like transitioning to a competitive generation market, with significant impacts on market dynamics and pricing.

[51] Source: Ceylon Electricity Board, Annual Report 2021 and CEB Statistical Digest 2022

*[Addition to previous table: *CEB has not yet published the costs for 2023. Therefore, it is not possible to indicate the average cost at the selling point. The average selling price for 2023 was calculated, based on the information in the tariff determination.]*

Currently, the government plans to revise electricity tariffs once every six months, as stipulated in the tariff methodology and associated rules. The calculated national average price after recent revisions is provided in Table 35, indicating the current national average all-inclusive price of electricity to be LKR 37.62 per kWh.

Table 35 Recent periodic revisions of the electricity tariffs

Tariff revision year and month	Revised all-inclusive national average tariff (LKR/kWh)	Increased/decreased percentage
2022 August	29.92	-
2023 February	46.65	56%
2023 July	40.87	-12%
2023 October	48.23	18%
2024 March	37.62	-22%

Table 36 displays the PCUSL[52]-approved supply costs, including cost breakdown. The approved supply cost for 2024 is LKR 41.57 per kWh (129.1 USD/MWh), potentially resulting in a cash deficit for CEB in the first half of 2024, as the estimated average selling price is LKR 37.62 per kWh (116.8 USD/MWh). To address this, PUCSL instructed CEB to reduce 2024 maintenance budgets by postponing planned generation maintenance. The energy component of generation costs is the highest, prompting CEB to seek reductions. Currently, CEB is conducting studies on long-term generation planning, and the next update is due by 2025. The planning exercise aims to minimize economic costs while maintaining the required reliability levels and adhering to policy guidelines.

Table 36 Cost of supply approved by PUCSL

Cost component	Total cost for 2024 (LKR million)	Cost for 2024 (LKR/kWh sold)	Cost for 2024 (Equivalent USD/MWh sold)
Generation Capacity	65,368	4.50	14.0
Generation Energy	361,111	24.88	77.3
Transmission	22,490	1.55	4.8
Finance	42,731	2.94	9.1
Distribution: CEB	102,962	7.68	23.9
Distribution: LECO	8,558		
Total Cost of Supply	603,219	41.57	129.1

[52] Public Utilities Commission of Sri Lanka

Sri Lanka’s prices compared to those of other countries in the region

Sri Lanka's electricity prices are high compared to other countries in South and Southeast Asia. According to a recent study by RMA, prices in Sri Lanka were found to be the highest, second, or third highest among countries in the region. The main reasons for this are primarily the reliance on liquid fuel for power generation and overpriced purchases of renewable energy for the grid.

Forecasting generating costs

To get an indicative forecast of generating cost for this study, the average generation costs of the presently approved CEB’s Long Term Generation Expansion Plan (LTGEP) were evaluated.

For reference, CEB’s LTGEP (the most recent version 2023-2042)[53] adheres to the following assumptions and policies:

- Sri Lanka’s electricity sales are expected to grow at 6% per year over the 10-year period 2023-2032, while the longer-term growth will be 5% per year.
- Sri Lanka will endeavour to reach a 70% share of grid energy from renewable sources by 2030 (share in 2022 was 52%).
- Liquid natural gas (LNG) will supplant liquid fuel, currently utilized for providing balancing power to bolster renewable energy-based power generation and to provide support during the dry season (Sri Lanka’s energy share from hydropower is about 40%; the resource is subject to significant seasonality and inter-annual variations). This will be achieved through the conversion of existing oil-fired power plants to operate on regasified LNG or through the establishment of new LNG-powered plants.
- The coal-fired power plant, completed in 2014, will operate throughout the period, providing the technical stability and competitively priced electricity to the grid, as more intermittent and seasonal renewable energy sources dominate the generation mix.
- Battery storage will be added as stated in the plan. Their costs are reflected in the fixed costs and hence has no impact on the generation energy costs shown in Table 37.
- A pumped storage power plant of 4x350 MW will be commissioned over 2029-2032. Their costs are reflected in the fixed costs and hence has no impact on the costs shown in Table 37.

Following assumptions were made during the calculations:

- The fuel prices were assumed to be constant over the planning window and the figures were based on the current market prices. Coal (including delivery costs): 150 USD/MT, Natural Gas: 14 USD/MMBTU, Diesel: 1.11 USD/Litre.
- Sri Lanka Rupee will not appreciate or depreciate, and the exchange rate considered to be 322 LKR per USD.

The assessment using CEB's LTGEP was conducted for the scenarios described below and the results are outlined in Table 37. The lowest costs will be reached when LNG becomes available, and when procurement of renewable energy-based generation is on a competitive basis. The estimated lowest generation costs by 2030 will be 61.8 USD/MWh, compared with 77.3 USD/MWh in 2024:

- Base case: LNG availability begins in 2028, while renewable energy continues to be procured at current (2024) feed-in tariff (FiT) levels and through non-competitive methods.
- Case 2: LNG becomes available from 2028, and procurement of renewable energy shifts to competitive bidding.
- Case 3: LNG is unavailable throughout, and existing and new renewable energy generation continues under current FiT levels and non-competitive procurement.
- Case 4: LNG remains unavailable throughout, but new renewable energy generation transitions to competitive procurement.

[53] Long-term generation expansion plan 2023-2042, CEB, Sri Lanka

Table 37 Grid Average energy cost of generation (USD/MWh)

Case	LNG availability	Renewable procurement	2025	2030	2035	2040
Base case	2028 onwards	Feed-in-tariffs	92.4	75.4	86.1	91.5
Case 2	2028 onwards	Competitive	87.4	61.8	69.2	73.5
Case 3	None	Feed-in-tariffs	98.1	97.1	112.1	123.0
Case 4	None	Competitive	93.0	83.5	95.2	104.9

Source: Calculated based on information available in CEB's Long-term Generation Expansion Plan 2023-2042

Interconnector with India

The potential impacts of the India-Sri Lanka interconnector from a commercial standpoint are yet to be fully determined, particularly regarding the type of PPA between the two countries. However, insights from India's energy exports to neighbouring countries provide valuable context. Bangladesh, for instance, has established interconnections with India, importing significant amounts of power at an average purchase price of approximately 95.6 USD/MWh. Similarly, Nepal imports electricity from India around 80.0 USD/ MWh. India's short-term, day-ahead market prices fluctuate between 28.2 to 119.9 USD/MWh, indicating potential variability in pricing in a competitive environment. Nonetheless, it is anticipated that longer-term PPAs will likely offer more cost-effective solutions. A thorough modelling exercise would be required to assess the impact of the interconnection with India on the electricity prices, which is not within the scope of this study.

Comparison LCoE with electricity cost and price forecast

Section 3.6 above has provided a detailed assessment of the LCoE. The calculation considered investment, debt/equity ratio, interest on debt and return on equity, and maintenance costs. The benefit was considered to be the electricity production. The LCoE values derived for scenario 1 are 159 (Mannar) and 183 (Puttalam) USD per MWh. The lowest estimates (based on APAC supply chain benefits) are 89 (Mannar) and 102 (Puttalam) in USD per MWh.

To determine the future role of offshore wind energy in the Sri Lankan energy market, it is required to compare its LCoE with forecast generation energy costs. However, a simple comparison with the grid average energy cost is incorrect due to the wide-ranging costs of electricity production from renewable energy sources, varying from zero for large hydropower to 37 LKR per kWh (equivalent to 120 USD/MWh) for rooftop solar PV signed after August 2022, and up to approximately 100 LKR/kWh (330 USD/MWh) for the most expensive oil-fired power plant.

Evaluating the LCoE against the grid average energy cost requires a comprehensive understanding of how offshore wind contributes to the grid, especially which power plant is displaced by OWP, in each time interval. CEB's modelling interval for long-term planning is one month, and the planning window is 20 years. The impact of offshore wind on lowering the grid average energy cost is more significant when it can replace expensive oil-fired power plants compared with displacing hydropower, during the rainy season. Storage in hydropower reservoirs may have other restrictions, related to reservoir capacity, and committed releases of water to irrigation in downstream agricultural areas.

For example, the lowest grid average energy costs calculated for 2035 is 69.1 USD/MWh (see Table 37, case 2: LNG available, renewable energy on competitive bidding) but the lowest LCoE under all siting and assumptions is 89 USD/MWh (for Mannar, see Table 30). This makes offshore wind energy appear to be more expensive, but the power plants displaced by offshore wind energy in any given month will vary. Displaced generation may have an average avoided cost more or less than 89 USD/MWh. In the longer term, the levelized cumulative value of the mix of energy displaced in each modelling interval and the investments required on any additional storage on the grid to minimise curtailments, will be the benefit to the grid, which can then be compared with the levelized cost of OWP.

However, conducting such an assessment entails detailed modelling of power generation unit dispatches, which exceeds the scope of this pre-feasibility study. We recommend undertaking this rigorous analysis in a subsequent project phase, in collaboration with the CEB, in alignment with CEB's modelling approach. In such a study, Sri Lanka's power system can be modelled without any offshore wind capacity after 2035, to establish a reference case, calculating dispatches from all power plants, and the total system investment and operating costs. Thereafter, OWP can be introduced into the model at the specific capacities in each year from 2035, and the model can be reoptimized to calculate the new total system investment and operating cost. By comparing the difference between the two cases, converted to the basis of per kWh, compared against the calculated LCOE, would yield a strong indication of the value of offshore wind to Sri Lanka's power system.

By this time, it is most likely that battery storage and other forms of storage would be required, to manage the larger solar PV capacity and the seasonal wind power capacity on the grid. This calls for a more rigorous analysis of power plant dispatches over the long-term planning window capturing storage requirements, curtailments and demand- side management to achieve the most economical mix of power plants.

Uncertainties and mitigation strategies

Table 38 highlights the main uncertainties of this chapter and proposes mitigation strategies for future work.

Table 38 Uncertainties and mitigation strategies

Element	Uncertainties	Suggested mitigation strategy	Priority
Wind climate	The offshore wind climate assessment is based on modelled wind data (e.g. Vortex, ERA5), which carries significant uncertainty, especially in Puttalam, where strong offshore wind gradients may lead to over- or underestimation of wind speeds and yield. There is a lack of high-resolution, site-specific wind measurements offshore. These uncertainties affect energy yield predictions, layout design, and LCoE estimation.	Deploy site-specific wind measurement campaigns using floating LiDAR or scanning LiDAR systems to capture offshore wind speed and turbulence with high accuracy.	High
Project concept	4 project concept variants are investigated for Mannar, and 2 variants for Puttalam. This is a limited selection, not all design parameters have been meticulously evaluated.	Perform a sensitivity analysis on key factors with a large influence on the LCoE, such as WTG, spacing, water depth and distance to port.	Low

Element	Uncertainties	Suggested mitigation strategy	Priority
	A general description of the seabed characteristics has been used to determine the foundation concept. The on-site soil composition is unknown.	Perform a geotechnical survey to determine the soil composition at different depths.	High
	The wind farm layouts used in this study are not fully optimised, micro-siting has not been performed. Nevertheless, the approach is deemed suitable for the purpose of the study (compare differences)	Perform a layout optimisation study to determine AEP gains resulting from optimised micro-siting.	Low
Energy yield modelling	The chosen wake model (TurbOPark) is a simplified approach (though one of the industry standards). The TurbOPark model is developed by Ørsted are likely validated against European wind farms. As such, the model accuracy for projects in Asia is unknown.	Perform an ensemble analysis with multiple wake and flow models and include multiple model types. Next to linear engineering models, the application of CFD and LES models should be investigated.	Low
LCoE	This is the second LCoE study on offshore wind for Sri Lanka, with some extra detail in respect to the first Roadmap study. This study involves major uncertainties as it is very challenging to predict multiple factors in the future, especially in a rapidly changing industry like offshore wind. Uncertainties are related to aspects, but above all to technological choices, site-specific factors, policy dynamics, and market conditions.	Over time, and step by step the level of detail and accuracy should be improved to reduce uncertainties. Examples of next steps could be: - further improve the quality of on-site wind measurements, and the detail of the lay-out set-ups etc.; - contact suppliers to request quotes; - contact financial agencies to request under what conditions (interest, debt tenure) they might be willing to fund; - contact local authorities if they are planning on financial incentive mechanisms for offshore wind.	Medium
System value of	Offshore wind appears costly, but this overlooks which power plants are actually displaced. The mix varies	Conduct full power system dispatch modelling with and without offshore wind post-	High

Element	Uncertainties	Suggested mitigation strategy	Priority
offshore wind	over time, and avoided costs may be higher or lower. Current analysis lacks detailed dispatch modelling to assess this.	2035, in close collaboration with CEB. Compare total system investment and operating costs per kWh to offshore wind LCoE to assess net value. This will support a future business case.	

4 Port appraisal

4.1 Preamble

The realization of offshore wind is contingent upon various factors, including the establishment of efficient and well-equipped port infrastructure. This chapter provides a comprehensive appraisal of port capabilities in Sri Lanka, focusing particularly on their suitability for supporting offshore wind activities. The assessment encompasses three critical categories of offshore wind ports: fabrication ports, marshalling ports and operations & maintenance (O&M) ports. O&M ports for offshore wind are further distinguished into two categories: Service Operations Vessel (SOV)-based, and Crew Transfer Vessel (CTV)-based, resulting in a total of four port assessment categories. For a breakdown on the categorizations of offshore wind ports and a further explanation, please refer to Table 39.

Table 39 Explanation of the various type of ports for offshore wind

<table>
<tr><th>Fabrication port</th><th>Marshalling port</th><th colspan="2">O&M port</th></tr>
<tr><td rowspan="2">Also known as manufacturing port. This type of port is a specialized facility designated for the construction and manufacturing of (major) components essential for offshore wind projects. While fabrication ports ideally possess comparable capabilities to marshalling ports, they may have lower minimum capability requirements (i.e. Berths[54] at fabrication ports may not necessarily require accessibility by installation vessels, and constraints such as tidal windows and berth availability can be more tolerable).</td><td rowspan="2">Also known as installation port or assembly port. This type of port serves as an intermediary facility crucial during the construction phase of an offshore wind farm. Typically situated near the offshore wind farm construction site, these ports are often closer than most fabrication ports associated with the project. Their primary function is to serve as temporary storage or assembly points for major components, including foundation and turbine components, sourced from various manufacturing locations. These components are gathered, organized, and sometimes assembled at the marshalling port before transported for installation at the offshore site.</td><td colspan="2">O&M port is the type of facility that accommodate operation and maintenance activities of the offshore wind farm. There are two types of O&M ports: O&M ports that use SOVs and those using CTVs. O&M ports depending upon SOV and to a greater extent, CTV, is notably sensitive to the proximity to the offshore wind farm site.</td></tr>
<tr><td>SOV-based
For SOV-based O&M strategies, larger vessels capable of extended offshore operations are employed. SOV-based O&M ports typically necessitate deeper and longer berths to accommodate these larger vessels. They also offer greater flexibility in sharing berthing space with other port users and tolerating vessel access restrictions due to less frequent returns to port. Moreover, SOV-based ports may require fewer onshore facilities, as certain functions can be integrated onboard</td><td>CTV-based
For CTV-based O&M strategies, where vessels and technicians operate on a single-shift basis, O&M ports often utilize historic ports and harbours that may have experienced declines in traditional industries. These ports are tailored to accommodate the relatively small size of CTVs and prioritize accessibility for short-term stays.</td></tr>
</table>

[54] Berth and quay can be used interchangeably

Fabrication port	Marshalling port	O&M port	
		the vessels, such as marine control and technician welfare facilities.	

The potential synergies and collaborative opportunities are included in the analysis by assessing ports in neighbouring Tamil Nadu's offshore wind developments in India. This emphasizes the importance of regional coordination in driving mutual economic benefits. This importance is further explained in Text box 4.

This chapter will first summarize the findings in the Roadmap and other studies for port assessment in Sri Lanka and Tamil Nadu. Following this, the criteria for assessment of the four types of offshore wind ports and the results of the port assessment are presented. Different scenarios for port usage and development will be established, and the chapter ends with the last section on the socio-economic analysis of these scenarios.

Text box 4 Importance of considering regional collaboration

According to the Roadmap, which outlines two deployment scenarios for offshore wind development in Sri Lanka, both high and low growth scenarios indicate that there will be limited development of local supply chain capability by 2030. The domestic supply chain is expected to remain relatively small under both scenarios, focusing mainly on O&M activities. Initially, offshore wind installations in Sri Lanka are likely to heavily depend on international suppliers.

The moderate volume of offshore wind expected in Sri Lanka does not naturally encourage localization of the supply chain. Unless there is an establishment of energy export capacity with India over time (or global hydrogen export), Sri Lanka's overall market size is projected to remain relatively small, potentially less than 5 GW by 2050 according to industry standards.

Despite growth limitations, offshore wind development in Sri Lanka becomes more attractive for developers and investors when considered alongside regional developments, particularly in ports and supply chains.

The state of Tamil Nadu in India, with optimal wind resources, is in close proximity to Sri Lanka. In early 2024, the Indian government initiated seabed leases for at least 4 gigawatts (GW) of capacity off the coast of Tamil Nadu (Memija, 2024). Realistic delivery timeframe of construction for these projects is 2032. Collaborative efforts between these emerging markets could yield mutual benefits, potentially reducing project costs in both countries, enhancing local economic benefits, and creating additional market opportunities for the industry.

4.2 Review of previous work

This section aims to provide a condensed summary of previous work on the contents of this chapter. Table 40 summarizes what is known from other studies, providing clarity about the starting point and preventing the risk of duplication. Where this study deviates from previous work is described in the table as well.

Table 40 Main findings from previous studies related to port appraisal

Name of previous study	Main findings
Roadmap	Among the four major ports in Sri Lanka, the Roadmap identified Colombo and Hambantota as most suitable for bottom-fixed offshore wind installation with minor upgrades needed. Conversely, Trincomalee and Kankasenuthurai require significant upgrades, including dredging and storage yard establishment. Hambantota stands out due to the available land for expansion and a development concept encompassing hinterland industrial zones. Limited substantial studies on Sri Lanka's offshore wind ports exist beyond the Roadmap, which primarily focuses on marshalling ports and does not delve into the examination of manufacturing and O&M ports. Other findings from the Roadmap are summarized in Table 41.
The Sri Lanka: National Port Master Plan by ADB in 2020	Acknowledges Hambantota's land availability advantage over Colombo. While focused on the transport sector, it provides valuable port specifications.
FOWIND studies in 2015*	Highlights Tuticorin as the most promising site, with smaller ports (i.e. Punnakayal, Koodankulam, Valinokkam, Manappad, Kanyakumari, Pamban, and Thirukkuvalai) identified for O&M activities.
The India Offshore Wind Ports Study by the Centre of Excellence in 2023*	Emphasizes Tuticorin's advantages for marshalling ports, despite challenges like a narrow breakwater gap and high berth occupancy rates. Additionally, potential O&M hubs include Tuticorin, Chinnamutton, Muttom, Koodankulam, Kallamoli, Thengapattanam, and Colachel, with Chinnamuton facing space limitations for berths and adjacent facilities.

** Notably, no studies have looked at fabrication ports in Tamil Nadu.*

Table 41 provides the assessment of various type of ports in Sri Lanka and India according to the Roadmap, and summarizes new ports as identified and used in this study. The location of all ports assessed in this study are visible in Figure 77.

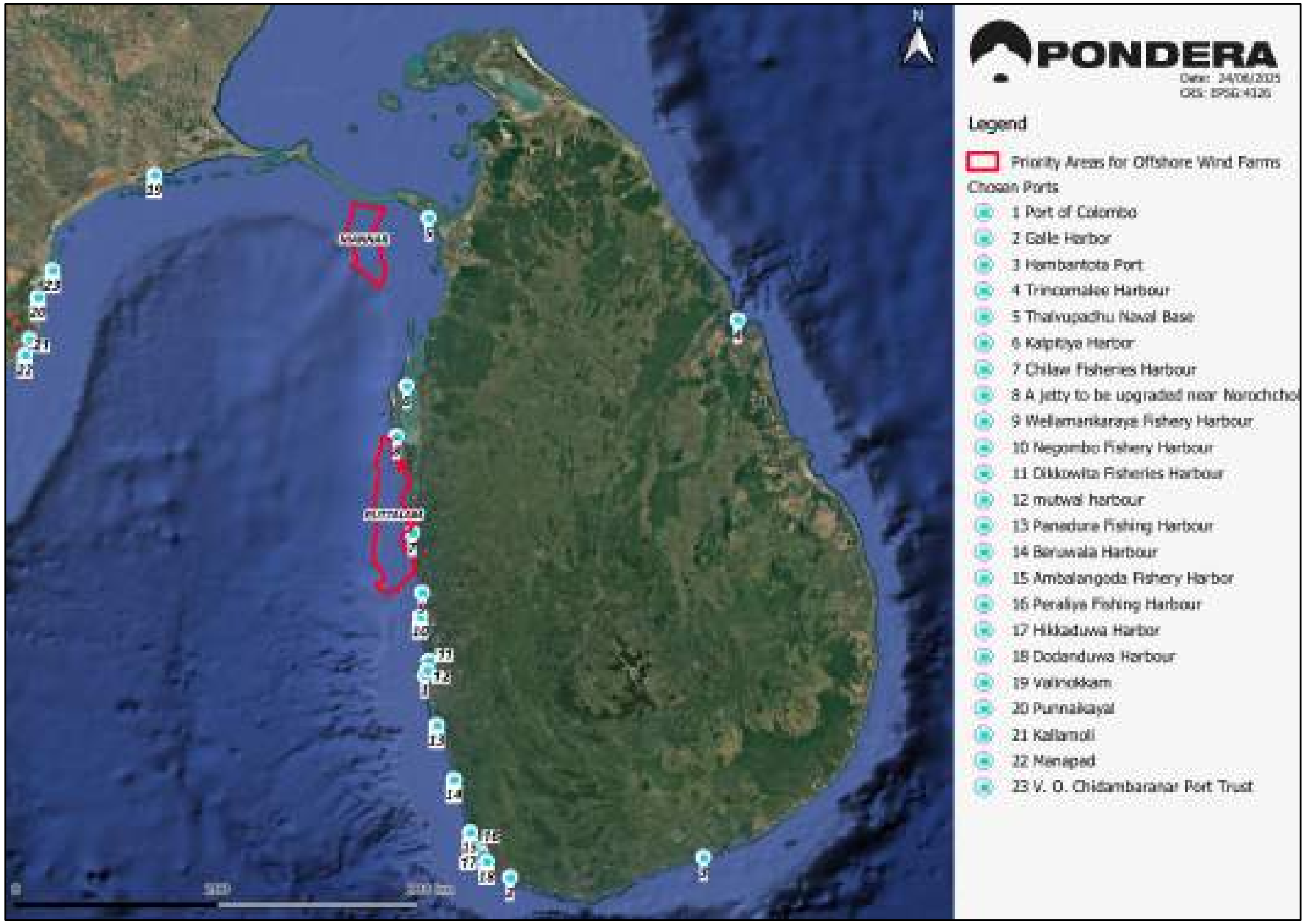
To improve the visual structure, several tables in this chapter are set in a smaller font than elsewhere in the report.

Table 41 Assessment of various type of ports in Sri Lanka and India according to the Roadmap, and new ports as identified in this study (blue = included, grey = not included)

		Fabrication	Marshalling	SOV O&M	CTV O&M	Explanation
Sri Lanka	Ports that have been identified in Roadmap					
	Colombo					No port in Sri Lanka was included for the fabrication ports assessment. Galle is considered unsuitable for marshalling activities due to its inadequate berth length and laydown area and its direction of growth to becoming a yachting destination. Oluvil is excluded in all four types of assessment because its entrance is constantly blocked by sand accumulation.
	Galle					
	Hambantota					
	Oluvil					
	Trincomalee					
	Small ports/Fishing harbours newly included in this study					
	Point Pedro					These facilities are excluded from all assessments because they are located above Adam's Bridge where the water is too shallow for vessels to pass from north to south.
	Kankesanthurai					
	Vidataltivu					
	A jetty to be upgraded at Talaimannar Pier					
	A jetty to be upgraded near Thalvupadhu Naval Base					Only facilities located on the west coast of Sri Lanka that are within the suitable distance from two sites (i.e. from A jetty to be upgraded near Thalvupadhu Naval Base to Dodanduwa) are considered because O&M ports are sensitive to distance from the offshore wind area. Lakvijaya Coal Jetty is excluded because it is fully utilized for coal transport.
	Kalpitiya					
	Chilaw					
	Lakvijaya Coal Jetty					
	A jetty to be upgraded near Norochcholai Power Station					
	Wellamankaraya					
	Negombo					
	Dikkowita					
	Mutwal					
	Panadura					
	Beruwala					
	Ambalangoda					
	Peraliya					
	Hikkaduwa					
	Dodanduwa					
India	Ports that have been identified in Roadmap					
	Tuticorin					Only Tuticorin was considered in the Roadmap.
	Small ports/Fishing harbours newly included in this study					
	Kattupalli					

		Fabrication	Marshalling	SOV O&M	CTV O&M	Explanation
	Ennore					These ports are located above Adam's Bridge where the water is too shallow, and no vessel can pass from north to south.
	Chennai					
	Mugaiyur					
	Cuddalore					
	Thiruchopuram					
	Silambimangalam					
	Parangipettai					
	Vanagiri					
	Thirukadaiyur					
	Karaikal					
	Nagappattinam					
	Thirukkuvalai					
	Rameswaram					
	Pamban					
	Valinokkam					These ports are located below Adam's Bridge and have been considered suitable for O&M activities in the "*India Offshore Wind Ports Study*" of the Centre of Excellence and the *"Pre-feasibility study for offshore wind farm development in Tamil Nadu*" of the Fowind project. Facilities further South of Manapad are excluded because of their considerable distance from the project areas.
	Punnaikayal					
	Kallamoli					
	Manapad					
	Koodankulam					
	Chinnamuttom					
	Kanniyakumari					
	Muttom					
	Colachel					
	Thengapattanam					

Figure 77 Location of ports assessed in this study



4.3 Port requirements for offshore wind

This chapter will provide the technical requirements for various type of offshore wind ports. These requirements will be used to assess the capabilities of various ports in the next section.

Due to the lack of studies on fabrication ports in the South Asian region, hard criteria for fabricating ports are obtained from studies in more mature markets like Scotland (ARUP's port for offshore wind study)[55] and from developing markets like Vietnam where port suitability has been studied (MTBS's study on Requirements Harbour and Infrastructure OWE Vietnam)[56]. Additional criteria, such as "quay strength" and "crane with lifting capacity," have been obtained from the MTBS study to augment the assessment process.

Meanwhile, the set of criteria for marshalling ports have been laid out in the roadmap and were adopted fully for this appraisal due to their applicability and relevance to the context.

Lastly, requirements for O&M ports have been informed by previous investigations into port infrastructure in India. Further distinction regarding the requirements for SOV-based O&M and CTV-based O&M ports makes reference to the work of ARUP in Scotland.

[55] Crown Estate Scotland. (Sep 2020). Ports for offshore wind A review of the net-zero opportunity for ports in Scotland. Retrieved from [ports-for-offshore-wind-report.pdf]
[56] Mtbs. (June 2021). Requirements Harbour and Infrastructure OWE Vietnam.

4.3.1 Fabrication port(s)

The typical requirements of a fabrication port for a 1 GW wind farm are provided in Table 42.

Table 42 Requirements for fabrication ports

Criteria	**Definitions**	**Parameters**		
		Unacceptable values	**Acceptable values**	**Preferrable values**
Yard area	An area of land within a port where components are preassembled before being loaded onto a shipping vessel for installation	< 15 ha	15 – 20 ha	> 20 ha
Water draft depth	The depth of water with which a ship can safely navigate	< 9 m	9 – 12 m	> 12 m
Air draft restriction	The presence of any barrier within the vertical distance measured from the vessel waterline to the highest point on the vessel	< 120 m	120 – 200 m	Unrestricted
Harbor entrance width	The width of a sheltered port area's entrance	< 200 m	200 – 300 m	> 300 m
Lock/gate presence	The physical restriction for entering and exiting the harbour	Present		Not present
Quay length	The length of a hard wall that vessels are moored against	< 200 m	200 – 400 m	> 400 m
Quay strength	The ability to uphold shipment's weight of a hard wall that vessels are moored against	< 10-20 t/m2	10-20 t/m2	> 10-20 t/m2
Cranes with lifting capacity	The equipment to handle wind turbines components	< 500t	500t	> 500t
Distance to offshore wind area	The measurement of the spatial separation between a port and the offshore wind site with navigational restrictions considered Note: Fabrication ports are not sensitive to distance if a marshalling port is used	> 400 km	200 – 400 km	< 200 km

4.3.2 Marshalling port(s)

The typical requirements of a marshalling port for a 500 MW wind farm are provided in Table 43.

Table 43 Requirements for marshalling ports

Criteria	Definitions	Parameters		
		Unacceptable values	Acceptable values	Preferrable values
Yard area	An area of land within a port where components are preassembled before being loaded onto a shipping vessel for installation	< 15 ha	15 – 20 ha	> 20 ha
Water draft depth	The depth of water with which a ship can safely navigate	< 9 m	9 – 12 m	> 12 m
Air draft restriction	The presence of any barrier within the vertical distance measured from the vessel waterline to the highest point on the vessel	< 120 m	120 – 200 m	Unrestricted
Harbor entrance width	The width of a sheltered port area's entrance	< 200 m	200 – 300 m	> 300 m
Lock/gate presence	The physical restriction for entering and exiting the harbour	Present		Not present
Quay length	The length of a hard wall that vessels are moored against	< 200 m	200 – 400 m	> 400 m
Quay strength	The ability to uphold shipment's weight of a hard wall that vessels are moored against	< 10-20 t/m2	10-20 t/m2	> 10-20 t/m2
Cranes with lifting capacity	The equipment to handle wind turbines components	< 500t	500t	> 500t
Distance to offshore wind area	The measurement of the spatial separation between a port and the offshore wind site with navigational restrictions considered	> 400 km	200 – 400 km	< 200 km

4.3.3 O&M ports

The requirements for SOV-based O&M ports and CTV-based O&M ports supporting a typical 500 MW offshore wind project are provided in Table 44 and Table 45 respectively. O&M ports are not expected to handle heavy components so “Quay strength” and “Cranes with lifting capacity” are eliminated from their table of criteria. “Office facilities” and “Infrastructure access” are added as soft criteria.

Table 44 Requirements for SOV-based O&M ports

Criteria	Definitions	Parameters		
		Unacceptable values	Acceptable values	Preferrable values
Physical characteristics				
Yard area	An area of land within a port where containers are stored and handled before being loaded onto or unloaded from a shipping vessel	<0.75 ha	0.75 – 3 ha	> 3 ha
Draft depth	The depth of water with which a ship can safely navigate	< 7 m	7 – 8 m	> 8 m
Air draft restriction	The presence of any barrier within the vertical distance measured from the vessel waterline to the highest point on the vessel	< 30 m	30 – 50 m	Unrestricted
Habor entrance width	The width of a sheltered port area’s entrance	< 20 m	20 – 25 m	> 25 m
Lock/gate presence	The physical restriction for entering and exiting the harbour	N/A Note: Delays are tolerable		
Quay length	The length of a hard wall that vessels are moored against	< 100 m	100 – 120 m	> 120 m
Layout				
Office facilities (meeting rooms, changing rooms, etc.) *	The dedicated spaces within the port infrastructure designed to support the administrative and logistical needs of personnel engaged in the ongoing O&M services.	N/A No unacceptable value applied	Not presence	Presence
Connectivity				
Distance to offshore wind area	The measurement of the spatial separation between a port and the offshore wind site with navigational restrictions considered	> 200 km	100 – 200 km	<100 km
Infrastructure access (road/railway/airport) *	The connectivity and transportation links that facilitate the smooth movement of personnel, equipment, and materials to and from the port facility	Disconnected from any transportation network (i.e. road/railway/airport) with no future plan for connection	Connected to at least 1 transportation network	Connected to more than 1 transportation network

**Soft criteria*

Table 45 Requirements for CTV-based O&M ports

Criteria	Definitions	Parameters		
		Unacceptable values	**Acceptable values**	**Preferrable values**
Physical characteristics				
Yard area	An area of land within a port where containers are stored and handled before being loaded onto or unloaded from a shipping vessel	< 0.75 ha	0.75 – 1.5 ha	> 1.5 ha
Draft depth	The depth of water with which a ship can safely navigate	< 3 m	3 – 4 m	> 4 m
Air draft restriction	The presence of any barrier within the vertical distance measured from the vessel waterline to the highest point on the vessel	< 12 m	12 – 20 m	Unrestricted
Habor entrance width	The width of a sheltered port area's entrance	< 15 m	15 – 20 m	> 20 m
Lock/gate presence	The physical restriction for entering and exiting the harbour	N/A No unacceptable value applied	Present	Not present
Quay length	The length of a hard wall that vessels are moored against	< 30 m	30 – 40 m	> 40 m
Layout				
Office facilities (meeting rooms, changing rooms, etc.) *	The dedicated spaces within the port infrastructure designed to support the administrative and logistical needs of personnel engaged in the ongoing O&M services.	N/A No unacceptable value applied	Not presence	Presence
Connectivity				
Distance to offshore wind area for CTV-based O&M	The measurement of the spatial separation between a port and the offshore wind site with navigational restrictions considered	> 100 km	100 – 75 km	< 75 km
Infrastructure access (road/railway/airport) *	The connectivity and transportation links that facilitate the smooth movement of personnel, equipment, and materials to and from the port facility	Disconnected from any transportation network (i.e. road/railway/airport) with no future plan for connection	Connected to at least 1 transportation network	Connected to more than 1 transportation network

**Soft criteria*

4.4 Port screening based on distance requirements of different types of port

4.4.1 Fabrication port

No screening needed because distance is not a hard criterion that is applied to fabrication port if a marshalling port is used.

4.4.2 Marshalling port

Table 46 provides the screening of marshalling port(s).

Table 46 Screening of marshalling port(s)

	Ports	Distance to Mannar site (km)	Distance to Puttalam site (km)
Sri Lanka	Colombo	200	50
	Hambantota	437	263
	Trincomalee	770	613
Tamil Nadu	Tuticorin	145	183

For marshalling port assessment, only ports within the acceptable OR the preferable range to the OWP sites will be assessed in the next section. Ports included in the assessment are Colombo, Hambantota, and Tuticorin.

4.4.3 SOV-based O&M port

Table 47 provides the screening of SOV-based O&M ports.

Table 47 Screening of SOV-based O&M ports

	Ports/Small ports/ Fishing harbours	Distance to Mannar site (km)	Distance to Puttalam site (km)
Sri Lanka	A jetty to be upgraded near Thalvupadhu Naval Base	25	113
	Kalpitiya	58	68

	Ports/Small ports/ Fishing harbours	Distance to Mannar site (km)	Distance to Puttalam site (km)
	A jetty to be upgraded near Norochcholai Power Station	78	5
	Chilaw	140	17
	Wellamankaraya	163	10
	Negombo	173	19
	Dikkowita	198	39
	Mutwal	199	47
	Colombo	200	50
	Panadura	229	73
	Beruwala	267	98
	Ambalangoda	298	129
	Peraliya	291	138
	Hikkaduwa	299	140
	Dodanduwa	308	149
	Galle	339	160
	Hambantota	437	263
	Trincomalee	770	613
Tamil Nadu	Valinokkam	99	172
	Tuticorin	145	183
	Punnaikayal	156	184
	Kallamoli	163	181
	Manapad	168	180

For SOV-based O&M ports, given the extensive list of potential facilities, those within the acceptable AND preferable range of both OWP sites will be included in the assessment. If Sri Lankan facilities meet this condition, no facilities in Tamil Nadu will be selected. This condition for selection shortens the list of ports that should be assessed, thereby increasing the likelihood that the chosen port will adequately support SOV-based O&M for both OWP sites. The rationale for including both sites is that SOV-based O&M ports have more stringent requirements compared to CTV-based ports, requiring potentially more costly upgrades if the facilities do not meet these higher demands.

This means the list of ports considered for assessment is confined to ports located north of Panadura port.

4.4.4 CTV-based O&M ports

Table 48 provides the screening of CTV-based O&M ports.

Table 48 Screening of CTV-based O&M ports

	Small ports/ Fishing harbours	Distance to Mannar site (km)	Distance to Puttalam site (km)
Sri Lanka	A jetty to be upgraded near Thalvupadhu Naval Base	25	113
	Kalpitiya	58	68
	A jetty to be upgraded near Norochcholai Power Station	78	5
	Chilaw	140	17
	Wellamankaraya	163	10
	Negombo	173	19
	Dikkowita	198	39
	Mutwal	199	47
	Colombo	200	50
	Panadura	229	73
	Beruwala	267	98
	Ambalangoda	298	129

	Small ports/ Fishing harbours	Distance to Mannar site (km)	Distance to Puttalam site (km)
	Peraliya	291	138
	Hikkaduwa	299	140
	Dodanduwa	308	149
	Galle	339	160
	Hambantota	437	263
	Trincomalee	770	613
Tamil Nadu	Valinokkam	99	172
	Punnaikayal	156	184
	Kallamoli	163	181
	Manapad	168	180

Given that CTVs are highly sensitive to distance and there are sufficient potential facilities available, for each OWP site, only those within the preferrable range will be selected for the assessment.

4.5 Port assessment

This chapter will assess the capabilities of various ports in Sri Lanka and India. Considering the limited feasibility of establishing a robust local supply chain for offshore wind in Sri Lanka in the short term, and the potential regional coordination, this assessment focuses on fabrication ports in India. This decision aligns with the findings of the Roadmap, which indicate limited development of local supply chain capability in Sri Lanka by 2030, with a focus mainly on O&M activities and initial heavy dependence on international suppliers for offshore wind installations. For marshalling and O&M ports, both Sri Lankan and Indian ports will be assessed.

4.5.1 Fabrication port in India

Drawing upon the understanding from previous work that supply chain development in Tamil Nadu presents a valuable opportunity and recognizing Tuticorin as one of the two promising installation ports for offshore wind development in the region (another one is Vizhinjam but it is excluded because it is still in its execution stage and will not be commissioned until December 2024), this assessment focuses solely on Tuticorin. This assessment solely considers Tuticorin Dry Cargo Terminal and Tuticorin Container Terminal because Tuticorin Coal Terminal shut down in 2018 and was subsequently abandoned, while Tuticorin Terminal Zone A is exclusively dedicated to handling liquid goods. The assessment details are outlined in Table 49.

Table 49 Assessment of Tuticorin as a fabrication port

Parameters				**Tuticorin Dry Cargo Terminal**								**Tuticorin Container Terminal**
Criteria	**Unacceptable values**	**Acceptable values**	**Preferrable values**	**Berth 1**	**Berth 2**	**Berth 3**	**Berth 4**	**Berth 5**	**Berth 6**	**Berth 8**	**Berth 9**	**Berth 7**
Yard area	< 4 ha	4 – 6 ha	> 6 ha	55 – 870 ha								
Draft depth	< 10 m	10 – 12 m	> 12 m	9.3 m	9.3 m	10.7 m	10.8 m	8.6 m	9.3 m	10.9 m	n/a*	10.9 m
Air draft restriction	< 40 m	40 – 100 m	Unrestricted	Unrestricted								
Habor entrance width	< 50 m	50 – 60 m	> 60 m	32.26 m	32.26 m	48 m	48 m	48 m	48 m	48 m	32.26	48 m
Locks/gate presence	N/A			N/A								
Quay length	< 200 m	200 – 400 m	> 400 m	168 m	168 m	192 m	192 m	168 m	168 m	345 m	334 m	371 m
Quay strength	< 10-20 t/m²	10-20 t/m²	> 10-20 t/m²	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Cranes with lifting capacity	< 500t	500t	> 500t	0 – 24 mt 25 – 49 mt 50 – 99 mt 100 – 149 mt (number of unit unknown)				Handling Equipment: - Wharf Cranes - Floating Crane - MHC - RTGs - Container Quay Cranes				
Note				Adjacent storage areas available	Adjacent storage areas available	Adjacent storage areas available	Adjacent storage areas available	Adjacent storage areas available	Adjacent storage areas available	Adjacent storage areas available. Handle containers and general cargo.	n/a	Specifically design for containers
Distance to offshore wind area	Not relevant			Not relevant								

** n/a= data not available*

According to the assessment, Tuticorin can be a potential candidate for becoming a manufacturing port with upgrades needed. For example, dredging activities should take place to improve the draft depth of at least four berths (i.e. Berth 1, Berth 2, Berth 5, and Berth 6). However, there can be certain limits regarding the depth of the water and whether the base is granite or not. The width of the harbour entrance and the length of the berths should also be expanded. Additionally, the port also lacks high tech lifting technology at site to handle large wind components.

It is noteworthy that information on ports' quay strength, while crucial for evaluating ports' suitability for fabrication and manufacturing activities, is challenging to obtain. This absence of quay strength data also extends to the marshalling ports assessment outlined below. Should such data become available, Tuticorin should be reevaluated against this criterion to see if it is well-suited to become a fabrication port.

4.5.2 Marshalling ports in Sri Lanka and India

Out of the four ports identified in the Roadmap as suitable for becoming marshalling ports for offshore wind in Sri Lanka, Colombo, and Hambantota are included in the assessment. Additionally, Tuticorin is incorporated due to its existing capacity to accommodate marshalling activities which has been confirmed by findings of previous reports. The assessment details are outlined in Table 50.

Table 50 Assessment of marshalling ports in Sri Lanka and India

Parameters				Ports		
Criteria	**Unacceptable values**	**Acceptable values**	**Preferrable values**	**Colombo**	**Hambantota**	**Tuticorin**
Yard area	< 15 ha	15 – 20 ha	20 ha	184 ha	2,000 ha	55 – 870 ha
Draft depth	< 8 m	8 – 12 m	> 12 m	12 – 18 m	17.2 m	9.3 – 14.2 m
Air draft restriction	< 120 m	120 – 200 m	Unrestricted	Unrestricted	Unrestricted	Unrestricted
Harbor entrance width	< 200 m	200 – 300 m	> 300 m	570 m	210 m	48 m
Lock/gate presence	Present		Not present	Present	Present	Not present
Quay length	< 200 m	200 – 400 m	> 400 m	940 – 1,292 m	300 – 838.5 m	168 – 370 m
Quay strength	< 10-20 t/m2	10-20 t/m2	>10-20 t/m2	n/a	n/a	n/a
Cranes with lifting capacity	< 500t (< 450 mt)	500t (450 mt)	> 500t (> 450 mt)	35 mt (14 container gantries) 41 mt (4 container gantries) 50 mt (2 container gantries) 80 mt (mobile cranes) 130 mt (mobile cranes)	16 mt (14 forklifts) 41 mt (dockside crane) 41 mt (multiple-purpose quay crane) 50 mt (mobile/tyre crane) 50 mt (2 dockside crane) 80 mt (mobile/tyre crane)	0 – 24 mt 25 – 49 mt 50 – 99 mt 100 – 149 mt (number of unit unknown) Handling Equipment: - Wharf Cranes - Floating Crane - MHC

						- RTGs - Container Quay Cranes
Distance to Mannar area	> 400 km	200 – 400 km	< 200 km	200 km	437 km	145 km
Distance to Puttalam area	> 400 km	200 – 400 km	< 200 km	50 km	263 km	183 km

** n/a= data not available*

None of the Sri Lankan ports passes all criteria to facilitate marshalling activities. If lock/gate can be relocated then Colombo can be the potential Sri Lankan port, as it scores better than Hambantota on several items, especially on the distance to the project areas. Generally, however, lock/gate relocation is considered to be more difficult to realize than other upgrades, for example, dredging, quay length expansion, etc.

Tuticorin is located closer to the Mannar site than Colombo. It also possesses the characteristics of a potential Marshalling port. However, it needs upgrades in breakwater widening. Other than that, all ports need upgrades in crane technology.

4.5.3 O&M ports in Sri Lanka and India

SOV-based O&M ports

Table 51 provides the assessment of SOV-based O&M ports in Sri Lanka.

Table 51 Assessment of SOV-based O&M ports in Sri Lanka

Parameters				Ports/ Fishing harbours/ Jetties								
Criteria	**Unaccept-able values**	**Accept-able values**	**Preferrable values**	**Thalvupadhu**	**Kalpatiya**	**Norochcholai**	**Chilaw**	**Wellaman-karaya**	**Negombo**	**Dikkowita**	**Mutwal**	**Colombo**
Characteristics												
Yard area	<0.75 ha	0.75 – 3 ha	> 3 ha	Not yet established but the available coastal area nearby is about 0.6 ha	0.3 ha	Not yet established but the available coastal area nearby is more than 0.75 ha	n/a	3.2 ha	n/a	8.1 ha	3.24 ha	184 ha
Draft depth	< 7 m	7 – 8 m	> 8 m	5 – 10 m (too large a range to assess)	4 – 6 m	5 – 10 m (too large a range to assess)	n/a	4 m minimum	n/a	3 – 6 m	4 – 6 m	12 – 18 m
Air draft restriction	< 30 m	30 – 50 m	Unrestricted	Unrestricted	Unrestricted	Unrestricted	Unrestricted	Unrestricted	Unrestricted	Unrestricted	Unrestricted	Unrestricted
Habor entrance width	< 20 m	20 – 25 m	> 25 m	N/A: Open sea	N/A: Open sea	N/A: Open sea	70 m (the narrowest part of the Chilaw Lagoon)	410 m	260 m	110 m	160 m	570 m
Lock/ gate presence	N/A			N/A								
Quay length	< 100 m	100 – 120 m	> 120 m	50 m minimum (wooden structure)	100 m	10 m minimum (concrete structure)	100 m minimum	350 m	400 m minimum	240 – 334 m	119.2 m	940 – 1,292 m
Layout												
Office facilities (meeting rooms, changing rooms, etc.) *	N/A	Not present	Present	Present (Navy offices)	Present	Present (Coal power plant offices)	n/a	Present	n/a	Present	Present	Present
Connectivity												

Parameters				Ports/ Fishing harbours/ Jetties								
Criteria	**Unaccept-able values**	**Accept-able values**	**Preferrable values**	**Thalvupadhu**	**Kalpatiya**	**Norochcholai**	**Chilaw**	**Wellaman-karaya**	**Negombo**	**Dikkowita**	**Mutwal**	**Colombo**
Characteristics												
Distance to Mannar area	> 200 km	100 – 200 km	< 100 km	25 km	58 km	78 km	140 km	163 km	173 km	198 km	199 km	200 km
Distance to Puttalam area	>200 km	100 – 200 km	< 100 km	113 km	68 km	5 km	17 km	10 km	19 km	39 km	47 km	50 km
Infrastructure access (road/ railway/ airport) *	Disconnected from any transportation network (i.e. road/ railway/ airport) with no future plan for connection	Connected to at least 1 transportation network	Connected to more than 1 transportation network	Only road access via the road network of Mannar island, the last kilometres was unpaved.	Connected to Kalpatiya Rd. The nearest bus stop is 650 m away.	Road connection to A3 Highway. The nearest bus stop is 1.5 km away	Connected to both road and railway system.	Connected to A3 Highway. The nearest bus stop is 2 km away.	Connected to both road and railway systems. The nearest stations for both modes of transport are 2.2 km away.	Connected to road system. The nearest bus stop is 1.4 km away	Connected to road system. The nearest bus stop is 450 m away.	Connected to roads but faces port access road congestions (queuing up to 5 km in several days in the week) Will be connected to a highway. Connected to railway system.

** n/a= data not available*

For both OWP sites, the most suitable facility appears to be the jetty near the Norochcholai coal power plant, which is scheduled for an upgrade. To accommodate SOVs, this jetty requires the establishment of a yard area, reassessment of the draft depth, and expansion of the concrete structure by at least 90 meters.

Once upgraded, the jetty can also accommodate SOV-based O&M activities in the Southern part of the Puttalam site. Colombo presents a viable option for Puttalam SOV-based O&M as well since the port readily meets all the requirements of an SOV-based O&M port.

CTV-based O&M ports

Table 52 provides the assessment of CTV-based O&M ports in Sri Lanka.

Table 52 Assessment of CTV-based O&M ports in Sri Lanka

Parameters				**Potential facilities for the Mannar site**									
					Potential facilities for the Puttalam site								
Criteria	**Unacceptable values**	**Acceptable values**	**Preferrable values**	**Thavulpadhu**	**Kalpatiya**	**Norochcholai**	**Chilaw**	**Wellaman-karaya**	**Negombo**	**Dikkowita**	**Mutwal**	**Colombo**	**Panadura**
Characteristic													
Yard area	<0.75 ha	0.75 – 1.5 ha	>1.5 ha	Not yet established but the available coastal area nearby is about 0.6 ha	0.3 ha	Not yet established but the available coastal area nearby is more than 0.75 ha	n/a	3.2 ha	n/a	8.1 ha	3.24 ha	184 ha	0.48 ha
Draft depth	< 3 m	3 – 4 m	>4 m	5 – 10 m	4 – 6 m	5 – 10 m	n/a	4 m minimum	n/a	3 – 6 m	4 – 6 m	12 – 18 m	2.5 – 3 m
Air draft restriction	< 12 m	12 – 20 m	Unrestricted	Unrestricted	Unrestricted	Unrestricted	Unrestricted	Unrestricted	Unrestricted	Unrestricted	Unrestricted	Unrestricted	Unrestricted
Harbour entrance width	< 15 m	15 – 20 m	> 20 m	N/A: Open sea	N/A: Open sea	N/A: Open sea	70 m (the narrowest part of the Chilaw Lagoon)	410 m	260 m	110 m	160 m	570 m	78 m
Lock/ gate presence	N/A	Present	Not present	Not present	Not present	Not present	n/a	Not present	Not present	n/a	n/a	Present	n/a
Quay length	< 30 m	30 – 40 m	> 40 m	50 m minimum (wooden structure)	100 m	10 m minimum (concrete structure)	100 m minimum	350 m	400 m minimum	240 – 334 m	119.2 m	940 – 1,292 m	75.5 m
Layout													
Office facilities (meeting rooms, changing rooms, etc.) *	N/A	Not present	Present	Present (Navy offices)	Present	Present (Coal power plant offices)	n/a	Present	n/a	Present	Present	Present	Present

Parameters				Potential facilities for the Mannar site									
					Potential facilities for the Puttalam site								
Connectivity													
Distance to Mannar area	>100km	75 – 100 km	< 75 km	25 km	58 km	78 km							
Distance to Puttalam area	>100km	75 – 100 km	< 75 km		68 km	5 km	17 km	10 km	19 km	39 km	47 km	50 km	73 km
Infrastructure access (road/ railway/ airport) *	Disconnected from any transportation network (i.e. road/ railway/ airport) with no future plan for connection	Connected to at least 1 transportation network	Connected to more than 1 transportation network	Only road access via the road network of Mannar island, the last kilometres was unpaved.	Connected to Kalpatiya Rd. The nearest bus stop is 650 m away.	Road connection to A3 Highway. The nearest bus stop is 1.5 km away	Connected to both road and railway system.	Connected to A3 Highway. The nearest bus stop is 2 km away.	Connected to both road and railway systems. The nearest stations for both modes of transport are 2.2 km away.	Connected to road system. The nearest bus stop is 1.4 km away	Connected to road system. The nearest bus stop is 450 m away.	Connected to roads but faces port access road congestions (queuing up to 5 km in several days in the week) Will be connected to a highway. Connected to railway system.	Connected to road system. The nearest bus stop is 1.6 km away

** n/a= data not available*

Kalpitiya and the jetty near the Norochcholai coal power plant are the two overlapping facilities that can be explored to accommodate both sites. However, considering that CTV-based O&M facilities are highly sensitive to distance and relatively easy to upgrade, it is more practical to have separate facilities closest to each site.

For the Mannar site, the jetty near Thavulpadhu Naval Base would be the optimal choice. To meet the requirements, the surrounding area of this jetty should be expanded and converted into a yard area.

For the Puttalam site, Kalpatiya, Wellamankaraya, Dikkowita, Mutwal, and Colombo can be suitable options, with minimal dredging activities needed. Considering that Norochcholai came out of the last assessment as a viable option, upgrades for it to meet SOV-based O&M facility requirements will also make it eligible to accommodate CTVs.

Further assessment of the facilities passed the assessment

A jetty to be upgraded near Thalvupadhu Naval Base

Onshore supporting infrastructure sticks out as a potential disadvantage for this facility since limited space exists nearby for O&M requirements. Essential amenities for the crew like hotels, restaurants, pharmacies, etc. are required to be developed within the direct vicinity. Figure 78 shows a satellite image of the area, and Figure 79 and Figure 80 show pictures taken during the site visit.

Figure 78 Satellite image of the jetty near Thalvupadhu Naval Base

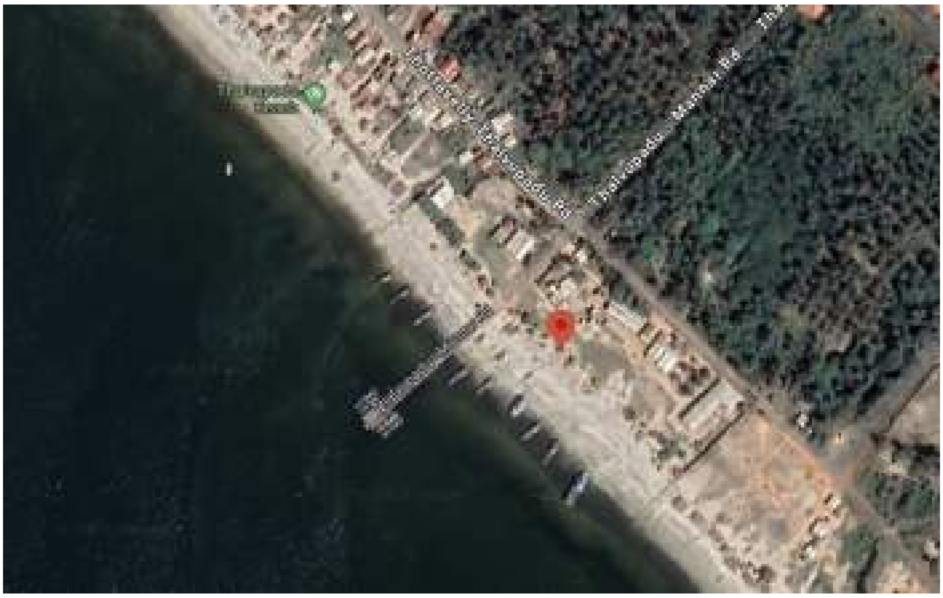


Figure 79 Photo from the site visit to the to-be-upgraded jetty near Thalvupadhu Naval Base

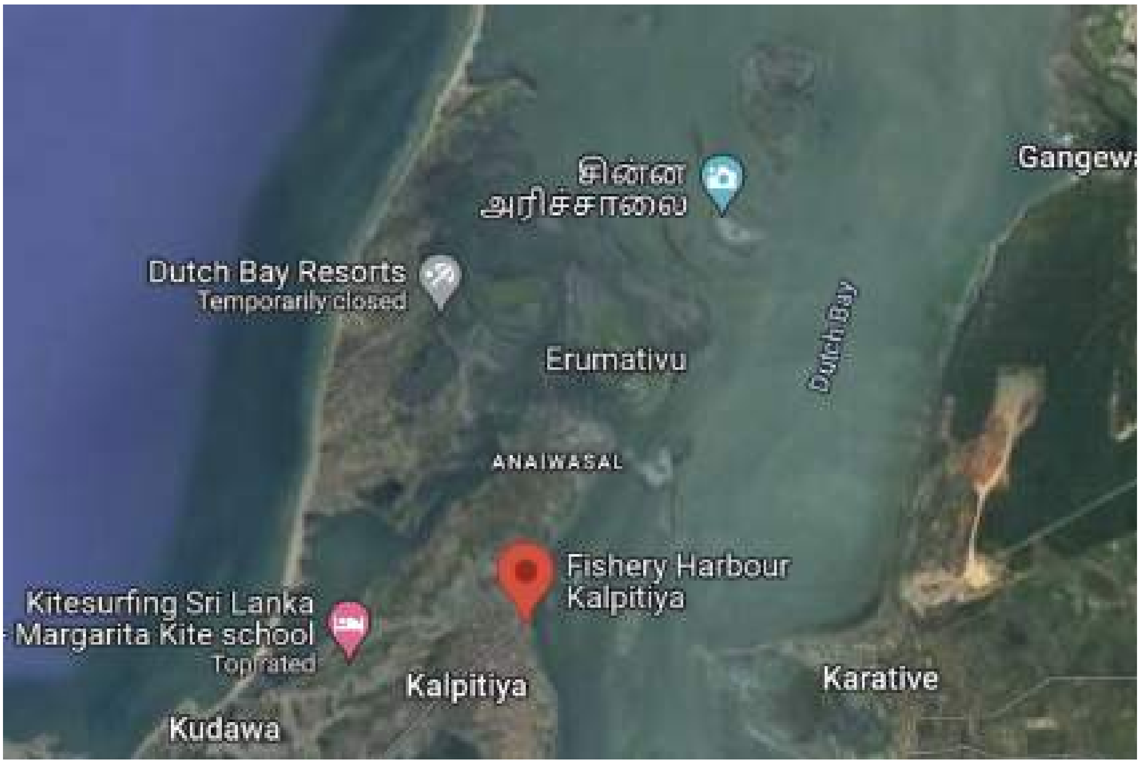
Figure 80 The project team at the jetty near Thalvupadhu Naval Base

Kalpatiya Fishing Harbor

The Kalpitiya fishery harbor, located in the northeastern region of Sri Lanka within the Puttalam district along a lagoon, is a natural harbour. While the harbour currently accommodates hundreds of vessels concurrently, plans for expansion are in place to accommodate future development. There are plenty of restaurants and pharmacies within walking distance from the fishery harbour (less than 1 km). Hotels are further away, concentrated to the West of the harbour and are within driving distance (about 2.5 km). Figure 81 and Figure 82 show satellite images of the area at different scales.

Figure 81 Satellite image of Kalpatiya Fishery Harbour

Figure 82 Location of Kalpatiya Fishery Harbour inside the Puttalam Lagoon



A jetty to be upgraded near Norochcholai Coal Power Plant

Norochcholai Coal Power Plant is Sri Lanka's first coal power plant operated by Ceylon Electricity Board (CEB) and is located in Norochcholai, Puttalam district, Northwestern province (Global Energy Observatory, n.d.[57]). The area surrounding the plant lacks many amenities, such as hotels, restaurants, and pharmacies, with the few available facilities situated approximately 2 km away. The adjacent communities have been reported to face significant environmental pollution threats and are highly vulnerable to poverty (Jayasinghe, 2023[58]). Figure 83 shows a satellite image of the area, and Figure 84 and Figure 85 illustrate pictures taken during the site visit.

[57] Retrieved from https://globalenergyobservatory.org/geoid/44405

[58] Retrieved from https://www.ncbi.nlm.nih.gov/pmc/articles/PMC9838292/

Figure 83 Satellite image of the jetty near Norochcholai Coal Power Plant

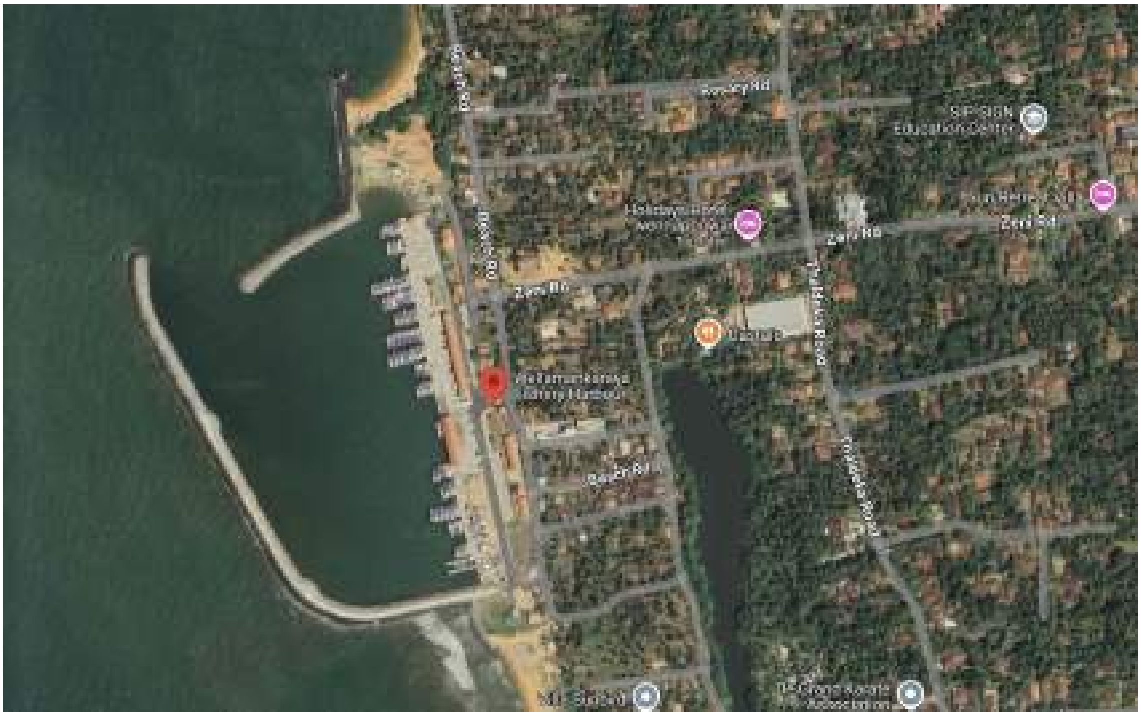
Figure 84 The project team at the to-be-upgraded jetty near Norochcholai Cola Power Plant

Figure 85 Photo taken on the to-be-upgraded jetty near Norochcholai Power Plant, overlooking the Lakvajiya coal jetty

Wellamankaraya

Wellamankaraya is the largest fishery harbour in Sri Lanka that was recently opened to the public in June 2022. Figure 86 shows a satellite image from the area. It is situated in the village of the same name where the population density is almost 8 times larger than that in Puttalam district and 5 times larger than that of the whole country. The onshore logistics of the fishing harbour do not seem to be clustered in the North. Hotels, restaurants, pharmacies, etc. can typically be found along the Southern coastline. Driving from Wellamankaraya to Colombo port and Colombo International Airport is estimated to take 1.5 to 2 hours. Buses are also available, but they can take to 2.5 to 3.5 hours. However, it might take more time since the road access to Colombo port is notoriously congested.

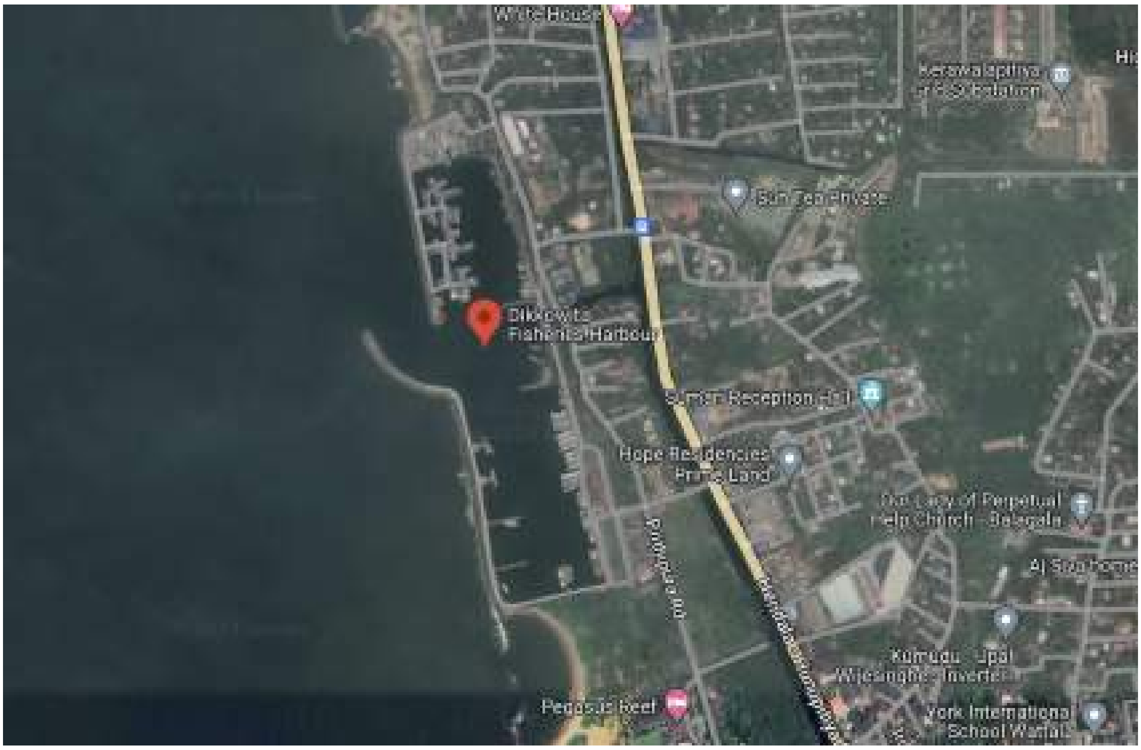
Figure 86 Satellite image of Wellamankaraya Fishery Harbour



Dikkowita

Dikkowita is a fishery harbour located in a densely populated suburban area adjacent to Colombo. Facilities such as hotels, restaurants, pharmacies, etc. can be found along the coastline both north and south of the harbour. Dikkowita is connected to the B152 road. Despite its short distance of 10 kilometres, it takes 1 to 1.5 hours to travel by car from Dikkowita Harbour to Colombo city centre due to frequent traffic jams. The nearest train station, Hunupitiya Railway Station, is over 5 kilometres away from Dikkowita Harbour, about a half-hour taxi ride. Dikkowita Harbour connects to this station via the B152 and B151 roads, and it takes approximately 15 minutes by train to reach Colombo Fort Station (Broekman et al., 2015). Buses from Dikkowita to Colombo and Negombo are frequent but often overcrowded and travel slowly along the B152 road due to traffic congestion. The closest bus stop to Dikkowita Harbour is a 1.2-kilometer away. The E03 expressway provides a faster connection between Bandaranaike International Airport and Colombo. Figure 87 shows a satellite image of the area.

Figure 87 Satellite image of Dikkowita Fishery Harbour



Mutwal

Mutwal Fishery Harbour is located adjacent to Colombo Commercial Port. This is the only harbour in Sri Lanka authorized for foreign vessels to land their catch. Ceylon Fisheries Corporation no longer uses Mutwal Harbour for its own commercial fishing activities. The harbour is now primarily used by the local fishing community and foreign fishing vessels (Ceylon Fishery Harbours Corporation, n.d.[59]). A satellite image of the area is shown in Figure 88.

[59] Retrieved from http://www.cfhc.gov.lk/TunaHub.htm

Figure 88 Satellite image of Mutwal Harbour

Colombo

Colombo Port, located in Colombo city on the west coast of Sri Lanka, is the country's principal port. The Port of Colombo plays a crucial role in Sri Lanka's economy, handling the majority of the country's import and export trade. The city is undergoing significant development, with many new hotels, residential flats, and the restoration of historic buildings. Additionally, a new port city is being developed to the south of the existing port. This new area will include hotels, conference centres, residential flats, shops, and marinas, and will be connected via an elevated highway, providing additional access points to the port. The western region is also seeing extensive urban development and improvements. Together, these developments in the western region and the city of Colombo significantly increase the demand for the Port of Colombo (ADB, 2020). A satellite image of the area is shown in Figure 89.

Figure 89 Satellite image of Colombo Port

Tuticorin

The Port of Tuticorin, also known as V. O. Chidambaranar Port, is an all-weather, major port in India. This artificial deep-sea harbour is located in Thoothukudi on the Coromandel Coast, strategically close to the East-West international sea route. Situated in the Gulf of Mannar, it is well sheltered from storms and cyclone winds by Sri Lanka to the southeast and the large Indian landmass to the west. Additionally, the port is immediately adjacent to a coal-fired thermal power station, which provides a feasible connection to an existing substation feeding into the grid (Fowind, 2016). Essential amenities are well established and clustered approximately 11 km north of the port. Figure 90 shows a satellite image of the area.

Figure 90 Satellite image of Tuticorin Port

4.6 Scenarios for port usage and development

The conclusions drawn from the Roadmap regarding port infrastructure in Sri Lanka are partly revised. Specifically, this study highlights that Hambantota, Kankesanthurai, and Trincomalee do not come out of the assessment as suitable facilities to support offshore development in Mannar and Puttalam.

Following this finding, this section presents two scenarios for port usage and development in Sri Lanka to support the development of offshore wind projects in Mannar and Puttalam:

1. Scenario 1 considers only Sri Lankan ports;
2. Scenario 2 explores ports in Sri Lanka and India.

Exclusive focus on Sri Lankan ports in scenario 1 helps identify opportunities for optimizing and enhancing local maritime facilities. This could maximize job creation, investments, and infrastructure development. This scenario allows for a detailed examination of the capabilities and limitations of Sri Lanka's port infrastructure, enabling tailored strategies for leveraging these assets for the offshore wind industry.

In scenario 2, examining how ports in India can contribute to offshore wind projects in Sri Lanka helps explore cross-border partnerships and synergies. This scenario considers the geographic proximity of India's ports to Sri Lanka's proposed offshore wind sites, as well as India's established maritime infrastructure and expertise. It aims to identify opportunities for bilateral cooperation, and import-export opportunities, with the goal of expediting the (more cost effective) development of offshore wind projects in the region. For this study, this region encompasses the Mannar and Puttalam areas in Sri Lanka and the Tamil Nadu area in India.

The mix of ports for the scenarios is selected from the initial list of ports in Table 41 and the selection is based on the findings from the port assessment in the previous section. Together, the two scenarios offer a holistic assessment, encompassing both national and international perspectives when it comes to options for port usage and development.

4.6.1 Scenario 1: Only Sri Lankan ports are used

Scenario development

This analysis assumes that the development landscape will witness the establishment of one to three projects at Mannar and one project at Puttalam. Each of these projects is expected to have a capacity of 500 MW. These assumptions serve as cornerstones for conducting comprehensive scenario analyses of the socio-economic analysis of port usage and development below.

Table 53 provides the mix of ports in scenario 1 for the port use and development, considering only Sri Lankan ports.

Table 53 Port scenarios for Mannar and Puttalam projects when only Sri Lankan ports are considered

Type of port	Mannar	Puttalam
Fabrication	None	None
Marshalling	Colombo	Colombo
SOV-based O&M	Wellamankaraya	Wellamankaraya*
CTV-based O&M	A jetty to be upgraded near Thalvupadhu Naval Base	A jetty to be upgraded near Norochcholai Coal Power Plant

** The Puttalam site may not need SOV facilities due to its proximity to land, CTV-based O&M is expected to lead*

When exclusively assessing Sri Lankan ports, none have been selected to host fabrication activities. This decision stems from the relatively limited size of the offshore wind market in Sri Lanka, which renders the establishment of a fabrication port economically unfeasible (at least at the short term). Additionally, the burgeoning offshore market in neighboring India presents a significantly larger opportunity, making it more logical to consider establishing fabrication ports in that region instead of Sri Lanka. Besides, offshore wind projects in India are expected to be realized earlier in time in India (early 2030s), compared to Sri Lanka (mid 2030s), making it more likely for fabrication ports to be established in India as well.

For marshalling activities, there is a need to minimize voyage durations for the installation vessels, which incur significantly higher charter rates compared to cargo vessels. This highlights the importance of having a port nearby. Colombo is selected as the marshalling port for scenario 1 according to the result of the above assessment. Potential upgrades and implications are discussed later in this chapter.

For SOV-based O&M activities, Wellamankaraya, Mutwal, and Colombo are potential options that can support operations in both Mannar and Puttalam, requiring few (Wellamankaraya and Mutwal) to no upgrades (Colombo). However, due to the high costs associated with upgrading a facility to an SOV-based port, only Wellamankaraya was selected. Although Wellamankaraya requires more intensive dredging activities compared to Mutwal (3 meters versus Mutwal's 1-2 meters), it is situated within the acceptable range to cater to O&M activities for projects in Tamil Nadu. This selection was made because, for Sri Lanka, particularly for Puttalam, developing an SOV port may not be economically beneficial given the smaller scale and proximity to shore of the potential offshore wind projects. CTVs are preferred due to their cost-effectiveness, operational flexibility, and suitability for nearshore sites, such as those in Sri Lanka. Wellamankaraya is chosen as it could address the needs of both Sri Lanka and Tamil Nadu, effectively serving two purposes with one facility.

For CTV-based O&M activities, the jetty near Thalvupadhu Naval Base has been chosen for the Mannar site, and the jetty near the Norochcholai Coal Power Plant has been selected for the Puttalam site. In the southern part of the Puttalam site, the ports of Wellamankaraya, Mutwal, and Colombo could serve as backup options if required. Colombo and Mutwal meet all criteria for CTV-based operations, while Wellamankaraya is the closest to the southern part of the Puttalam site and requires minimal upgrades. However, access to Colombo Port may be hindered by traffic congestion, and converting the traditional Wellamankaraya fishing harbor for offshore wind activities could encounter opposition. Mutwal, currently utilized by foreign vessels and the local fishing community, might accommodate additional activities without overcrowding.

4.6.2 Scenario 2: Sri Lankan ports and Indian port(s) are used

Scenario development

Table 54 provides the mix of ports for scenario 2 for the port use and development, considering both Sri Lankan and Indian ports.

Table 54 Port scenario 2 for Mannar and Puttalam projects when Sri Lankan and Indian ports are considered

Type of Port	**Mannar**	**Puttalam**
Fabrication	Tuticorin	Tuticorin
Marshalling	Tuticorin	Tuticorin
SOV-based O&M	Wellamankaraya	Wellamankaraya*
CTV-based O&M	A jetty to be upgraded near Thalvupadhu Naval Base	A jetty to be upgraded near Norochcholai Coal Power Plant

** The Puttalam site may not need SOV facilities due to its proximity to land, CTV-based O&M is expected to lead*

When extending the consideration to Indian ports for offshore wind development in Sri Lanka, Tuticorin emerges as a prime candidate. It possesses the potential to assist Sri Lanka in facilitating offshore wind development, covering fabricating and marshalling. However, this does not go without Tuticorin undergoing substantial upgrades to be able to facilitate such activities, to be elaborated later in this chapter.

On the other hand, Colombo possesses all the qualities to be a potential marshalling port but faces an obstacle with the presence of a lock/gate, which is non-negotiable for a marshalling port. Relocating or alleviating this obstacle is considered more challenging than other types of upgrades, explaining why Colombo is replaced by Tuticorin in this scenario.

The selection of ports for O&M activities is similar for scenario 1.

4.7 Socio-economic analysis of different scenarios

The socio-economic analysis will delve into aspects such as job creation resulting from port development, necessary upgrades to prepare ports for various offshore wind development activities and the corresponding investment required for these enhancements. It is important to note that the focus of this analysis is exclusively on Sri Lanka.

Table 55 gives examples of the type of labor needed over the various stages of a typical 500 MW offshore wind project. Generally, most jobs are created during the production and O&M stage.

Since Sri Lanka will not house a manufacturing port for offshore wind, there will probably be little to no socio-economic impact in the production and transportation phase. The focus of this section will therefore be on the installation and O&M stages.

Table 55 Examples of labour for various phases of a typical 500 MW offshore wind project (source: IRENA, 2013)

	Planning	Production	Transport	Installation	O&M	Decommissioning
Examples of professions	Ship crew, legal, energy, real estate, and tax experts, engineers	Factory workers	Truck drivers, Ship crew	Ship crew	Ship crew, technicians, engineers	Ship crew, truck drivers, technicians, engineers

The type of supplier opportunities that will open up in the installation and O&M stages can fall into diverse industries that can be categorized into three types: primary, secondary, and tertiary sector suppliers. Table 56 further delineates what each sector contains.

Table 56 Classification of suppliers that are incurred from installation and O&M stages of an offshore wind development (QBIS, 2020)

Type	Classification	Examples of suppliers in installation and O&M phases
Primary suppliers	Suppliers for the core activities involved in installation and O&M of an offshore wind farm. Often highly specialized businesses with a substantial part of their turnover generated from offshore wind.	Installation vessel suppliers, CTV or SOV suppliers, local turbine inspection suppliers, specialized O&M suppliers etc.
Secondary suppliers	Suppliers in sectors other than offshore wind whose services may be required by the offshore wind developers and/or their primary offshore suppliers.	Local shipyards, equipment companies, steel manufacturers, electricians, cleaning and inspection services, fuel suppliers, etc.
Tertiary suppliers	Suppliers with no direct or indirect involvement in the core activities of an offshore wind farm. These suppliers may cater to the staff of offshore wind developers and their primary and secondary suppliers.	Local catering companies servicing installation and O&M operations, such as taxi companies, hotels, restaurants, shops, cinemas, bakeries, etc.

4.7.1 Scenario 1: Only Sri Lankan ports are used

Port upgrades needed

Table 57 summarizes the required major upgrades and their level of effort for scenario 1.

Table 57 Upgrades needed for scenario 1 and their level of effort (red = extensive, yellow = moderate, green = low)

Type of port	Name of port	Major upgrades needed
Fabrication port	None	N/A
Marshalling port	Colombo	Lock/gate relocation and equipment procurement and installation
SOV-based O&M port	A jetty to be upgraded near Norochcholai Coal Power Plant	Yard and quay length expansion
	Mutwal	Dredging of at least 1 – 2 m
	Wellamankaraya	Dredging of at least 3 m
	Colombo	No major technical upgrades
CTV-based O&M port	A jetty to be upgraded near Thalvupadhu Naval Base	Yard expansion
	A jetty to be upgraded near Norochcholai Coal Power Plant	Yard and quay length expansion
	Mutwal	No major technical upgrades
	Wellamankaraya	Dredging of at least 1 m
	Colombo	No major technical upgrades

Fabrication port

For fabricating activities, excluding the use of foreign ports is impossible since the limited market size for offshore wind in Sri Lanka does not allow investments in manufacturing ports in Sri Lanka to be feasible on the short term. Other foreign fabrication ports would be needed to fill the void. However, reliance on fabrication ports in other continents increases the risk of supply chain constraints in terms of availability and higher project costs.

Marshalling port

Relying solely on Sri Lankan ports for marshalling activities, particularly Colombo, requires upgrades as described in the port assessment section (such as lock relocation and additional crane lifting capacity). However, implementing such initiatives can be costly and time-consuming. Typically, projects of this nature involve extensive planning, engineering, and construction efforts. Therefore, it might be challenging to incentivize the port to invest in such expensive expansions, as marshalling activities are mostly short-term endeavors for offshore wind and might not lead to favourable return on investment. Nonetheless, the necessity of conducting modification plans can be justified when other industries, such as the maritime sector, can also leverage the same infrastructure. Furthermore, investments in Colombo's infrastructure can empower the workforce to develop offshore wind capabilities early on, enabling them to offer marshalling expertise and services to other regions. For Sri Lanka, this can extend to the nearby market of India, enhancing regional cooperation and economic opportunities (DNV, 2022).

According to the Roadmap, a 500 MW offshore wind project can create roughly 1,100 full time jobs during the installation phase of a project life cycle. With the assumption that one to three projects at Mannar and one project at Puttalam will be commissioned, an estimate of around 2,200 to 4,400 full time jobs could be created if Colombo becomes a marshalling port.

O&M port

A jetty to be upgraded near Norochcholai Coal Power Plant is a potential candidate for O&M activities in Mannar and the Northern part of the Puttalam potential site. To facilitate the accommodation of SOVs, yard and quay length expansion is needed. This enhancement would enable smooth operations and ensure compatibility with the requirements of SOVs engaged in offshore wind maintenance tasks. The surrounding onshore logistics pose significant challenges, as evidenced by studies indicating the local community's entanglement in a cycle of poverty (Jayansinghe, 2023). Essential amenities for crew members are notably absent in close proximity to the facility. This deficiency would require comprehensive planning to address logistical needs efficiently.

For Wellamankaraya fishing harbour to become an SOV-based O&M port, dredging activities are necessary. The current draft depth at the harbour is 4 meters, while a minimum depth of 7 meters is required for SOVs. Therefore, dredging of at least 3 meters would be needed for Wellamankaraya to meet this requirement. This upgrade would also enable the harbour to facilitate CTVs, as the requirement for CTV operations is a minimum dredging of 1 meter.

It is worth mentioning that attracting more traffic to the ports over a long period of time (i.e. at least 25 years of an offshore wind project lifetime) would exacerbate the congestion issue the port of Colombo is currently experiencing. Reports indicate queues stretching up to 5 km on several days of the week. It could lead to delays in transporting personnel, equipment, and materials to and from the offshore wind project site, impacting the project timelines. This applies both for Marshalling and O&M ports. Additional expenses may be incurred for overtime pay, expedited shipping, or alternative transportation methods to mitigate delays and meet project deadlines. Timely deployment of maintenance crews and equipment to offshore assets may be compromised, potentially leading to disruptions in operations and reduced energy production. The port is linked to a railway system and is planned for connecting to a highway in October 2024, which might reduce congestion issues in the future.

Becoming an O&M port can stimulate economic development around the jetty near Thalvupadhu Naval Base, the jetty near Norochcholai Power Plant, Wellamankaraya. This is especially true for the jetty near the naval base, as its nearby onshore facilities appear limited. Additionally, potential pollution issues near the Norochcholai Power Plant should be carefully considered when establishing a hub for offshore O&M in this region, as they could potentially harm the health of the staff working on offshore wind O&M if they are stationed here. It is also important to note that Sri Lanka will probably not have a strong local offshore supply chain. Therefore, the primary source of added value for local suppliers is expected to arise within the secondary industries (e.g. local shipyards, equipment companies, steel manufacturers, electricians, and inspection services) and the tertiary industries (e.g. taxi companies, hotels, restaurants, shops, cinemas, and bakeries).

According to the Roadmap, O&M activities of a typical 500 MW project would require 400 full-time jobs over the span of 25 years. Based on this and taking into account the potential (2 – 4) projects in Mannar and Puttalam, an estimated 800 to 1,600 full-time jobs would be required for the O&M stage. In general, offshore wind O&M activities are expected to bring long-term positive impacts to the harbor communities (Rudolph et al., 2015). However, incorporating a new purpose—specifically dedicating part of an existing fishing port to offshore wind activities—could potentially heighten social tensions within the community. There is, however, limited evidence available regarding the extent of these social impacts (Atkins Ltd & ABP Marine Environmental Research Ltd, 2014; Hattam et al., 2015).

Concluding, if only Sri Lankan ports are used, Sri Lanka will have to rely on further foreign ports for manufacturing, potentially risking the competitive price of offshore wind projects at home. Marshalling activities solely reliant on Sri Lankan ports also means that the local ports would bear costly and time-consuming infrastructure upgrade projects, with uncertain returns on investment given the short-term nature of these activities. However, amidst these challenges, there will be the need for at least 2,200 full-time jobs for marshalling activities and emergence in the tertiary industries surrounding O&M ports, which could provide employment opportunities for locals over 25 years, notably in less developed areas of the countries.

4.7.2 Scenario 2: Sri Lanka ports and Indian port(s) are used

Port upgrades needed

Table 58 summarizes the required major upgrades and their level of effort for scenario 2.

Table 58 Upgrades needed in scenario 2 and their level of effort (red = extensive, yellow = moderate, green = low)

Type of port	Name of port	Major upgrades needed
Fabrication port	Tuticorin	Dredging, breakwater widening, quay length expansion and equipment procurement and installation
Marshalling port	Tuticorin	Breakwater widening and equipment procurement and installation
SOV-based O&M port	A jetty to be upgraded near Norochcholai Coal Power Plant	Yard and quay length expansion
	Mutwal	Dredging of at least 1 – 2 m
	Wellamankaraya	Dredging of at least 3 m
	Colombo	No major technical upgrades
CTV-based O&M port	A jetty to be upgraded near Thalvupadhu Naval Base	Yard expansion
	A jetty to be upgraded near Norochcholai Coal Power Plant	Yard and quay length expansion
	Mutwal	No major technical upgrades
	Wellamankaraya	Dredging of at least 1 m
	Colombo	No major technical upgrades

The required upgrade for O&M ports is already elaborated under scenario 1, so below the required upgrades for Tuticorin are discussed.

The water depth at certain berths in Tuticorin would require enhancement to ensure seamless vessel traffic regardless of tide conditions. Although some berths currently maintain an acceptable depth for operations, there remains a concern regarding future advancements in offshore wind technology and the increasing size of components and vessels. This may pose limitations on accommodating larger cargo and installation vessels. Moreover, for vessels engaged in marshalling activities, restricted access to ports only during high tide could compromise their operational efficiency (Source: World Bank, 2020).

Furthermore, the existence of a breakwater poses a limitation on the width of harbor entrances for WTG installation vessels. Currently, the gap in the breakwater is insufficiently wide for these vessels to navigate through, particularly when transporting blades exceeding 100 meters in length, which may protrude beyond the vessel's deck. Therefore, widening the breakwater should be taken into consideration.

The majority of berths in Tuticorin fall short of the minimum quay length required to facilitate flexibility in scheduling inbound and outbound vessels. The inadequate length also restricts the number of vessels that can be concurrently moored at these berths. Additionally, it exacerbates the situation that all berths at Tuticorin are reported to have an occupancy rate exceeding 50%, compounding the challenges posed by the inadequate quay length. This presents a challenge particularly for marshalling activities, as while fabrication processes may tolerate delays, marshalling activities do not.

Finally, the port must be equipped with cranes with a lifting capacity of at least 500 tons to manage the handling of large WTG components, whether it functions as a fabrication port or a marshalling port.

Fabrication port

When Indian ports are included in the consideration, Tuticorin emerges as the primary candidate for a fabrication port.

For fabricating activities, utilizing Tuticorin could be strategically advantageous due to its proximity to the sites in Sri Lanka, making it a more viable option for a manufacturing port than ports located in other countries (lower potential projects cost and potential risks of supply chain constraints), provided that it undergoes appropriate upgrade plans. Additionally, the incentive to develop Tuticorin as a fabrication port is bolstered by India's recent announcement of a 4 GW offshore wind tender in Tamil Nadu in February 2024. There has been discussion surrounding the ambition to establish Tamil Nadu as a regional hub for offshore wind development. This ambition is fuelled by the region's expertise and capabilities in manufacturing, particularly the production of wind turbines (Times of India, 2023). As shown in Table 58, Tuticorin needs to undergo dredging, breakwater widening, quay length expansion and equipment procurement to be fitted to become a fabricating port.

Upgrades of this kind do not appear to require the physical resettlement of people, as they are contained within the existing port facilities. However, there is a risk of affecting economic activities due to pollution and sedimentation. The Gulf of Mannar is home to barracudas, Pearl (Pinctada fucata), and Chank (Turbinella pyrum) populations. Although pearl fisheries are no longer active and there are additional landing centres beyond Tuticorin, the potential environmental impacts of the port development must be carefully managed to protect the local economy (The Biodiversity Consultancy, 2023).

Marshalling port

For marshalling activities, Tuticorin satisfies most requirements, but upgrades are required in breakwater widening and lifting equipment. Relying on Tuticorin as marshalling port, would eliminating the need for time-consuming and costly expansion plans at Colombo port.

O&M port

Although Tuticorin is close enough to accommodate SOVs commuting to both sites, it is technically not feasible for CTVs to sail from India to the offshore wind sites. Therefore, it seems more logical to leave O&M operations to local facilities in Sri Lanka. So, the number of jobs established during the O&M phase remains similar as estimated under scenario 1.

Overall, given India's significant offshore wind ambitions, it is probable that India, particularly Tuticorin, will prioritize the development of a large purpose-built port to support offshore wind projects in the region. Other than the scale of proposed projects, it is very likely that offshore wind development in India starts earlier in time than Sri Lanka. Tuticorin port could therefore potentially serve not only Indian projects but also supply (later) offshore wind projects in Sri Lanka.

In this proposed scenario 2, Tuticorin emerges as a prime candidate for facilitating efficient fuel-saving fabrication and marshalling operations for offshore wind areas in Sri Lanka. Leveraging Tuticorin's strategic location and operational capabilities could significantly enhance logistical efficiency and reduce fuel consumption in the fabrication and marshalling processes associated with offshore wind projects (and thus lowering overall project costs). Tuticorin's role should be delineated within a broader strategy that optimizes logistical operations across multiple port facilities to maximize overall efficiency and effectiveness in supporting the burgeoning offshore sector in the region.

Regarding the O&M activities, Sri Lankan ports can fulfill these functions and findings are similar as described under scenario 1.

5.1 Preamble

Electricity produced at OWP plants is required to be stepped up to a higher voltage, since distances to shore are too large for transmission at the generating voltage. Once stepped up to a transmission voltage and delivered to an onshore substation, power has to be connected to either an existing node or a newly built node on Sri Lanka's transmission network that has the adequate capacity to deliver power to the load centers. The offshore sites are in the northern and north-western provinces of the country, whereas the major demand for electricity is in the western province, requiring reliable transmission capacity to transfer power from north to south.

This chapter explains the conceptual electrical system within each offshore wind farm to electrically interconnect wind turbines, and the transmission of the power output to the shore. Moreover, the transmission network in the north and north-western zones of Sri Lanka is explained, along with planned upgrades over the period 2025-2035. Then, the possible connection options to serve the power from each wind farm is described, along with power flow and contingency analyses and results. The recommended grid connection of each wind farm and an indicative cost estimate is provided.

5.2 Review of previous work

Under the Offshore Wind Development Program of the World Bank, the Offshore Wind Roadmap for Sri Lanka was published in June 2023. Studies conducted to formulate the roadmap included an assessment of the existing and planned grid infrastructure. The availability of the transmission network in the identified areas and the upgrades mentioned in the Long-Term Transmission Development Plan 2015-2024 were considered in these studies to appraise the adequacy of the transmission network for integration of offshore wind farms. Based on the high-level assessment conducted, the necessity to strengthen the transmission network in the Northern, Western, and Southeastern parts of the country was established, considering the likely scale of offshore wind farms and the strength of the existing transmission network in these areas. However, the roadmap recognizes the need to consider specific engineering designs of the offshore wind farms to determine the most suitable grid connection topologies.

This study undertakes site specific assessments to identify the suitable grid connection topologies including the voltage level, point of connection and the maximum capacity that can be connected with the grid. Under present legislative provisions, transmission assets can be owned and operated only by the transmission licensee. Therefore, different ownership modalities possible for grid connection infrastructure, as alluded to in the roadmap, are not assessed in this study.

Supplying power to India through the proposed India-Sri Lanka interconnector and conversion to green hydrogen and other energy forms were identified as likely enhancements of utilisation, if offshore wind generation exceeds the national demand. However, these assessments were primarily qualitative and highlighted the key issues in relation to grid integration of offshore wind farms.

5.3 Methodology

Identification of appropriate electrical system configurations for the proposed offshore wind farms in Puttalam and Mannar was carried out by conducting power system analyses for different capacities of the two offshore wind farms. The studies were conducted for the milestone year of 2035, using power system models, capturing the existing generation and transmission network and the planned capacity additions and network improvements.

The main criteria used in assessing the offshore wind capacity that can be developed in the two areas is the dispatchability of variable renewable energy in the power system. I.e. the ability of the power system to absorb the power generated by the offshore wind farms with the electricity demand expected to be available by the milestone year. Since the dispatchability is a system-wide characteristic, once the total offshore wind capacity that can be dispatched in the grid is identified, the share of capacity between the two offshore wind farms is assessed by conducting power flow studies.

Initially, the possibility of connecting the proposed wind farms to the available transmission network was studied, and the maximum capacity that can be grid connected in the two areas were identified, subject to the overall dispatchability and the ability to connect to the local transmission network. As it is desirable to develop offshore wind farms in larger capacities, the network infrastructure required to interconnect offshore wind farms in blocks of 500 MW was assessed. However, given the electricity demand forecasts and the generation and transmission network development plans are accurate only in the short term to medium terms, this study does not assess the feasibility of extending the identified offshore wind farm capacities beyond 2035. With the offshore wind resource available in the two areas being substantially larger than the electricity requirement of the country by 2035, it is expected that further offshore wind capacities would be developed upon developing the initial capacities identified by this study.

5.3.1 Electrical System within the Wind Farm

The electrical system of an offshore wind farm comprises all electrical components of the wind farm up to the point of common coupling (PCC), beyond which point, grid infrastructure is shared with other users. Therefore, the development of an offshore wind farm includes the development of both offshore and onshore infrastructure. This section describes the electrical systems of Puttalam and Mannar offshore wind farms to highlight the electrical infrastructure that needs to be developed as part of the two projects.

5.3.2 Offshore Electrical Infrastructure

Wind Turbines

The wind turbine model(s) and wind farm layout(s) have been described in Chapter 3. To perform power flow and other studies related to grid connection and operation of the offshore wind farms, a wind turbine model containing a 20 MVA synchronous generator coupled with a 15 MW the turbine in the wind farms was assumed.[60] A step-up transformer installed within the wind turbine elevates the voltage to 33, 66, or 132 kV for onward transmission.

Sri Lanka’s transmission voltages are 132 kV and 220 kV, with 400 kV planned to be introduced in the future. There was a sub transmission network of 66 kV used until late 1990s, which was gradually replaced or upgraded to 132 kV as a result of policy decisions at that time. Distribution voltages used in Sri Lanka are 11 kV and 33 kV. Retail customers are supplied at 400 V.

While the offshore wind turbine models currently available in the market uses sub-transmission voltages up to 66 kV, considering the assessments are done for development of offshore wind farms by the milestone year 2035, it is expected that offshore wind turbines to be available with 132 kV transmission voltage, reducing the number of cables required to reticulate power from the turbines to the transmission substation.

[60] In the assumed wind turbine model, the generator comprises 100 pole-pairs and at the rated rotational speed of 0.792 rad/s, it generates electricity at a frequency of 12.6 Hz. The generating voltage is 4.77 kV. A 20 MVA AC-DC-AC converter converts the electricity produced in the generator to the grid frequency of 50 Hz.

Submarine Cables

Within the offshore wind farm, the electricity generated by the wind turbines will be reticulated through submarine cables. Cables with high current carrying capacities will be used such that one cable can collect power generated by several turbines, to reduce the number of submarine cables used. It is assumed that 8-9 turbines installed in one row will be connected through a single three-core 132kV submarine cable. These submarine cables will collect the generated power from the wind turbines and transmit it to either an offshore or an onshore collector substation.

Based on the generation capacity of the selected wind turbine and the number of wind turbines connected through one cable, the maximum current a cable is expected to carry is 800 A. 132 kV XLPE submarine cables with 1,000 mm^2 copper conductors can be used to carry this current with acceptable power losses and voltage drop.

Collector Substations

Typically, an offshore collector substation is used to further increase the reticulation voltage prior to being transmitted toward the onshore grid. However, both Puttalam and Mannar offshore wind farms are located relatively close to the shore, allowing sub-transmission voltages such as 33 kV or 66 kV for reticulation. However, as 66 kV is not used in rest of the transmission network, maintainability of 66 kV reticulation voltage in Sri Lanka in the long term can be difficult. Use of 33 kV necessitates a large number of cables to be drawn in parallel to reticulate 500 MW. Therefore, the reticulation voltage was selected as 132 kV, allowing power to be transmitted without any significant voltage drop or power loss, even without the voltage getting stepped up. Therefore, offshore substations will not be required for the two wind farms.

Layout Offshore Electrical Infrastructure

The offshore electrical infrastructure of the Mannar and Puttalam project concept has previously been presented in Chapter 3.

5.3.3 Onshore Electrical Infrastructure

Apart from the offshore electrical infrastructure that needs to be developed for collection and transmission of power generated from the offshore wind turbines to the shore, the electrical system of the offshore wind farms includes onshore infrastructure that needs to be developed as a part of the project.

Step-up and Switching Substations

The submarine cables from the offshore wind farm need to be connected to an onshore collector substation constructed close to the shore, where switching and stepping up of voltage for onward transmission is done. To avoid the entire wind farm getting interrupted owing to a fault or a maintenance activity occurring in one of the submarine cables, provisions for electrical isolation and tripping of each cable will be made available at the onshore substation. Considering the high capacity of the two offshore wind farms (500 MW or more), onward transmission of the collected power at 132 kV is not feasible. Therefore, at the onshore substation, the voltage is required to be further increased to 220 kV by using 132/220 kV step up transformers.

Transmission Lines

To reduce costs, power transmission beyond the onshore substation will be done using overhead bare conductors. A 220 kV double circuit transmission line typically used in Sri Lanka will be constructed as part of the project, to transmit power from the onshore substation up to the PCC.

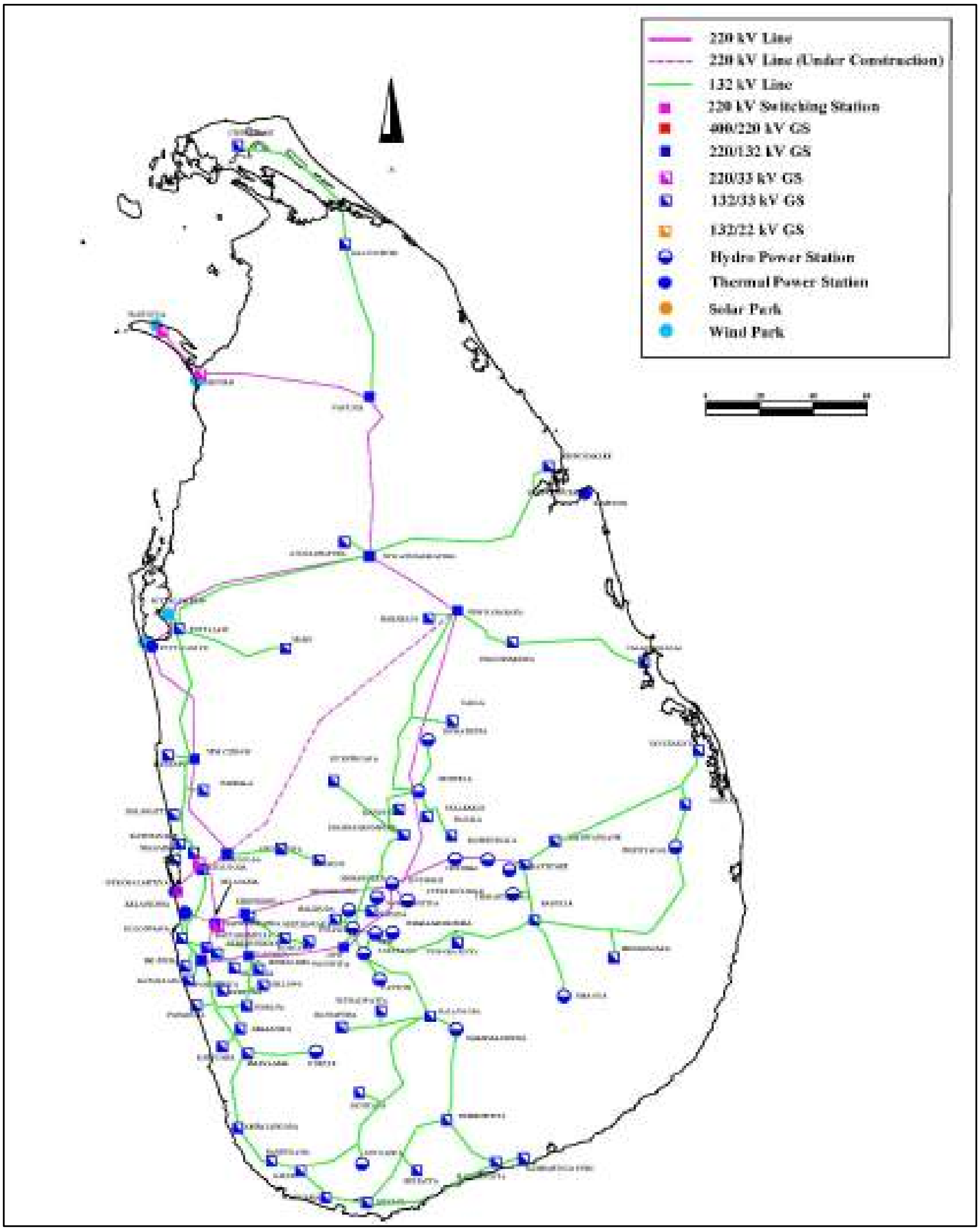
5.4 Grid Connection of the Offshore Wind Farms

With capacities exceeding hundreds of megawatts, offshore wind farms are connected to the rest of the power system through the high voltage transmission network. The availability and ability of the transmission network to connect the offshore wind farms is a primary limiting factor of OWP development. Therefore, a detailed assessment of the grid connection of the two offshore wind farms was undertaken.

5.4.1 The Existing Transmission Network of Sri Lanka

The transmission network of Sri Lanka covers the entire country and is continuously being expanded to serve the increasing demand and to collect power generated by a geographically scattered set of power plants, especially power generated using renewable sources. The grid map of Sri Lanka, as of 2022, is presented in Figure 91.

Figure 91 Map of the Sri Lankan Power System in 2022 (source: Statistical Digest 2022 of Ceylon Electricity Board)



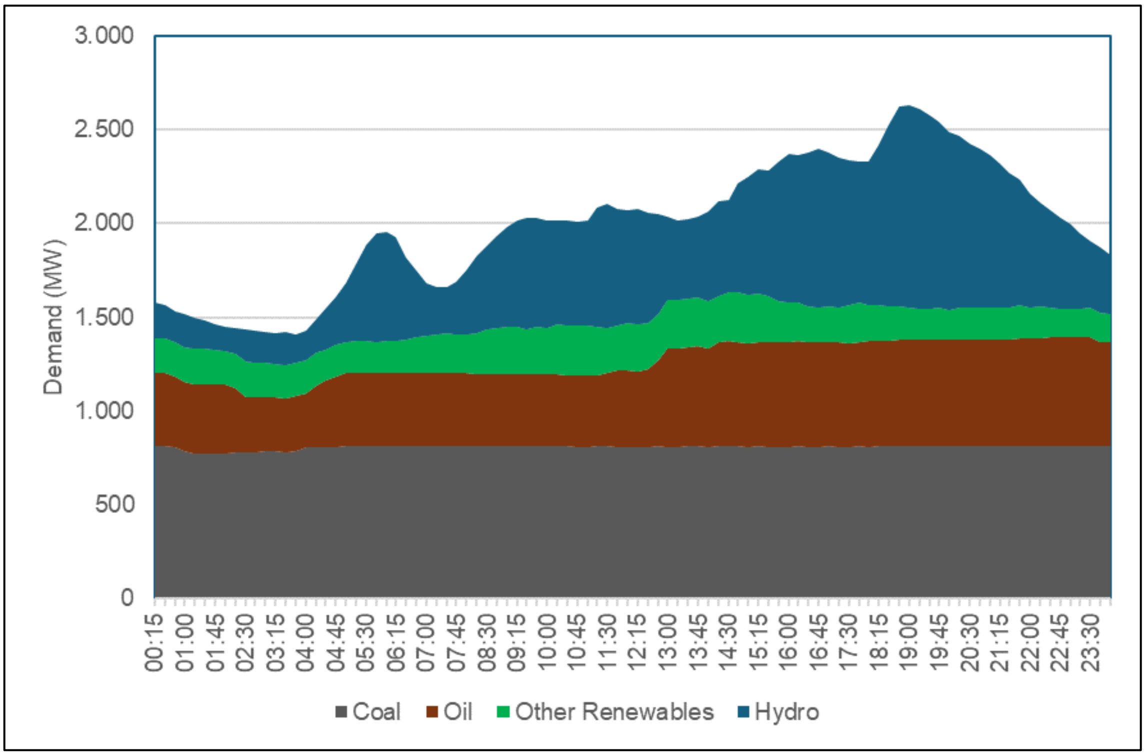
For electricity transmission, only 132 kV and 220 kV voltages are used at present. 400 kV has been selected as the next higher voltage level to be used in Sri Lanka. Apart from short lengths of underground cables installed closer to the commercial hub Colombo, the transmission lines are typically bare conductor-overhead lines.

5.4.2 Electricity Demand and Forecast Growth

In addition to grid connection, the scale and characteristics of the demand also present challenges to development of offshore wind farms, owing to the high capacity and seasonality effect of wind power generation. Despite being a relatively small power system, the electricity demand has been growing at a rapid pace, instigating expansion of the power system in terms of generation capacity and network connectivity.

Electricity demand in Sri Lanka grew at 5.8% per year over 2015–2019 but declined in 2020 and 2021 owing to the pandemic and in 2022 due to load shedding caused by a shortage of fuel imports. In 2022, the per capita electricity consumption was 655 kWh, down from 687 kWh in 2021. The peak demand in 2022 was 2,708 MW, with 16,056 GWh of net generation, registering an annual load factor of 68%. The peak demand further dropped in 2023 to less than 2,250 MW. However, the electricity demand is picking up again, recording 2,631 MW on 2 May 2024. Compared with the evening peak, the off-peak demand occurring in the early morning is relatively low, almost half of the evening peak. Figure 92 depicts the typical variation of electricity demand within the day[61]. Due to the absence of prominent seasons, this daily variation generally repeats throughout the year with slight changes based on weather conditions and between holidays and working days.

Figure 92 Daily Load Curve of the Sri Lankan Power System (Source: Data provided by CEB)



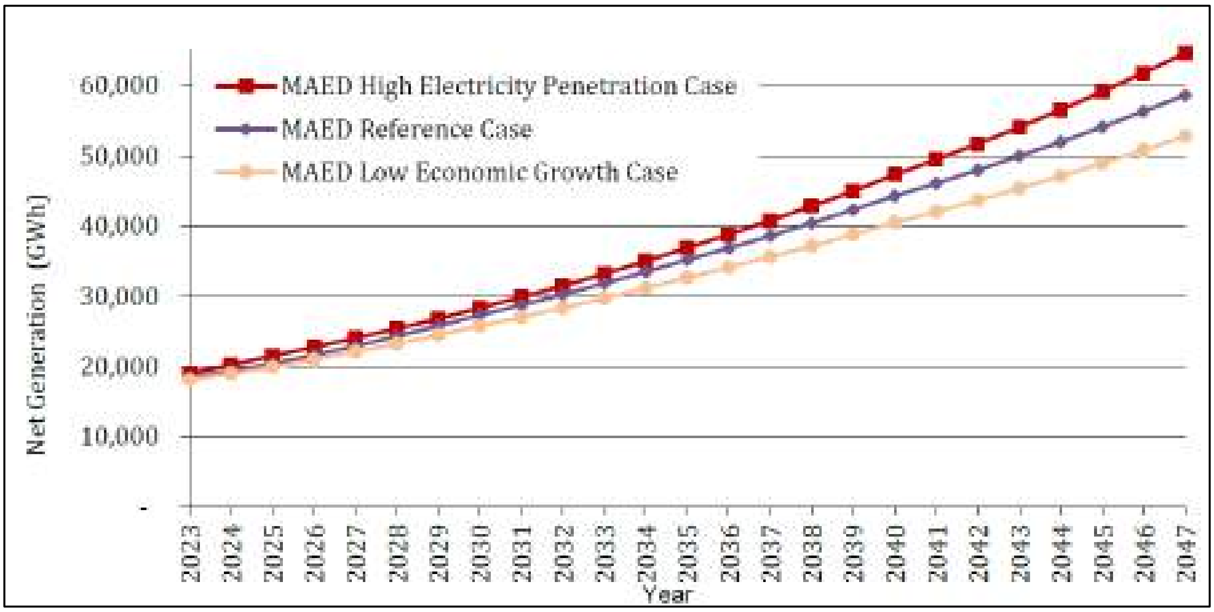
Note 1: This includes (i) centrally dispatched power plants and (ii) distributed generation for which telemetering is available. A very significant capacity (of about 1000 MW in 2025), mostly rooftop solar PV, is not telemetered and hence does not appear in the profile.

[61] Variation in electricity demand during the day is represented by the daily load curve of the day. The maximum night peak recorded up to the date of writing this report in 2024 was on 2nd May 2024 (source: Ceylon Electricity Board).

An average demand growth rate of about 6% per year is forecast from 2025, resulting in a forecast annual energy demand of 32,646 GWh and a peak demand of 5,650 MW by 2035.

Figure 93 shows the projections made for the electricity demand with growth projections made under various scenarios. Based on the projected growth in electricity demand, the offshore wind farm capacity that the power system can absorb is expected to increase in the future.

Figure 93 Projection of Electricity Demand under Different Economic Conditions (Source: CEB Long Term Generation Expansion Plan 2023-2042)



5.4.3 Ability to Connect Offshore Wind Farms to the Sri Lanka Power System

To assess the ability of the power system to accommodate an offshore wind farm, three main criteria should be checked:

1. Whether the wind farms can be dispatched (generate power) such that the power generation is utilized in real time by the loads in the system (including any storage systems).
2. Whether the connected wind farms would affect the stability of the power system.
3. Whether the network is available and has sufficient capacity to connect and operate the wind farm.

Each criterion is assessed in more detail below.

Dispatch of Offshore Wind Farms

To assess whether the offshore wind farms can be dispatched in the Sri Lankan power system, dispatch studies should be conducted, giving due consideration to all possible demand and supply scenarios such as maximum and minimum demand that could occur during the operational life of the wind farms, the other generating sources available to meet the demand and their operating characteristics. These studies are done at overall system planning level, using system-wide generation, load, and network details, typically using sophisticated dispatch modelling software.

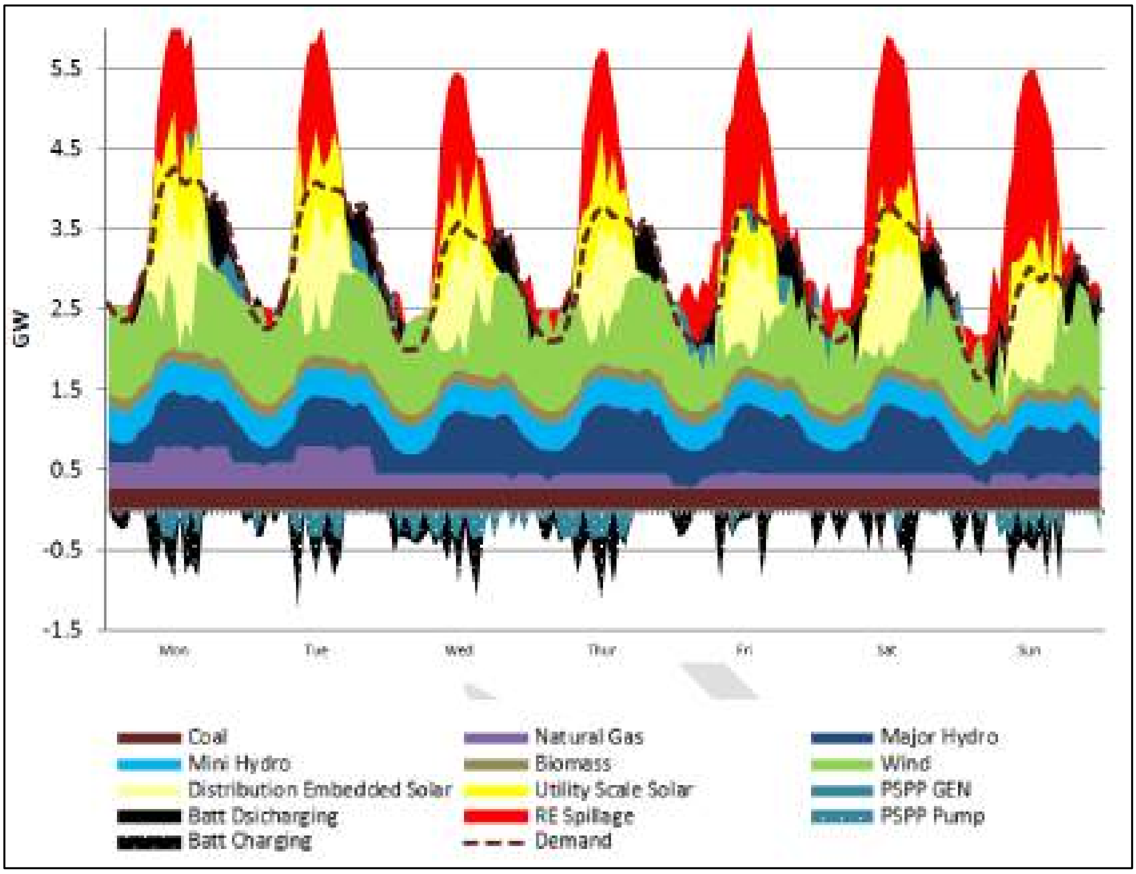
In the recently conducted long-term generation planning process (*CEB Long Term Generation Expansion Plan 2023-2042*), CEB has identified the safe limit of wind generation capacity that can be accommodated by the power system every year. Part of this wind power capacity is already operating in the power system and Table 59 presents the additional wind power capacity that can be dispatched in the power system each year from 2025 to 2042.

Table 59 Additional Wind Power Capacity Dispatchable in the Sri Lankan Power System

Year	Additional Wind Power Capacity (MW)
2025	100
2026	290
2027	250
2028	200
2029	250
2030	200
2031	200
2032	150
2033	150
2034	150
2035	150
2036	150
2037	150
2038	150
2039	150
2040	150
2041	150
2042	150
Total	3140

Despite the additional wind capacities given in Table 59 being identified as feasible to dispatch, a substantial amount of wind power generation is expected to go unutilized during high wind season. Figure 94 shows the amount of wind power and other generation expected to be spilled in 2030 during high wind seasons (due to excessive generation over and above the demand).

Figure 94 Expected weekly dispatch profile during high wind season in 2030 (source: CEB Long Term Generation Expansion Plan 2023-2042



Note 1: Demand and dispatch profiles for one week in 2030 are shown
Note 2: Sri Lanka's peak demand reached about 2.7 GW in 2024.

Out of about 2,100 MW of additional wind power capacity identified to be dispatchable until 2035, about 630 MW is already in various stages of development.[62] Leaving provisions for another 470 MW of wind power capacity that is already committed for grid connection, at least 1,000 MW of wind power capacity can be dispatched in the Sri Lankan power system by the end of 2035. A further 750 MW of capacity additions are expected from wind power by 2040.

This study assumes that the 1,000 MW of additional capacity of wind power dispatchable by 2035 can be allocated for offshore wind, without violating the criteria used by CEB in assessing the dispatchability of wind power during the planning studies. Without conducting further assessments on dispatchability, the ability of the power system to absorb offshore wind capacity beyond 1,000 MW up to 2035 cannot be confirmed. However, as noted above, with the annual growth in demand, the dispatchable capacity of offshore wind will continue to increase beyond 2035. Table 60 shows the allocation of dispatch capacity for onshore and offshore wind as used in this study.

[62] Thambapavani Stage II – 50 MW, Ceylex (Mannar) – 20 MW, CEB IPP – 50 MW, CEB Silawatura – 100 MW, Adani Green Energy (Mannar) - 265 MW, Adani (Pooneryn) – 235 MW.

Table 60 Allocation of Dispatch Capacity for Wind Power

Year	Dispatchable Capacity of Wind Power (MW)	Allocation of Wind Capacity (MW)	
		Onshore Wind	Offshore Wind
2025	100	100	-
2026	290	290	-
2027	250	250	-
2028	200	200	-
2029	250	250	-
2030	200	-	-
2031	200	-	-
2032	150	-	500
2033	150	-	-
2034	150	-	-
2035	150	-	500
Total	2090	1090	1,000

System Stability

The impact of offshore wind farms on power system stability is also an important criterion to be assessed in the process of identifying the offshore wind capacity that can be accommodated in the grid. The fluctuation of generation and the inability of wind farms to provide inertia[63],or spinning reserve[64], as well as the inability to improve system fault levels can compromise the overall stability of the power system.

In establishing the dispatchable wind power capacity described above, these stability studies have also been conducted by CEB. Therefore, as long as the capacity of offshore wind farms added to the system does not exceed the capacities indicated in Table 60, stability of the system will not be deteriorated beyond acceptable levels.

Network Adequacy

Upon identifying the capacities of offshore wind farms that can be dispatched in the power system, based on the location of the offshore wind farms and the existing network infrastructure available closer to the wind farm locations, the ability of the network to connect the offshore wind farms should be assessed. As the realistic timeline for development of offshore wind farms in Sri Lanka has been identified as 7 to 10 years, by the time the offshore wind farms are ready to be connected to the power system, the existing network could be substantially expanded, improving the possibilities of connecting offshore wind farms to the grid. At the same time, considering the scale of development of offshore wind (i.e. 1,000 MW) in comparison with the total installed capacity of about 17 GW by 2035, idling network resources are unlikely to be available for connection of offshore wind farms without undertaking additional network strengthening. Subject to such strengthening work, the adequacy of the network is assessed.

[63] Stored kinetic energy to support the grid during disturbances that cause reduction or increase of grid frequency

[64] Reserve capacity that is ready to provide additional power when demanded; since wind is a pass-through source, holding spinning reserve in wind turbines is not practiced, allowing the turbine to harness the maximum energy from wind at all times.

5.4.4 Existing network infrastructure in the project areas

Puttalam Offshore Wind Farm

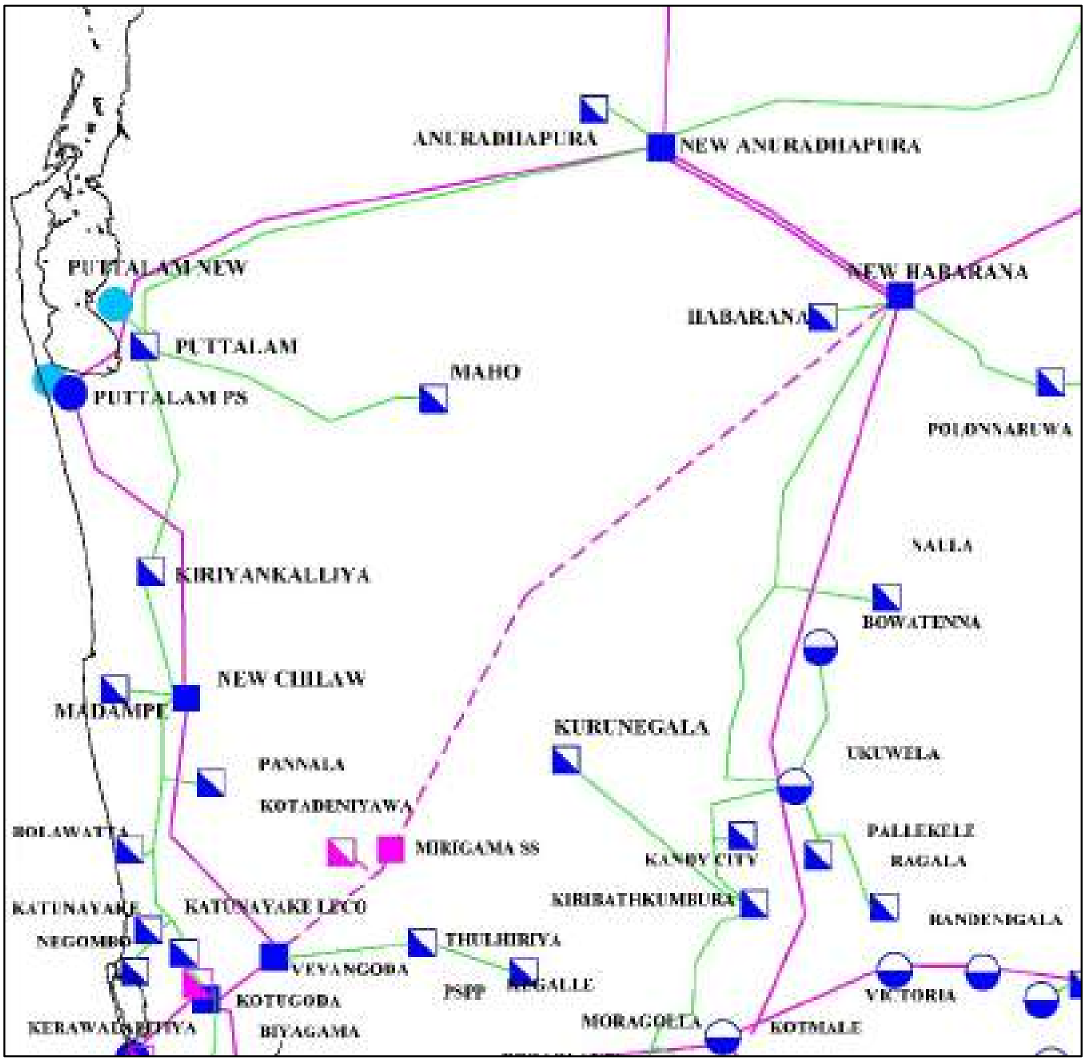
The submarine cables from the offshore wind farm will land onshore close to Udappuwa area in Puttalam District, about 30 km south of the existing coal power plant in Norochcholai.

As shown in Figure 95, Puttalam has a 33/132 kV grid substation in Kalladi junction, which is supplying the local electricity demand. Some of the existing 10 MW wind power plants are connected to the national grid at Kalladi grid substation. The capacity of Kalladi grid substation is fully utilized and the space limitations in and around the substation prohibits further expansion of the substation.

The 220 kV transmission network is also available in Puttalam (see network infrastructure in Figure 95), due to the presence of the 900 MW Norochcholai coal power plant. Two 220 kV transmission lines connect the Norochcholai coal power plant with New Anuradhapura (from north) and New Chilaw (from south). The identified landing point of the Puttalam offshore wind farm is located in between the Norochcholai coal power plant and New Chilaw 33/220 kV grid substation.

Due to the connectivity with the grid substations in Veyangoda, Kotugoda, and Biyagama, which are important load centers of the power system, the 220 kV transmission line from Norochcholai to New Chilaw is important for safe operation of the Norochcholai power plant, which is the largest power plant in the power system. The line already carries 810 MW (net) from Norochcholai power plant and a further 65 MW of onshore wind power. The 810 MW capacity is expected to be operational until the end of the currently approved long-term generation expansion plan in 2042, whereas the 65 MW of onshore capacity is likely to be repowered with higher capacity turbines, as the agreements on these come to end of term starting 2030. Therefore, this study assumed that the importance of Norochcholai power plant to maintain stability and to serve the baseload of the grid, will prevent any capacity of the Norochcholai-New Chilaw transmission line to be released to serve OWP to the grid.

Figure 95 Network Infrastructure Near Puttalam Offshore Wind Farm

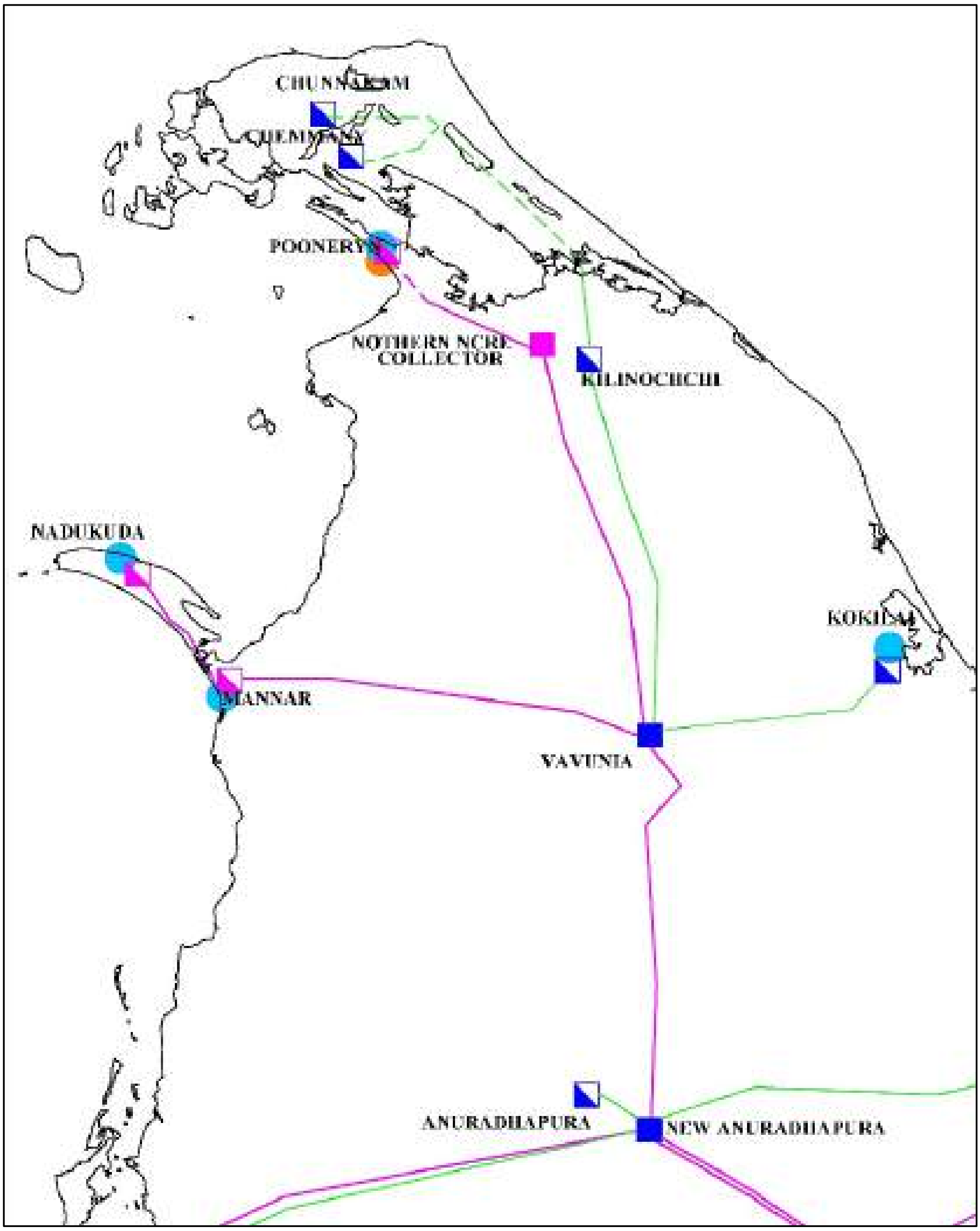


Note: Puttalam PS is the Norochcholai power plant described in the text

Mannar Offshore Wind Farm

To supply the demand in Mannar area (see network infrastructure in Figure 96) and to connect the existing 100 MW Thambapavani wind farm to the national grid, a 220 kV transmission line between Mannar grid substation and the New Anuradhapura grid substation (via Vavuniya grid substation) is available. However, the capacity of this line is already committed to the existing and on-going wind power development in the Mannar area. If some of the projects this transmission capacity is reserved for do not get developed, such transmission capacity can be used for the connection of offshore wind farms. However, such reallocation of transmission capacity can take time due to time extensions awarded to projects in the pipeline.

Figure 96 Network Infrastructure Near Mannar Offshore Wind Farm



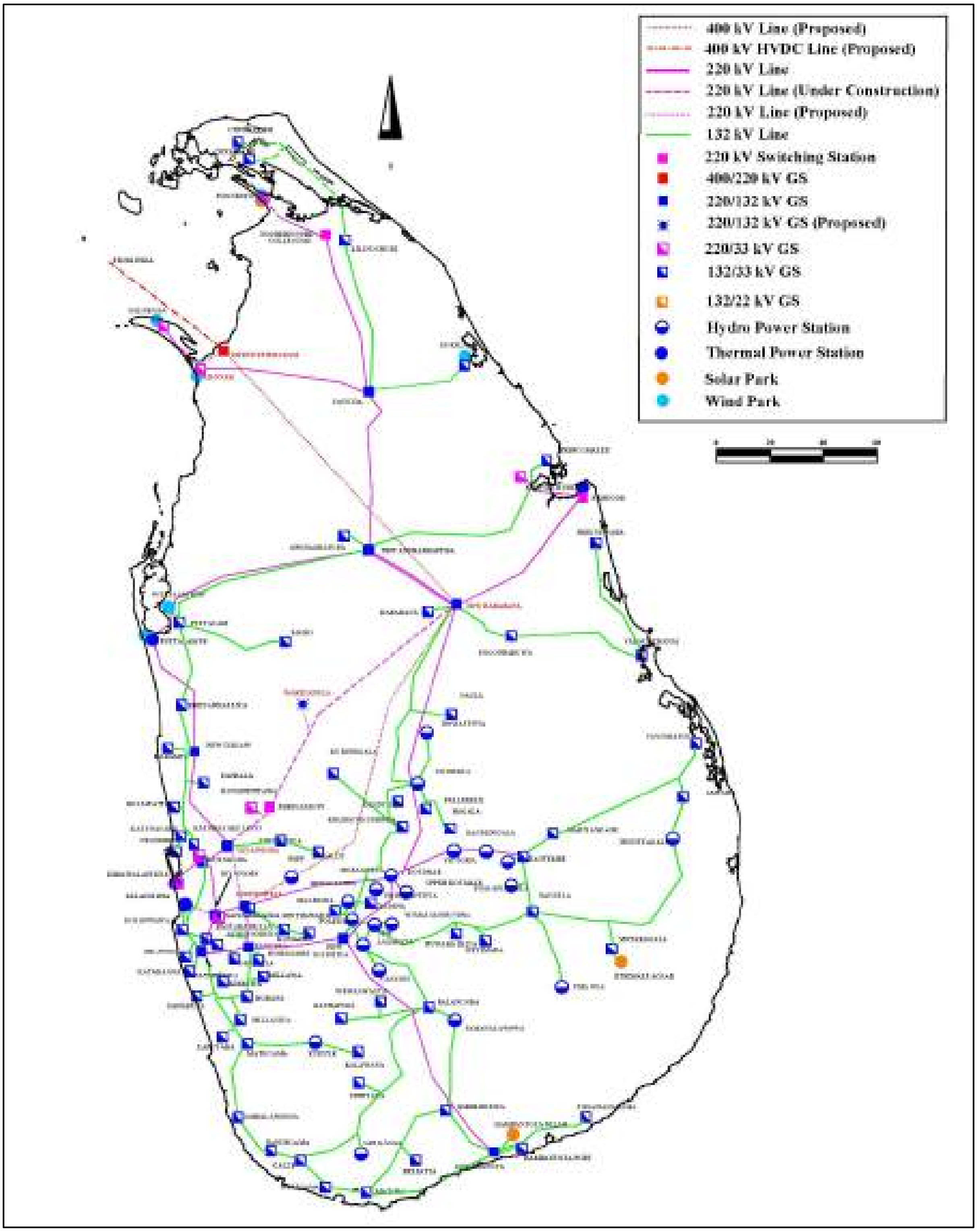
Some planned network upgrades relevant for connection of the offshore wind farms to the power system. By the time the offshore wind farms in Puttalam and Mannar are ready for grid connection, the transmission network of Sri Lanka is expected to have undergone significant developments, especially to cater to the increasing demand and to facilitate the development of renewable energy in north and northwestern regions of the country. In addition, the planned India-Sri Lanka grid interconnection will need the network in the Mannar area to be substantially strengthened.

Since the two offshore wind farms are in northwestern and western regions, high level network upgrades can influence power flows from both wind farms. The following planned network strengthening activities are relevant for the assessment of network adequacy of the two offshore wind farms (visualized in Figure 97, planned substations are marked in red):

1. Construction of the 220 kV transmission line from Veyangoda to New Habarana
2. Construction of a new 132/220 kV substation in Wariyapola.
3. Connection of the New Habarana-Veyangoda 220 kV transmission line with the Wariyapola grid substation through a line in-line out connection.[65]
4. Construction of 220/400 kV HVDC substation in Mannar (Thiruketiswaram to the north of Mannar is the proposed location) to facilitate the India-Sri Lanka grid interconnection.
5. Installation of an HVDC interconnector between Madurai in India and Mannar in Sri Lanka.
6. Construction of a 400 kV transmission line from Mannar HVDC substation to New Habarana grid substation.
7. Construction of a 220 kV transmission line from the existing 33/220 kV Mannar grid substation to the 220/400 kV HVDC substation.
8. Construction of a new 33/220/400 kV grid substation in Kirindiwela in the Western province.
9. Construction of a 400 kV transmission line from New Habarana grid substation to Kirindiwela grid substation.
10. Construction of a 220 kV transmission line from Kirindiwela grid substation to Veyangoda grid substation

[65] Line-in line-out connections are done by bringing in and take out a transmission line from a substation. Instead of tapping into an existing transmission line (called a T-off connection), a line-in line-out connection provides more operational flexibility and reliability.

Figure 97 Map of the Sri Lankan Power System with proposed upgrades (planned substations are marked in red)



To identify the most suitable grid connection arrangements for the two offshore wind farms, power flow analyses were conducted, modelling the existing and planned network infrastructure in conjunction with the operation of the respective offshore wind farms. Different options available for grid connection of each wind farm were tested to ensure the most economical and technically feasible option is identified. Appendix A provides the details, and the results of the network modelling and power flow analyses conducted.

Puttalam Offshore Wind Farm

To connect the Puttalam offshore wind farm with the grid, the following connection options were studied.

1. Connecting the onshore substation of the Puttalam offshore wind farm to the existing Norochcholai power station.
2. Tapping the existing 220 kV transmission line between Norochcholai power station and the New Chilaw grid substation using a line in-line out connection from the transmission line to the onshore substation.
3. Connecting the onshore substation of the Puttalam offshore wind farm to the planned Wariyapola grid substation.

According to the results obtained from the power flow analyses, only the Wariyapola connection is feasible for the Puttalam offshore wind farm as the other connection arrangements can exceed system operating limits during (n-1) contingencies.[66]

Therefore, the following electrical system and the grid connection arrangement are proposed for Puttalam offshore wind farm.

- The Puttalam offshore wind farm will be of 500 MW capacity, comprising multi-MW offshore wind turbines.
- Four 132 kV submarine cables will each connect 8-9 wind turbines together and transmit the power collected from the wind turbines to a new onshore substation.
- At the onshore substation, the voltage will be stepped up to 220 kV.
- A new 220 kV double circuit overhead transmission line of approximately 50 km will be constructed from the Puttalam onshore substation to Wariyapola grid substation.
- At Wariyapola grid substation, the 500 MW Puttalam offshore wind farm will be connected with the national grid.

Mannar Offshore Wind Farm

As a radial transmission node[67] in the network, Mannar does not present many alternatives to grid connection of the offshore wind farm. As discussed in the previous sections, Mannar has two connection options: 1) the existing 33/220 kV Mannar grid substation and 2) the planned 220/400 kV HVDC substation. However, given the landing point of the submarine cables of the offshore wind farm is close to the existing Mannar grid substation, grid connection at the Mannar grid substation is the most cost-effective option. At the same time, the new 220 kV transmission line that will be constructed to connect the Mannar grid substation to the HVDC substation will establish a strong connection between the offshore wind farm and the HVDC substation, allowing the generated power of the offshore wind farm to be transmitted across the 400 kV network in parallel with the 220 kV network.

[66] Power system contingencies are identified as N-1 or N-2, to define the failure of a single element or two elements of the transmission system (which has a total of “N” elements). An element can be a transmission circuit, a transformer, switching equipment, etc. Sri Lanka’s planning criterion is that the transmission system should withstand a n-1 contingency, without violating any operating limit or interrupting any customer of the transmission system.

[67] A radial node is a dead-end of a transmission network, which has only one path to connect to the rest of the transmission network. A radial node does not offer an alternative path for power flow, in case the line connecting to the next point in the network fails.

The power flow studies presented in Appendix A have identified a minor overloading condition (the current being a few percent above the rated current) of one of the two circuits of the transmission line from the existing 220 kV Mannar grid substation to the HVDC substation yet to be built, when the other circuit is out of operation. This is an undesirable condition. However, instead of constructing a dedicated transmission line for the Mannar offshore wind farm, it is possible to slightly increase the line capacity by selecting a different conductor, as the construction of the line is yet to commence.

Accordingly, the following electrical system and the grid connection arrangement is proposed for the Mannar offshore wind farm.

- The Mannar offshore wind farm will be of 500 MW capacity, comprising multi-MW offshore wind turbines.
- Four 132 kV submarine cables will each connect 8-9 wind turbines together and transmit the power collected from the wind turbines to the existing Mannar grid substation over an average distance of about 53 km.
- At the Mannar grid substation, the voltage will be stepped-up to 220 kV using transformers installed as part of the project (Mannar grid substation currently does not have 132/220 kV step up transformers).
- The 500 MW Mannar offshore wind farm will be connected with the national grid at the existing Mannar grid substation.
- However, since the capacity of the existing 220 kV line from Mannar grid substation to New Anuradhapura grid substation (via Vavuniya) is already allocated for other wind farms, construction of the 15 km 220 kV double circuit overhead transmission line between Mannar grid substation and the HVDC substation is imperative for the evacuation of power from Mannar offshore wind farm.

Since the transmission line between Mannar grid substation and the HVDC substation is likely to get overloaded with the connection of the offshore wind farm, enhancement of the planned capacity will be undertaken by the project. Table 61 presents a summary of the identified offshore wind farm capacities that can be connected with the grid under different network upgrading scenarios. As summarized in the table, without additional network upgrades, only a limited capacity can be connected.

Table 61 Grid-connectable offshore wind by 2035 (scenarios)

	Offshore wind farm capacity possible for grid connection	**Mannar**	**Puttalam**	**Remarks**
1	With the planned upgrades	250 MW	200 MW	Upgrading of the transmission network infrastructure is planned for Mannar in parallel with the ongoing onshore wind development in Mannar. However, only limited capacity is uncommitted. No substantial transmission network upgrades planned in Puttalam area.
2	With additional upgrades of the grid	500 MW	500 MW	Further upgrading of the transmission network in Mannar and Puttalam is possible to accommodate offshore wind.

	Offshore wind farm capacity possible for grid connection	Mannar	Puttalam	Remarks
3	With 1 and 2 above, in combination with the interconnector with India	1,000 MW	500 MW	500 MW of India-Sri Lanka interconnection capacity is assumed to be allocated to export wind power generated in Mannar to India. Offshore wind farm in Puttalam will still have transmission constraints, preventing export of generation by an offshore wind farm in Puttalam to India.

While Table 61 presents the offshore wind farm capacities that can be grid connected by 2035, this capacity can be further increased with increasing electricity demand in the system. For example, based on the current demand forecasts, by 2040, the capacity that can be connected in Mannar can be increased to 1,500 MW, provided the necessary network upgrades are undertaken to transmit power collected from Manner to other parts of the country. The following will facilitate further increase in capacity of Mannar Offshore Wind farm to 1,000 and 1,500 MW:

- Construction of two (1,000MW) or three (1,500 MW) offshore substations to step up the voltage to 220 kV close to the offshore wind turbines to reduce losses.
- Connection of the offshore substation to the 220 kV bus at Mannar grid substation using 3 (1,000 MW) or 4 (1,500 MW) HVAC cables.
- Upgrading of the 15 km 220 kV overhead transmission line between Mannar grid substation and the HVDC substation in Thiruketiswaram to increase the power transmission capacity between Mannar grid substation and HVDC substation.
- Allocation of 500 MW transmission capacity of the India-Sri Lanka interconnector to transfer power from Mannar Offshore Wind Farm to the Indian Electricity Market.
- The proposed 400 kV double cct. transmission line between the HVDC substation and New Habarana has sufficient capacity to transfer up to 2,000 MW. Therefore, spare capacity available upon transmission of power from India to Sri Lanka can be used to supply power from Mannar Offshore Wind Farm to rest of the Sri Lankan grid.[68]

[68] This will be subject to stability and reliability studies to ensure that the Sri Lankan power system can sustain safe operation if one of the two circuits of the 400 kV transmission line trip off.

6.1 Preamble

Favourable market conditions are essential for offshore wind development in Sri Lanka, as they attract investments, reduce financial risks, and lower costs. Due to global competition, enormous targets and limited supply chain, projects in the most attractive markets will be built first. Market conditions encompass a broad range of factors, the key ones of which are included in this chapter. First, an overview of Sri Lanka's macroeconomics will be given, highlighting key trends and discussing factors that could influence offshore wind development. Following this are the procurement options for offshore wind. The remaining (and largest) part of this chapter addresses commercial risks and bankability considerations.

As a general structure for each component, (1) the current status in Sri Lanka will be given, (2) various options to support (the implementation of) an OWP project will be introduced including pros and cons, and (3) recommendations will be made on the most favourable route for Sri Lanka. Each main section ends with providing the key insights. The relationship with India will be elaborated upon, where relevant. While the study is centred on offshore wind development in the priority areas of Puttalam and Mannar, most of the findings are applicable at a national level, as the aspects investigated are relevant nationwide.

6.2 Overview of previous work

The Roadmap addresses several topics discussed in this chapter; however, these are generally covered only briefly. Some of the topics in this chapter are not included in the Roadmap. More detailed information on what is (briefly) covered by the Roadmap, and what is not, can be found in Table 62. For the topics mentioned in the Roadmap, the aim of this study is to provide more details and incorporate additional local (and regional) context where possible.

Table 62 Coverage of Roadmap related to items in this chapter

Item	Covered in Roadmap	Additional scope of current study
Sri Lanka Macro-economics	Brief overall explanation of macro-economic climate and developments, GDP and power market.	Inflation drivers, currency reserves, fiscal stability, IMF plan.
Procurement options	Discusses the various procurement systems and recommended the government-led approach (one-competition model) for Sri Lanka.	Not applicable, this study follows the recommendation of the Roadmap.
Commercial risks and bankability considerations	An extensive assessment of commercial risks and bankability considerations is not part of the Roadmap. However, it briefly touches upon the risks from the following items: environmental and social, grid connection, PPA, offtake creditworthiness, exchange rate, repatriation of profits, curtailments, currency depreciation, developers track record, political and regulatory stability, lending capacity of local banks, business case and	Technical Supply chain Ports Grid connection Standards Financial Financial support mechanisms such as pricing, tax arrangements and grants/ subsidies. Costs Electricity price Interest rates

Item	Covered in Roadmap	Additional scope of current study
	international lenders' E&S requirements. Regarding financial support mechanisms, several instruments mentioned but not elaborated or specified for the local context.	Taxation

6.3 Sri Lanka macroeconomics

Macroeconomics play a crucial role in offshore wind projects by influencing economic factors (such as currency values, inflation rates, interest rates, government policies, energy demand, market prices, and many more) and thus economic returns and viability of offshore wind projects. The economic situation and forecasted economic development will impact the willingness of (foreign) investors to invest in Sri Lanka. Several key aspects of macroeconomics in Sri Lanka are described in more detail below.

6.3.1 GDP

The Gross Domestic Product (GDP) can be seen as the overall buoyancy of the economy. Over the past decade, Sri Lanka's GDP has experienced notable fluctuations. In 2011, the GDP growth rate was robust at around 8.0%, buoyed by post-war reconstruction and relatively higher foreign investment. However, growth began to decelerate in subsequent years, averaging around 3.5% due to political instability and external debt pressures. More recently, the COVID-19 pandemic severely impacted the economy. The pandemic disrupted key sectors such as tourism, exports, and remittances, which are vital to the Sri Lankan economy. In 2022, Sri Lanka faced significant economic challenges, including a severe foreign exchange crisis and high inflation, which hindered growth. Table 63 shows the annual GDP growth from 2011 to 2022, and the forecast till 2026. The GDP growth rate over 2023 is estimated to be -2.3%[69], reflecting the ongoing economic struggles and the need for comprehensive policy reforms. Despite these challenges, Sri Lanka has made concerted efforts to reinforce its economic resilience through infrastructure investments, enhancing trade relations, and implementing fiscal and monetary reforms. It is therefore expected that the GDP will resume its growth path if no major unforeseen events occur.

Table 63 GDP growth of Sri Lanka[70]

Year	Growth (%)
2011	8.7
2012	8.6
2013	4.1
2014	6.4
2015	4.2
2016	5.1
2017	6.5
2018	2.3
2019	(0.2)
2020	(4.6)
2021	4.2
2022	(7.3)

[69] Central Bank of Sri Lanka
[70] World Bank Gorup

Year	Growth (%)
2023 (e)	(2.3)
2024 (f)	2.2
2025 (f)	2.5
2026 (f)	3.0

Notes: ( ): Denotes negative values, e: denotes estimated, f: denotes forecast

6.3.1 Currency Reserves

Sri Lanka's currency reserves are another significant indicator of its economic stability, reflecting the ability to manage external shocks and meet its international financial obligations. Over the past decade, Sri Lanka's foreign exchange reserves have experienced significant volatility, influenced by various factors such as trade balances, foreign debt, and economic policies. In 2012, Sri Lanka's foreign exchange reserves stood at approximately $7 billion, supported by strong inflows from remittances and tourism. Owing to the country’s increased import expenditure and debt repayments, reserves declined until the country made international borrowings in 2019. International borrowings and reasonably favourable global market conditions in 2019 assisted the country in seeing a boost in the official reserves to $7.6 billion. However, owing to COVID-19 pandemic, tourism, remittances and export earnings declined significantly and in 2021, the reserves fell sharply to approximately $3.1 billion, largely due to continued debt repayments and a lack of substantial foreign investment. Sri Lanka’s official reserves were below $3 billion from Jan 2022 until April 2023[71]. Efforts to stabilize and increase reserves include seeking financial assistance from international organizations, implementing import restrictions, and promoting export diversification. In April 2024, the reserves grew back to $5.4 billion. To the best of our knowledge, no targets for the future have been set.

6.3.2 Inflation

Inflation is an important factor for offshore wind because it affects the costs of (mostly locally sourced) materials, financing, and overall project viability. The 2022 economic crisis in Sri Lanka resulted in inflation to soar to unprecedented levels. By September 2022, inflation peaked at around 70% year-on-year, fuelled by global commodity price hikes, supply disruptions, and a significant depreciation of the Sri Lankan rupee[72].

To combat the inflationary pressures, the Central Bank of Sri Lanka implemented a series of stringent monetary policies starting in August 2021. Key policy interest rates were raised by 11 percentage points, and the Statutory Reserve Ratio was increased by 2 percentage points. These measures aimed to curb demand-driven inflation and stabilize the external sector. Despite the initial economic stagnation, these policies gradually moderated inflation, with headline inflation dropping to 57.2% by December 2022 and further decelerating to single-digit levels by mid-202372.

The disinflation process was supported by improved domestic supply conditions, subdued aggregate demand, better external sector performance, and a normalization of global commodity prices. By September 2023, headline inflation had eased to 1.3% year-on-year. Sri Lanka aims to stabilize inflation at around 5% over the medium term and has been able to do this in 2024 although there were short-term fluctuations due to administrative price adjustments and geopolitical tensions (year-on-year inflation rate in March 2024 was 0.9% but in April 2024 was 1.5%[73]). The successful disinflationary path reflects the combined efforts of tight monetary policies and favourable external factors.

[71] Central Bank of Sri Lanka – Annual Report 2022
[72] Keynote speech delivered by Dr. P. Nandalal Weerasinghe at the Annual Research Symposium 2023 of the University of Colombo
[73] Central Bank of Sri Lanka – CCPI based headline inflation continued to increase in January 2024

6.3.3 Foreign exchange rate

The USD/LKR[74] exchange rate has significantly declined in recent years, although improved throughout 2023 and 2024. The years of depreciation reflected Sri Lanka's profound economic challenges, exacerbated by ongoing debt restructuring and balance of payments difficulties. As described in Section 6.3.1 GDP, the country's economy contracted in 2020, 2022 and 2023, fostering an environment of economic uncertainty and currency volatility[75]. In general, the volatility of the LKR fuels investor concerns over the country's fiscal health and ability to stabilize its financial markets.

The Central Bank of Sri Lanka has maintained stringent monetary policies to curb inflation, but these measures have also contributed to elevated interest rates, especially over 2022-2023, impacting investment sentiment and FDI inflows. In this volatile economic climate, the depreciating LKR poses significant implications for FDI in Sri Lanka. A weakened currency makes imports more expensive and raises operational costs for foreign investors, potentially deterring new investments. Moreover, fluctuating exchange rates add a layer of uncertainty, complicating long-term financial planning and investment decisions.

6.3.4 Financial Stability

The financial stability of a country refers to its ability to maintain a stable and robust financial system, and related to offshore wind, to meet payment obligations of the power sector. Recently, the financial stability in Sri Lanka faced significant challenges in the aftermath of an economic crisis, characterized by a contraction in economic activity, high inflation, and increased interest rates. These conditions strained balance sheets and led to a considerable decline in financial intermediation, reflecting subdued demand and supply for credit amidst deteriorating credit quality.

However, by late 2023 and 2024, financial markets showed signs of stabilization with eased market conditions compared to 2022. The Financial Stress Index indicated broadly low levels of stress, and volatility in the share market indices subsided. Improvements in the foreign exchange market liquidity and the appreciation of the Sri Lankan Rupee were noted, driven by increased inflows that enabled easing of import restrictions. Additionally, some confidence has been brought by the IMF's Extended Fund Facility in March 2023[76].

Looking ahead, the easing of domestic monetary policy since mid-2023 is expected to support the recovery in financial intermediation and economic activity, improving income levels and alleviating pressures on household and corporate balance sheets.

6.3.5 Power Sector

Power Demand Trends
Electricity demand has been growing in Sri Lanka over the past years except for the sudden downturn with the COVID-19 pandemic and the economic crisis that emerged in 2022. The expected growth in demand for electricity requires investments in new power generation projects, including offshore wind power. However, there are certain factors to be considered such as the availability of the transmission network, its capacity and impact of offshore wind on the grid stability, which is elaborated in Section 5.4.2 Electricity Demand and Forecast Growth.

Power Sectors' Financial Health
Sri Lanka's power sector has faced financial challenges, with state-owned utilities often operating at a loss due to several reasons including high generation costs and improper implementation of the tariff methodology. The priority areas in this study have a good potential for offshore wind power development in Sri Lanka. However, the CAPEX per megawatt as well as the size of offshore wind

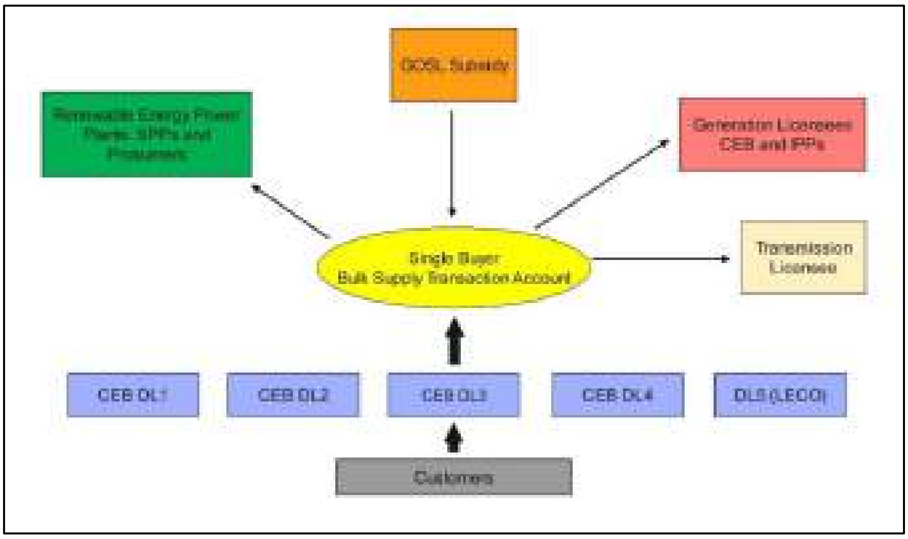
[74] LKR is the internal code for Sri Lanka Rupee (SLR)
[75] Capital News – USD/LKR forecast: will the Sri Lankan rupee keep falling?
[76] Central Bank of Sri Lanka – Financial Stability Review for the Year 2023

projects are relatively high, compared with other renewable energy developments currently operational in Sri Lanka. The largest onshore wind farm in operation is 103 MW, completed in 2021, reportedly at an investment of USD 130 million. A comprehensive analysis which includes power system dispatch modelling in the long-term, is required to understand the future role of offshore wind power and the impact of it on the average energy cost of the grid. This has been discussed in detail in Section 3.6.5 Electricity costs and prices in Sri Lanka.

Sector Organization and Cash Flows
Currently, CEB is the main national utility and was established under Act No. 17 of 1969 to operate the electricity industry. CEB is internally unbundled into generation, transmission, and four distribution divisions. Accordingly, electricity generation in Sri Lanka is done by CEB, independent power producers (IPPs), and small power producers (SPPs). The sole transmission licensee is CEB while there are five distribution licensees: four under CEB, and Lanka Electricity (Pvt) Ltd (LECO) as the fifth. PUCSL was formed in 2002 as the regulatory body of the electricity and water service industries, and PUCSL has been regulating the electricity industry since 2009.

Currently, Sri Lanka power sector operates in a single-buyer model where CEB, as the transmission licensee, is the single buyer and it purchases electricity from IPPs, SPPs, prosumers (surplus energy from rooftop solar photovoltaics) and from CEB's own generation operating under CEB's license and sells to the distribution licensees. Figure 98 shows the revenue flow of the present system.

Figure 98 The present revenue flow mechanism



Notes: DL1-5: distribution licensees; LECO: Lanka Electricity Company (Pvt) Ltd; IPP: independent power producer; SPP: small power producer (less than 10 MW); GOSL: government of Sri Lanka

In June 2024, the new Electricity Act was approved by the parliament, which is expected to be implemented in the near future. It facilitates the unbundling of CEB with the objective of gradually converting the single-buyer system to a wholesale electricity market model in the longer term. This is expected to attract further private investment and international financing for new generation including offshore wind.

A bulk supply account will be established to record all financial transactions relating to the purchase of bulk electricity from generation licensees through Power Purchase Agreements (PPAs) or standardized PPAs[77], to pay for transmission and to receive payments from distribution licensees by selling electricity to them through power sales agreements.

[77] Power plants up to 10 MW using renewable energy sources are procured through a simplified PPA, that is standardized and non-negotiable.

Existing Power Sector Market Mechanism
Market mechanisms are gradually evolving to incorporate more competition and private sector participation, particularly in renewable energy projects. Policies and incentives are being developed to attract investment in solar, wind, and other renewable energy sources, aiming to diversify the energy mix and enhance sustainability.

To encourage investments in renewable energy-based electricity generation, initially the government approved and CEB implemented the following favourable conditions, specifically for electricity production from renewable energy sources: (i) non-negotiable standardized, power purchase agreement (SPPA), thereby reducing transaction costs and delays, (ii) standardized power purchase tariffs (SPPT), (iii) must-run, must-take conditions, enabling the investor to sell all his product (electricity) while CEB has no right to refuse, (iv) no project security deposits, bonds or penalties (allows the investor freedom and flexibility to manage project risks, even to the extent of abandoning the investment after signing the SPPA). There are only two specific limitations on the investor, namely, (v) the absence of “deemed energy payments” which relate to situations CEB may be unable to purchase owing to transmission limitations, (vi) the installed capacity to be limited to 10 MW. Most importantly, no royalty is charged for the use of renewable resources, and the resource value is expected to be passed on to customers through lower electricity bills.

Government policies on achieving 70% renewable energy target are beneficial for offshore development. However, there are no sufficient policies and regulations related to offshore projects at present. The adaptation of strong policies will be required to regulate offshore wind projects and address the issues that will arise during their implementation. This is elaborated in the ongoing parallel study Regulatory Gap Analyses. Well-designed policies and incentives can attract both domestic and international investors to offshore wind projects.

Relationship with India
There is a strong and multifaceted macroeconomic relationship between Sri Lanka and India. India is one of Sri Lanka's largest trading partners, with bilateral trade encompassing a large range of goods and services. Indian investments in Sri Lanka, particularly in infrastructure and telecommunications, play a pivotal role in the island nation's economic landscape. Remittances from Sri Lankan workers in India (although smaller compared to those from the Middle East region) and vice versa bolster household incomes and contribute to economic stability. Development cooperation initiatives further strengthen ties, with India providing assistance in various sectors, including infrastructure and capacity building. This comprehensive economic interaction underscores a mutually beneficial relationship that supports growth and development in both countries.

As mentioned before, macroeconomic factors significantly impact offshore wind projects, shaping economic conditions and crucially affecting their financial viability and returns.

6.4 Procurement options

To attract sufficient investment in offshore wind projects in Sri Lanka, it is crucial to provide clarity on the process of seabed and development rights. Seabed rights focus on obtaining the right to use a specific seabed area, serving as an early step in the process by securing the physical space for offshore wind farms. In contrast, development rights encompass all the necessary permissions to develop and operate the wind farm, covering the entire project lifecycle from site assessment to decommissioning. While seabed rights deal mainly with spatial rights, development rights involve broader regulatory compliance, including adherence to environmental and safety regulations.

Seabed and development rights are closely tied to the procurement system or seabed allocation mechanism employed. The procurement process in Sri Lanka, following the new Electricity Act, includes competitive bidding, with calls for proposals from the SLSEA and/or CEB varying in terms of risk allocation and private financing. These calls define tender specifications, including preapproved PPA details and tariff structures by the PUCSL. Before obtaining licenses, applicants can enter into PPAs with CEB, following a PUCSL letter permitting further formalities. The design of competitions aims to attract sufficient developer participation, fostering competitive tension in lease and power offtake agreements.

According to the Roadmap, there are two procurement options for offshore wind: a government-led approach and a developer-led approach (see Text box 5 for further explanation). Due to the relatively small market size of offshore wind in Sri Lanka and the absence of sufficient market competition, adopting a government-led approach is one of the key recommendations of the Roadmap.

Text box 5 Explanation of major procurement systems for offshore wind (source: text adjusted from Roadmap)

Government-led approach
A government-led procurement system for offshore wind involves the government taking charge of site selection, early development work (including initial permits), and coordinating infrastructure and regulations. Consequently, the government will organize a tariff/price-based competitive tender or auction where developers propose projects. The government takes a very proactive role and provides enough information and data to help bidders estimate a competitive power price.

Since this approach involves only one competition, it is sometimes called the one-competition model. An advantage of this system is that the government has a dominant role in shaping the roll-out of offshore wind, de-risking the development and creating a more attractive market for participation.

Developer-led approach
A developer-led approach for offshore wind involves private parties independently identifying suitable sites (usually within areas advised by the government) and obtaining exclusive rights. Thereafter, developers carry out studies to obtain data, conduct feasibility studies, secure permits, and plan and finance projects. They then participate in competitive bidding or negotiate directly with governments or utilities for PPAs.

Because this process usually involves two separate competitions (one for the seabed lease and one for the tariff agreement), it is known as the two-competition model. Although developers take on most of the financial and operational risks, an advantage of this system is that it drives innovation through competition, leading to cost-effective and viable wind farms.

Parallel to this work, a study is being conducted into the possibilities of legally regulating the development of offshore wind in Sri Lanka, the adjustments that need to be made for this, and the legal framework that needs to be drawn up. Text box 6 provides a section from this study that indicates that the ultimate choice of Sri Lanka to go for a centralized (government-led) or decentralized (developer-led) approach has not been made yet.

Text box 6 Quote from the study Legal and Regulatory Analysis for Offshore Wind

> “Selecting the most optimal model for offshore wind development, whether centralized or decentralized would depend on the GOSL’s risk appetite, resources and expertise. While a centralized approach grants the government control over project planning, it could expose developers to bureaucratic hurdles and restrict innovative solutions. There is also a risk that the government may not be adequately resourced to undertake the complex technical functions required to implement the centralised model successfully. Conversely, a decentralized model empowers developers with decision-making flexibility, fostering market-driven innovation and faster project advancement. However, this may lead to fragmented policies and higher risk exposure for developers due to fluctuating market conditions which would also ultimately result in high energy prices.
>
> In light of the above, policymakers must carefully weigh the advantages and disadvantages of each approach, aligning the chosen model with Sri Lanka’s overarching goals, resources and technical capabilities.”

This study builds on the recommendation from the Roadmap and assumes that the government-led pathway towards offshore wind will be followed. This is an important assumption, as the choice for the type of procurement system influences the content and recommendations in the remaining sections of this chapter.

6.5 Commercial Risk and Bankability Considerations

Commercial risk for offshore wind refers to financial uncertainties and challenges affecting project profitability and viability. The bankability of offshore wind refers to how acceptable a project is for financing by banks and other investors. Often, commercial risks and bankability considerations touch upon the same topics. Effectively managing commercial risks enhances a project's bankability by providing confidence to lenders and investors that the project is viable. This chapter focuses on the main commercial risks and does not attempt to be exhaustive. Categories addressed include technical, financial, and environmental and social aspects. For all items, the current status will be discussed, including solutions and mitigation measures to reduce potential risks and bankability issues.

6.5.1 Technical

Supply chain

Offshore wind is a global industry that sources components from around the world and relies on specialized vessels, equipment, and skilled labour. Competing with more mature and larger markets for these precious resources presents a significant challenge for Sri Lanka as an emerging market, posing supply chain risks. Additionally, the industry currently faces significant supply chain issues due to resource scarcity, leading to an inability to meet demand and increasing prices. Other general commercial risks in offshore wind projects involving the supply chain include quality issues, contractual disputes, cost escalations, compliance concerns, and technological risks.

To mitigate potential commercial risks related to the supply chain under current circumstances, Sri Lanka could align with the development of offshore wind in India. Aligning both markets will create a larger potential market, which is more attractive for parties to participate in and will help create a stronger and more robust supply chain. Additionally, efforts should be made to create a more localized or regional supply chain that has potentially lower costs. India, with a larger offshore wind target, is expected to develop a local supply chain capable of serving the wider region, including Sri Lanka, relatively quickly. Given the established trade relationship with India, collaboration presents a logical path for strengthening the regional offshore wind supply chain.

At the same time, this presents opportunities for Sri Lanka to develop parts of the supply chain domestically (see Text box 7 for opportunities), in collaboration with international partners. By actively supporting the design and development of an offshore wind supply chain, including proactive planning to address workforce gaps and implementing recruitment and training programs, the government can create an attractive environment for developers and generate economic benefits for Sri Lanka. A key mitigation strategy could also be the implementation of realistic and adhered-to planning for project development. This ensures that all parties can properly plan and coordinate their activities, fostering a more reliable and efficient development process.

Despite the efforts by the Sri Lankan government, the offshore wind industry will most likely remain a global industry, posing external risks. However, it is worth mentioning that by the mid-2030s, when offshore wind projects are expected to begin in Sri Lanka, current global supply chain issues may have eased.

Text box 7 Opportunities for Sri Lanka to develop supply chain industry

Sri Lanka's existing industries and expertise provide potential for developing local supply chain elements. The presence of a large dry dock and marine service companies indicates the nation's familiarity with maritime operations, which are crucial for offshore wind project construction and maintenance. These facilities could serve as a foundation to build the necessary capabilities for offshore wind. Additionally, local companies have demonstrated their capacity in engineering and constructing substations and power lines, which can be leveraged to establish the infrastructure needed to connect offshore wind farms to the grid. A skilled workforce (biologists, marine engineers, logistics specialists, construction workers, and marine operators) is available to some extent.

To promote a (partial) domestic supply chain, some countries set local content requirements. However, it is worth mentioning that, while tempting as a policy measure, local content requirements could hinder the success of (affordable) offshore wind development (see Text box 8 for the risks of local content requirements in the case of Taiwan).

Text box 8 Risks of local content requirements – Example from the case of Taiwan

Taiwan's Phase 3 block development now imposes a minimum Local Content Requirement (LCR) of 70%, which could render offshore wind farms in the country prohibitively expensive to construct. The economic competitiveness of Taiwanese components is currently limited due to the nascent stage of the offshore wind industry in the country, which involves a steep learning curve. Taiwan is only at the stage where it is attempting to catch up with more mature markets, such as those in Europe, which have spent decades developing a global offshore wind supply chain. As a result, made-in-Taiwan blades are approximately 20% more expensive than their European equivalents, and Taiwanese underwater foundations cost at least 30% more than those from Korea or Malaysia. Even with shipping costs factored in, Taiwanese offshore wind components remain at a price disadvantage.

The imposition of stringent LCRs risks can also undermine the local supply chain, particularly in the absence of large, energy-demanding, and creditworthy customers. This is because with substantial investment costs of offshore wind that can be further exacerbated by LCRs, developers rely heavily on bank financing to proceed. However, banks are only willing to provide such financing if there are guaranteed large customers to purchase the generated energy. In the case of Taiwan, only one company, TSMC, stands out as having the significant demand for green energy and the financial stability to meet international credit standards. If companies like TSMC in Taiwan are unwilling to accept the high electricity prices associated with offshore wind power (partly due to LCRs), the sector's development could stagnate. This could lead to severe economic consequences, including significant job losses.

Ports
Offshore wind projects necessitate suitable ports for manufacturing, storage, installation, and maintenance operations. An extensive appraisal of Sri Lankan and Indian ports in Chapter 4 reveals port infrastructure needs considerable upgrades to support offshore wind development across all necessary ports.

Detailed recommendations for port development and upgrades are provided in Chapter 4. While developers can partially invest in port infrastructure (adding to the project costs), there are economic limits to what a single offshore wind project can achieve. Government or private investment in port facilities will be required for the required upgrades. Considering the long-term rollout of offshore wind in the region, these investments can be profitable, with costs recoverable through leasing port capacity and facilities to wind developers. An opportunity for these ports exists to not only service the Sri Lankan market but also the larger Indian market.

Grid connection
The grid is essential for offshore wind for efficient integration and transmission of electricity from offshore wind to onshore networks. Important aspects in this regard are ensuring grid connection capacity and availability, implementing required upgrades and arrangements (including the export cable), and establishing clear responsibilities between the developer and CEB.

Chapter 5 has explored the capacities of the Sri Lankan grid over time to connect offshore wind farms. One of the main takeaways is that to develop large-scale offshore wind, the regional and national grid needs to be expanded. The current and near-term grid capacity and availability are insufficient for both project areas. If in place, the planned interconnector with India can significantly increase the absorption capacity of the surrounding grid and enable the Mannar area (in the future) to accommodate far larger offshore capacities than Puttalam. However, all additional grid infrastructure requires large-scale adjustments (described in Chapter 5) and investments. Currently, CEB struggles with limited financial capacity to implement solutions to serve onshore wind power and other developments in north and north-west of Sri Lanka, posing a significant challenge for any further commitments to build transmission infrastructure to absorb OWP.

In the relationship between the developer and CEB, there should be clarity about who is responsible for which part of the grid infrastructure, including bearing costs, conducting construction, and carrying out operational activities. The approach for this varies among countries; in some countries, the developer is responsible for all offshore infrastructure up to the onshore substation, while in others, the government assumes full responsibility for grid connections, including offshore substations and export cables.

Allocating responsibility to the developer for the export cable presents both advantages and disadvantages. On the one hand, having the developer manage the export cable could streamline project management and potentially expedite timelines, leveraging the developer's expertise and vested interest in timely completion. It could also mitigate government expenditure on these extensive projects, thereby reducing fiscal pressure. On the other hand, this approach may pose challenges such as increased financial burden on developers, which lead to higher project costs which would need to be compensated through higher PPA tariffs.

In contrast, government or CEB responsibility for grid connections could ensure standardized infrastructure and centralized oversight, potentially leading to more integrated and cohesive grid systems. However, this might also involve significant public sector investment and resource allocation, which could strain government budgets and impact other public projects.

In the Sri Lankan context, the complexity and scale of required investments necessitate a balanced consideration of both models, as each option presents a distinct set of pros and cons that must be thoroughly evaluated to determine the most effective strategy for grid infrastructure development. However, it is advised that the responsibility for the development, construction, and operation of export cables in Sri Lanka should rest with the developers. Assigning this responsibility to transmission companies could lead to significant challenges. For instance, in France, this approach necessitated substantial counter-guarantees from the French State under the concession agreement, amounting to several hundred million euros per project. Although this was ultimately bankable in France due to the involvement of RTE (French TSO, the transmission system operator) and financial backing from the French government, such an arrangement would present significant bankability issues in Sri Lanka.

Lastly, to ensure reliable grid access, grid access guarantees and performance guarantees from the off taker (as unbundling and liberalization take place, this might become the grid owner/ operator) should be put in place. More information regarding these (and other) grid topics (such as curtailment) is covered in Section 6.5.2 Financial (PPA).

Compliance with standards

Offshore wind technological standards specify requirements for systems, services, and components applying to all phases of offshore wind projects. Their main purposes are to:

(i) Ensuring safety and reliability by setting safety levels for human health and structural integrity;

(ii) Establishing uniformity in terminology, specifications, and processes across stakeholders, and;

(iii) Formalizing technical aspects of project contracts or procurement agreements.

International standards are developed by organizations such as the International Electrotechnical Commission (IEC), the International Organization for Standardization (ISO), and the American Petroleum Institute (API). While sometimes mandated by legislation, they are generally required by stakeholders such as banks, investors, and contractors. Compliance with these standards is usually included in contracts with investors and insurers, offering clarity and confidence. Governmental authorities typically expect developers to adhere to relevant industry standards. Compliance is either mandatory (by legislation) or strongly encouraged (by incentives).

Countries with established offshore wind markets often adopt national standards. In most cases, this means that the international standards are harmonized to the national context (see Text box 9 for an example in the Netherlands). Some national standards can deviate from international standards to address specific needs, such as better representing local environmental conditions or imposing stricter health, safety, and technology requirements. For instance, South Korea has developed national standards to achieve high local content goals and foster the growth of its local industry.

Text box 9 Example of national standards for offshore wind in the Netherlands

In the Netherlands, national standards can be recognized by ‘NEN’, which serves as a comprehensive guideline outlining the agreements, specifications, or criteria that products, services, or methods must adhere to. A NEN-EN-IEC standard simply means that this European directive (EN) is also adhered to in the Netherlands (NEN). It is to be read as a European standard and international standard (IEC) that is used in the Netherlands. There are no changes made to the content of the standards.

One specific NEN norm relevant to offshore wind turbine construction is NEN-EN-IEC 61400. This norm outlines technical specifications and guidelines for the design, manufacturing, and installation of wind turbines, including those installed offshore. It covers aspects such as structural design, safety considerations, electrical systems, and environmental conditions, providing a framework for ensuring the reliability and performance of offshore wind turbines while complying with regulatory requirements.

Table 64 lists various (general) potential commercial risks related to standards for offshore wind in Sri Lanka. Addressing these risks involves developing a robust regulatory framework, ensuring alignment with international standards, and fostering collaboration with experienced international partners.

Table 64 Potential commercial risks related to standards for offshore wind in Sri Lanka

Potential risk	Explanation
Regulatory Compliance	The lack of established national standards for offshore wind in Sri Lanka can lead to uncertainties and inconsistencies in regulatory compliance, potentially causing delays and increased costs.
Inconsistent Standards	Differences between standards can complicate design and construction processes, leading to inefficiencies and higher costs.
Market Access	Failure to meet international standards can limit access to global markets and reduce potential investment opportunities.

In response to the potential commercial risks of standards listed in Table 64, Sri Lanka could consider developing national standards for offshore wind. Additionally, Table 65 provides further reasons for this approach. Like other countries, Sri Lanka could adopt or harmonize IEC standards to become Sri Lankan Standards (SLS) or impose amendments to fill certain gaps. Key recommendations on this topic should be substantiated by solid research on the objectives of renewable energy development and the country's legal framework.

Table 65 Examples of reasons to develop national standards

Reason	Explanation
Quality assurance	Standards for offshore wind development are established based on best practices, technological advancements, and safety protocols. Complying with these standards ensures the quality and reliability of offshore wind projects, reducing risks associated with construction, operation, and maintenance.
Global competitiveness	Adhering to standards enhances Sri Lanka's competitiveness in the global renewable energy market. Projects developed in compliance with recognized standards are more attractive to international investors, lenders, and stakeholders, facilitating access to financing and partnerships.
Risk mitigation	Standards provide comprehensive guidelines for risk assessment and mitigation in offshore wind projects. By following these standards, Sri Lanka can identify potential risks early in the project lifecycle and implement effective measures to mitigate them, thereby safeguarding investments and ensuring project success.
Environmental and social responsibility	Standards for offshore wind development often include provisions for environmental conservation and social responsibility. Compliance with these standards promotes sustainable practices, minimizes negative environmental impacts, and fosters positive community engagement. Standards can also contribute to a high level of attention and good practices in Health and Safety measures during construction and exploitation.
Regulatory alignment	Aligning with standards facilitates regulatory harmonization and streamlines project approval processes. This reduces bureaucratic hurdles and uncertainties, expediting project development timelines and improving overall project efficiency.

6.5.2 Financial

Financial Support Mechanisms
Financial Support Mechanisms (FSMs) are essential for offshore wind development as they help to offer investors a more stable return and de-risk projects for lenders. This is especially the case for an emerging market like Sri Lanka, where risks and uncertainties tend to be higher. FSMs can also be seen as measures to compensate for the ‘non-viable or unprofitable top’ of investments. When applied effectively, they can stimulate market growth and contribute to job creation and

broader economic benefits. Pricing mechanisms for renewables are a form of FSMs, and the various options are described in more detail Table 66. Each of these mechanisms offers different levels of revenue predictability and risk mitigation. The fixed pricing and premium pricing mechanisms can be considered as a form of subsidy.

Electricity generated by licensed producers is purchased by CEB, with tariffs approved by PUCSL. All renewable energy projects in Sri Lanka are operating under the IPP framework, using PPAs based on either Feed-in-Tariffs (FiT) or competitively determined tariffs. The FiT is ideally recalculated annually and publicly announced. Any project with a capacity of less than 10 MW (or rooftop solar pv) will be eligible for the tariff applicable at the time of signing. This tariff remains fixed for 20 years. In subsequent years, new FiT rates (either higher or lower) may be introduced, but the tariff for agreements signed in previous years will remain unchanged. For projects over 10 MW, competitive bidding is implemented to determine the tariff, which remains fixed for the term of the agreement (apart from some smaller escalation provisions).

Table 66 provides an overview of the various global FSMs. The last two options, premium pricing mechanism and competitive pricing mechanism, require a wholesale market with liquidity deep enough to accommodate larger trading on gigawatt volumes of offshore wind. Sri Lanka might not be ready for these options since the country is still early in market reforms. A more detailed assessment of all three options and their suitability within the Sri Lankan market context are needed in order to recommend a preferred one for future offshore wind projects.

Table 66 Overview of various global FSMs

Aspect	Fixed pricing mechanism	Premium pricing mechanism	Competitive pricing mechanism
Another common name	Feed-in Tariff	Feed-in Premium / Contract for Difference	Auction/ bidding
Who determines the price	The government	The government and the market	The market
Pros	• Guarantee return on investment for projects • Effective tool to kick start the renewable industry	• Support return on investment for projects • Sharing the financial burden of the government • More controlled deployment compared to FiT • Can promote technological advancement since only projects can justify higher cost can be given the premium • Reduce pressure on grid infrastructure (compared to FiT)	• Reflect the market price • Lift off the fiscal burden for the government

Aspect	Fixed pricing mechanism	Premium pricing mechanism	Competitive pricing mechanism
Cons	• Costly to operate, can only be utilized for early adoption of renewable energy • Fail to reflect market price for electricity • Discourage renewable energy technology advancement • Grid access issues due to overinvestments on projects, surplus of intermittent generation capacity, priority access to the grid	• Still costly to operate • Managing premium pricing schemes requires robust regulatory frameworks • Can cause distorted market signal and investment uncertainty	• Expose projects to price volatility • Intense competition can lead to price wars • Can create unfriendly environment for new entrants to compete with established players who can leverage economies of scale

Electricity price

In countries where a competitive wholesale market operates, the regulated electricity price can be a significant commercial risk for offshore wind projects because it directly affects how much revenue the projects can generate from selling electricity over time. Fluctuations in electricity prices, which can happen due to factors such as market demand, generation costs, and government policies, may impact the project's expected income and profitability. However, Sri Lanka operates on the single-buyer model, and competition is only at the point of bidding for prices for a PPA, in response to a solicitation issued.

From 20th October 2023 to 5th March 2024, Sri Lanka had the highest electricity retail[78] prices among South Asian countries. Since then, there have been several downward revisions in electricity prices, one in March, another in July 2024, again in January 2025. These high prices may be attributed to higher feed-in-tariffs paid to renewable energy projects, less competitive procurement of coal, and excessive requirement to use oil-fired power plants which should have been converted to operation on natural gas over a decade ago. The average customer price (total expected income divided by energy sales) reached LKR 48 per kWh (16 UScts/kWh) in October 2023, and since the March 2024 downward revision, stood at LKR 39 per kWh (13 UScts/kWh). Then, next price revision placed the average price of electricity to be LKR 27 per kWh (9 UScts/kWh). Prices were further reduced in January 2025 and again increased in June 2025. At the time of finalising this report, the average price of electricity in Sri Lanka stands art at LKR 27 per kWh (9 UScts/kWh).

Wholesale electricity prices in Sri Lanka for IPPs have been primarily determined through long-term PPAs with CEB. Competitive bidding requirements for tariffs are mandated by law. CEB, and later as the Electricity Act 2024 gets implemented, the National System Operator (NSO), must obtain clearance for the resource from SLSEA before calling for bids. Agreements often set fixed prices, where IPPs are compensated based on their operational costs. This model provides price stability for IPPs, ensuring a predictable revenue stream over the contract's duration, typically spanning 20 years. However, this approach can be limiting in a dynamic market environment, as it does not always reflect real-time changes in supply, demand, and generation costs. The fixed nature of these agreements has often led to inefficiencies, with electricity prices not aligning with actual market conditions.

[78] Many countries in the region do not publish the wholesale prices, in a manner they can be compared.

The Electricity Act 2024 mandates competitive bids be issued for the procurement of PPAs. The Act also provides for a competitive wholesale market to be established, but this may take several years. As Sri Lanka moves toward a more liberalized power market, the pricing mechanism for IPPs is likely to evolve in a way that wholesale electricity prices would be determined through competitive bidding, market auctions, and real-time trading on an electricity exchange. This shift will expose IPPs to market risks, where prices fluctuate based on supply and demand dynamics, fuel costs, and other market variables.

In this new environment, IPPs will need to navigate greater price volatility, which could impact their revenue stability. While this offers the potential for higher profits during periods of high demand, it also introduces the risk of lower revenues when market prices dip. To manage this risk, IPPs may explore financial hedging strategies (see Text box 10 for explanation) or seek more flexible PPA terms that allow for price adjustments in line with market conditions. Risk management strategies can be associated with various pricing mechanisms (from Table 66), as elaborated briefly below.

First, by securing a fixed price for electricity through mechanisms such as FITs, developers can mitigate the risk associated with fluctuating electricity prices. This provides predictable revenue streams, reducing the impact of market volatility on project income.

With the premium pricing scheme, developers receive a market price plus a premium for their electricity. This premium can help buffer against market price fluctuations, offering a level of financial stability. However, if the market price drops significantly, the total revenue might still be at risk, which is why hedging strategies could be supportive.

Under competitive pricing mechanisms, such as auctions or tenders, developers bid to supply electricity at the lowest possible price. This can introduce significant price risk, especially if market prices (for instance for equipment cost, material costs, labour costs) fluctuate after the contract is awarded. To manage this risk, flexible contract terms and hedging strategies become important, allowing developers to protect against adverse price movements and maintain financial stability.

The legislation in Sri Lanka outlines a gradual reduction of the current 10 MW threshold for renewable energy projects eligible for FiTs over the coming years. In the initial phase of implementation of the Electricity Act, offshore wind PPAs are expected to be subject to be procured through a structured competitive bidding scheme, aiming to provide a predictable power dispatch while mitigating the risk of an uncontrolled boom in new project development. It is foreseen that bids will be issued for specific projects (siting areas defined) by the “single buyer”, the National Transmission System Operator (NTSO), with whom the PPA will be signed by the successful bidder. In the next stage, it is expected that the NTSO will issue competitive bids a day-ahead of the requirements, to tap the surplus capacity surpassing PPA commitments not only in wind power but in other types of both renewable and conventional, to a short-term market. Liberalisation of the wholesale market, where distribution companies will be allowed to have direct PPAs with generators, is expected a few years (typically five years) later. This requires successful sector liberalisation leading to a wholesale market that is well-functioning and maturing quickly to offer the types of mechanism required.

Text box 10 Hedging strategies in offshore wind

Hedging is a financial strategy used to manage and reduce risks associated with price fluctuations. It involves taking a position in financial contracts, such as futures, options, or forward contracts, that offset potential losses from changes in asset prices or market conditions. Essentially, hedging acts like insurance for investments, allowing businesses to protect themselves from adverse price movements that could impact their profitability. In the context of offshore wind projects, developers often use hedging to secure predictable revenue streams by locking in prices for electricity sales over the project's lifespan. This helps to stabilize cash flows and minimize financial uncertainties, making the project more attractive to investors who seek stability and predictable returns. Hedging strategies can vary depending on market dynamics, regulatory environments, and specific risk profiles of the project.

It is important to note that the role of hedging for offshore wind should not be overestimated, especially in the Sri Lankan context. Even in mature wholesale markets, power price hedging is typically illiquid beyond 3-5 years. For offshore wind, hedging is mostly used as short- to medium-term protection for the portion of a wind farm that isn't under a CfD or CPPA.

Grants can provide direct funding for specific projects or research. There are currently no government funds available for offshore wind. Below are two examples of funds for energy efficiency projects.

One example is the Sustainable Guarantee Fund managed by SLSEA that provides guarantees for investors seeking loans for energy efficiency projects. The fund received its starting capital from the consolidated fund and collects an annual premium and interest payments from the guarantees it provides[79]. This fund also accepts contributions from the Fund of Authority.

There is also talk to establish the Sustainable Energy Guarantee Fund that will provide guarantees for small loans to energy service companies (ESCOs) for energy conservation projects[80]. The fund would start with an initial capital grant of fifty million rupees (approximately USD 0.5 million) and investors will pay an annual premium of at least 0.5% of the guaranteed amount[81]. Moreover, the fund also collects interest, service charges, and penalties from investors.

Costs

Offshore wind is very capital intensive, with a 500 MW project easily costing several billion dollars. High costs increase financial risk and impact bankability by deterring investors and reducing potential returns. Accurately managing costs is crucial for ensuring the viability of such projects.

DEVEX covers the costs incurred during the early stages of a project, including site selection, environmental assessments, engineering design, and securing permits. These costs are typically borne by the project developers and carry a high level of risk due to the uncertainty of whether the project will ultimately proceed to construction. DEVEX can determine investor confidence and secure initial funding. Any delays or cost overruns during this phase can significantly impact the project's overall bankability. Of the three cost categories, DEVEX is the smallest. In Section 3.6 on LCoE, the DEVEX for the 500 MW reference project is estimated at $0.2 million USD per MW, reflecting mature market costs. There is potential scope for refining this aspect down to reflect local market costs.

CAPEX involves the substantial costs required for the construction and installation of the offshore wind farm, including turbines, foundations, subsea cables, and grid connections. Given the large scale of these investments, CAPEX is often funded through a combination of equity from developers and debt from financial institutions. The allocation of risk between these parties is critical, as high CAPEX can deter investors if potential returns do not justify the financial exposure. CAPEX is the highest cost category. In Section 3.6 on LCoE, the CAPEX for the 500 MW reference project for Mannar is estimated at $3.6 million USD per MW.

OPEX encompasses the ongoing costs associated with operating and maintaining the wind farm throughout its lifecycle. These costs, while lower than CAPEX, are nonetheless significant and include expenses such as routine maintenance, repairs, and personnel. Unexpected increases in OPEX can erode margins and impact the financial performance of the project. In Section 3.6 on LCoE, the OPEX for the Mannar reference project of 500 MW is estimated at $55 million USD per year.

In Section 3.6, anticipated costs for offshore wind development in Mannar and Puttalam are outlined for the LCoE calculations. It's important to recognize the considerable uncertainty surrounding these cost estimates, primarily because development is slated for several years in the future, during which interest rates, costs, and prices are expected to fluctuate. Additionally, the absence of benchmark offshore wind farms in Sri Lanka and neighbouring regions such as India adds complexity to accurately estimating costs.

A potential (cost) advantage for wind farm development in Sri Lanka is its proximity to Tamil Nadu. International wind farm developers may view projects in Sri Lanka as an extension of India's wind energy market, expanding opportunities by several gigawatts. This geographic proximity offers synergies in project planning, shared development teams and equipment, and collective procurement of crucial wind farm components such as turbines, foundations, and cables. Therefore, integrating the development of wind farms in Sri Lanka with ongoing projects in India is an opportunity to capitalize on these synergies effectively. This could lead to advanced economies of scale and cost reductions. One scenario in the LCoE analysis assumes this potential cost reduction through this joint development with India and a regional (and partly localized) supply chain.

Taxation and profit repatriation arrangements

Tax exemptions can be considered as a form of subsidy as they lower initial costs and improve the return on investment for offshore wind projects, making them more financially viable and attractive to investors. Over time in Sri Lanka, (some categories of) power project have received tax exemptions for a certain period (also known as tax holiday)[82]. However, these exemptions have been removed from 1 April 2023 onwards for renewable energy projects with a capacity of at least 100 MW of solar or wind power that commenced on or after 1 April 2021 (exemption from customs duty remains).

There are currently no concessions on corporate taxes for any projects. However, for power generation projects, imported equipment is exempt from customs duty and VAT.

To attract investors, it is advisable to establish favourable tax regimes, such as tax exemptions, in advance. This avoids the need for individual developers to negotiate themselves, reducing uncertainty and enhancing the appeal of Sri Lanka's wind energy market.

Additionally, procedures for profit repatriation in Sri Lanka significantly impact the financial viability of projects. Repatriating profits from renewable energy ventures requires a separate agreement between the developer and the Ministry of Finance. Clear arrangements are essential to facilitate profit repatriation and ensure the attractiveness of investments in Sri Lanka. This should also consider potential issues such as convertibility risk and access to hard currency (concepts which are described in the sections about macroeconomics and PPA), both of which are also relevant for profit repatriation.

[82] KPMG – Proposed amendments to the Inland Revenue Act

PPA

A Power Purchase Agreement (PPA) is a long-term contract for buying and selling electricity under agreed terms. It is crucial for the bankability of offshore wind projects as it can provide stable revenue, mitigate financial risks, and ensure long-term investment security depending on its structure. While a PPA alone can be used to support a project, it is also possible to have a combination of a PPA and subsidies to further enhance financial stability and attractiveness, linking with the pricing mechanisms (from Table 66):

1. Fixed Pricing Mechanism: This approach within a PPA offers a fixed price for electricity, ensuring stable and predictable revenue throughout the contract term.
2. Premium Pricing Mechanism: Under this mechanism, the PPA stipulates that electricity will be sold at the market price (real time market, price not predictable) plus a predetermined premium or a counter-fluctuating premium in the case of Contract for Difference (CfD).
3. Competitive Pricing Mechanism: This involves a bidding process where developers compete to supply electricity at the lowest possible price under a PPA. Once signed, the price is fixed.

A well-structured PPA, possibly in combination with subsidies, is fundamental to securing financing and ensuring the long-term success of offshore wind projects. However, it is crucial to recognize that a PPA alone is not sufficient. The broader power sector must be financially sustainable over the long term to support these PPA projects effectively. This sustainability requires a system that can consistently recover costs, whether through regular and transparent consumer tariff adjustments or through a robust regulatory framework capable of managing subsidies efficiently.

For the power sector to attract substantial investments from IPPs and other private entities, the financial framework must ensure stable and predictable cash flows. While guarantee products can help mitigate risks, they are not a comprehensive solution. Multilateral Development Banks (MDBs), International Financial Institutions (IFIs), and other investors will scrutinize the financial health of the sector to determine its ability to support long-term projects. Therefore, the financial integrity of the power sector is a critical factor that must be addressed alongside the structuring of PPAs.

Below the following key factors will be discussed related to (bankable) PPAs:

- Off-taker’s Creditworthiness
- Term and Pricing
- Grid Connection Arrangements
- Curtailment
- Insurance and Force Majeure
- Default and Termination Provisions
- Arbitration and Dispute Resolution
- Regulatory and Legal Framework

Due Diligence and Independent Review is not included, as due diligence and independent review on the overall project has to be done before the PPA is signed. So due diligence clauses, if found in PPAs, are minor sections.

Off-taker’s Creditworthiness

Creditworthiness refers to the financial stability of the off taker, assessed by banks to mitigate the risk of payment defaults. Currently, CEB holds sole responsibility for electricity offtake in Sri Lanka, with a history of reliability in payments. However, a 2019 crisis due to stagnant electricity prices led to severe cash shortages and delayed payments. With recent electricity price increases, CEB's financial situation is improving. While it is assumed that CEB will serve as the designated off-taker under the PPA, ongoing sector reforms may result in this role being transferred to transmission companies, distribution companies, or even corporate entities. For the purposes of this analysis, only CEB is considered under this section.

The new Electricity Act no 36 of 2024, aims to facilitate Direct Power Purchase Agreements (DPPAs) and introduce a partially liberalized energy market. Despite this, in the near term, the CEB is likely to remain the primary contracting party for PPAs due to the absence of a legislative

framework and sufficient/suitable other off-takers (like large companies or industries) capable of accommodating large-scale intermittent power from offshore wind projects.
Although CEB has generally been able to meet its payment obligations, it is highly conceivable that banks financing offshore wind projects worth several billion dollars will demand stronger guarantees. These guarantees can possibly be achieved through government backstopping for CEB, which is already the practice for PPAs for large IPPs, or as a last resort with support from IFIs (such as WB, ADB etc.).

Term and Pricing
The PPA should have a sufficiently long term, typically 15, to provide assurance of stable revenue streams for the project for a long enough period to secure the long-term financing necessary to cover the capital expenditures. It should have a fixed or indexed pricing structure, for instance linked to inflation or currency exchange, providing revenue certainty.

The current Sri Lankan PPA is generally valid for 20 years and, at times, denominated in Sri Lankan Rupees (LKR). In thermal PPAs, a significant portion of the capacity costs is denominated in USD. In renewable energy PPAs of projects larger than 10 MW, many are denominated in USD. In relatively small renewable energy power plants, procured through competitive bidding with PPAs denominated in LKR, the tariff was recalibrated to compensate for the difference in exchange rates between the moment of tender winning and PPA closure. After PPA closure, compensation levels in LKR remain fixed, with exceptions made for certain increases in O&M costs. When ensuring fair compensation in PPAs for future large-scale projects, two critical aspects are inflation and currency volatility, which are explained in more detail below.

Inflation can threaten the bankability of PPAs by increasing operational and capital costs, potentially misaligning tariff revenues with rising expenses, thereby straining cash flow and debt servicing.

The instability and significant volatility of the LKR in recent years is a considerable concern. Currency depreciation increases the cost of repaying foreign debt and purchasing imported materials for projects with revenue in local currency but expenses in foreign currency. It also erodes equity returns for investors making investing in the projects less attractive in the first place.

As elaborated in Section 6.3 Sri Lanka macroeconomics, inflation has proven to be a considerable risk in Sri Lanka. Local and foreign inflation are both relevant to the project viability and bankability. Incorporating inflation into the compensation mechanism is paramount for safeguarding the financial viability of projects. To determine the extent to which inflation should be factored in and the minimum level of security needed, an analysis of inflation risks should be conducted. This analysis should include the cost elements, the timing of these costs, and their vulnerability to inflation. Additionally, mitigation measures should be considered, including indexation, larger contingencies, or insurance.

With PPAs denominated in LKR for smaller renewable energy projects, projects can be financed by local banks, which operate in LKR. Local banks are allowed to lend in USD too, but funds available for power sector projects are limited. Unlike local banks, international lenders require payments in USD, necessitating a corresponding adjustment in the currency denomination of the PPA. Consequently, continuing with the present practice of having USD-denominated PPAs (for larger renewable energy projects) would align with the financial realities of offshore wind projects and secure international financing. If, the PPAs remain LKR-denominated, a robust currency adjustment mechanism should be considered covering deprecation (decline in currency value) and convertibility risks (difficulties in exchanging LKR for foreign currencies).

SLSEA and CEB should also consider support schemes to reduce the PPA price to an affordable level. Table 67 below present these options. These are grant funding, viability gap funding, production based subsidy, FiT, Feed-in Premium (FiP), and CfD. For more details on grant funding please refer to the Section Grants under Domestic Financial Support below; on FiT. FiP, and CfD refer to Table 66 under Financial Support Mechanism above.

Technical and economic life of offshore wind extends much longer than typical terms of PPAs. Mechanism for PPA extension often improves the long-term viability of the project for investors.

Table 67 Options to reduce PPA price

Support scheme	Description	Mechanism	Impact on PPA price
Grant funding	Direct financial assistance provided by the government or other institutions to support the upfront costs	Provides a lump sum to reduce investments required to develop the project	Reduces the project cost, allowing for a lower PPA price
Viability gap funding	Financial support provided to cover the shortfall between a project's total cost and its revenue potential, making it financially viable and attractive to private investors	Covers the difference between the expected project cost and the amount that can be financed	Makes the project financially viable, enabling a lower PPA price for the off taker
Production-based subsidy	A fixed payment provided for each MWh of electricity produced by the project	Offers a payment per MWh generated, lowering the cost of production	Lower the cost per unit of electricity produced, allowing developers to offer lower PPA prices
FiT	A policy mechanism offering fixed payments for each unit of electricity generated and fed into the grid	Guarantees a fixed price per unit of electricity generated for a specific time span	Reduces risk and stabilizes revenue (PPA price cannot change as FiT is fixed)
FiP	A premium payment on top of the market price for electricity (real time market)	Provides an additional payment above the market price per unit of electricity generated	Reduce revenue volatility, which can translate into lower PPA prices
CfD	A long-term contract where the government pays the difference between the strike price and the market price (usually the average price of electricity in the market over a set period)	Ensures stable revenue by compensating for market price fluctuations	Guarantees a predictable return, allowing for lower PPA prices

Grid Connection Arrangements

In Sri Lanka's bundled electricity industry structure, CEB is vertically integrated, managing all transmission, and much of generation and distribution. Consequently, CEB has the obligation to connect the power plant to the national grid by a specified date, ensuring that the developer can sell power once ready.

At the bidding stage, Sri Lanka specifies the grid point, clearly outlining which lines must be financed and built by the winning bidder. The winning bidder then exchanges a grid connection proposal with the CEB. Up to this grid point, however, all development costs are the responsibility of the seller, meaning the developer must bear the expenses associated with creating the infrastructure necessary to connect their generators to the CEB grid. These details are subsequently included in a single line diagram in the PPA.

With the ongoing market reforms, it is likely that the responsibility for grid connections will be separated from the PPA and managed by an independent transmission company rather than CEB, which will most likely no longer be the sole counterpart in these agreements. This shift implies that developers will have to negotiate separate agreements for grid connection, adding a layer of complexity to the project development process. The independent transmission company will be responsible for ensuring the readiness and availability of grid connections, which includes significant liabilities related to potential revenue losses. This introduces new potential risks, such as coordination challenges because more actors are involved, and contractual complexity because the developers have to negotiate separated agreements for grid connection and power sales.

Curtailment

The off-taker's commitment to purchase a substantial volume of electricity at predetermined terms and prioritize integrating energy into the grid reduces revenue risk.

Currently in Sri Lanka, PPAs for renewable energy plants with a capacity of less than 10 MW, such as wind and solar, operate under a 'must-run, must-take off' framework. While this framework has been effective, it lacks sufficient guarantees for power purchase and supply. Smaller projects sometimes face issues when transmission lines are down for a few hours in bad weather, which are usually quickly resolved. However, offshore wind projects require more robust assurances for offtake. The current framework presents significant challenges, especially in ensuring a reliable mechanism for electricity purchase.

Larger-scale private renewable energy projects, require operating under a different framework compared with smaller projects. While specific details of the PPA have not been publicly disclosed, it is understood that agreements in PPAs for larger power plants will provide more robust guarantees compared to those for smaller projects. These enhanced guarantees are designed to be stronger for both the power off-taker and the investor. They include guarantees that the project will be completed on schedule and will meet performance expectations. The latest PPA template published for an onshore wind project includes a clause on curtailment, acknowledging that curtailment may occur due to grid outages or constraints that restrict the wind farm facility’s output. Moreover, the amount of curtailed output during a contract month will be calculated according to Schedule 9 (Energy Charge).

Generally, there are various options for risk allocation when it comes to curtailment. If the generator or developer assumes the curtailment risk, they may incur financial losses due to reduced energy output, as they would bear the impact of any limitations on power generation. Conversely, if the transmission company assumes the curtailment risk, they become responsible for managing and mitigating the grid constraints and outages that lead to curtailment. Should the off-taker—such as CEB or other entities—assume this risk, they may need to compensate the generator for the curtailed output, potentially resulting in higher costs for the off-taker but providing financial stability for the generator. While there could be scenarios where curtailment risk is shared between parties, specific details on how such risk-sharing would be structured are not provided in existing Sri Lankan PPAs.

In the case of transmission constraints, solutions must be implemented to avoid prolonged disruptions in power offtake. Some curtailment may occur in situations when there is excess power supply relative to demand. The need for Government support might arise since significant financial liabilities due to curtailment may require the Government to step in. Possible forms of support could include subsidies, risk-sharing mechanisms, or regulatory interventions to stabilize financial impacts and ensure the sector's overall sustainability. However, this is not explicitly mentioned in the existing Sri Lankan PPA.

To make PPAs more acceptable to developers and banks, it is essential to minimize the impacts of curtailment through mechanisms such as upfront compensation arrangements, clearly defined limits on the duration of curtailment, and established procedures for its application. These measures would provide greater certainty and reduce financial risks for all parties involved. A robust balancing mechanism also needs to be developed in order to compensate developers for potential actions ordered by the system operator in order to balance the system.

Insurance and Force Majeure
Adequate insurance coverage and well-defined force majeure clauses protect against unforeseen events and mitigate project risks. These are key aspects for bankable PPAs and are further elaborated below.

It is crucial to distinguish between force majeure events affecting the off-taker and those affecting the project itself[83]. In cases where the off taker is impacted, the PPA should typically guarantee continued capacity and energy payments to the project during the force majeure period. If such delays affect the Commercial Operation Date (COD), the project can claim deemed completion, entitling them to deemed capacity payments to cover debt service and additional project costs incurred due to the delay[83]. It is important to clearly define and specify the scope of force majeure events within the PPA. Moreover, the obligation for insurance in force majeure events should not fall on one party but to be shared by both CEB and the developer[83].

The force majeure clause in the Sri Lankan PPA aligns with international norms regarding the definition and categorization of events, while excluding events caused by negligence or poor maintenance. However, it does not clearly distinguish the impacts on the off-taker and the project regarding payment continuation. Additionally, it fails to explicitly mention the harmonization of force majeure definitions across related project agreements. Remedies such as time extensions for construction delays or extensions of the contract term are also not addressed. These elements should be incorporated to better align with best practices observed in bankable PPAs.

Apart from covering force majeure, insurance is required to be present during the construction and the operation phase. During the construction phase, the insurance requirements include All Risks (Property Damage) Insurance, Employers Liability Insurance, and All Risks Marine Cargo Insurance[83]. The Sri Lankan PPA meets these requirements through several clauses. Clause 11.3.1(i) addresses All Risks (Property Damage) Insurance by requiring comprehensive structure, plant, and equipment insurance, including contractor's all risks insurance, which covers the replacement cost of the project plant. Employers Liability Insurance is mandated by Clause 11.2.1, which ensures coverage for claims related to sickness, death, or injury to employees of the Project Company and its contractors and sub-contractors. Additionally, All Risks Marine Cargo Insurance is explicitly mentioned in Clause 11.3.1(i), covering the replacement cost of plant and equipment shipped to the power plant[84].

During the operational phase, the insurance requirements include maintaining All Risks (Property Damage) Insurance, Employers Liability Insurance, and Political Risk Insurance. The PPA provisions address these needs comprehensively. Like stated before, Clause 11.3.1(i) and Clause 11.2.1 in the Sri Lankan PPA address the first two kind of insurance. Political Risk Insurance, while not explicitly stated, is implied under Clause 11.4.1, which suggests the need to consider comprehensive insurance coverage, including political risk insurance, if commercially reasonable[84]. This would include protection against actions by the host government, such as issues with currency convertibility, changes in law or tax, cancellation of permits, or expropriation[83]83[83]. Generally, for both phases, the Sri Lankan PPA's insurance clauses meet the essential requirements although political risk insurance is not explicitly detailed.

Default and Termination Provisions
Clear provisions outlining termination events, penalties, and dispute resolution mechanisms are essential to mitigate contract risks.

[83] United States Department of Commerce – Understanding the Power Purchase Agreements
[84] CEB – Development of 50 MW wind farm facility at Mannar on Build, Own and Operate (BOO) basis

A default by either the buyer or the seller can give the non-defaulting party the right to terminate the PPA. Both parties also have the right to terminate the PPA if fulfilling the contract becomes impossible through no fault of either party. This situation typically arises from force majeure events, including political and non-political events, that persist for an extended period, making it impossible for one or more parties to meet their obligations under the PPA. PPA termination provisions typically details which compensation parties are entitled to in different events and how to calculate this compensation. Lenders are particularly concerned about the off-taker’s ability to prematurely terminate the PPA, as this would leave the project without revenue to service the project debt. Therefore, the seller’s events of default and force majeure provisions are scrutinized to ensure they do not allow the off taker to end the project prematurely. In the event of termination, lenders typically want assurances that the project debt will be settled.

The termination provisions under the Sri Lankan PPA provide clear processes for addressing defaults, ensuring the non-defaulting party can pursue remedies and terminate the agreement after due notice periods. Specifically, the non-defaulting party must give a 30-day written notice to the defaulting party, followed by a 60-day notice period for termination. For the seller's defaults, additional steps involve the seller’s lenders, giving them an opportunity to remedy the default.

The Sri Lankan PPA also states that if a force majeure event prevents substantial performance for an extended period of three years, the other party can terminate the agreement with a 90-day notice, giving the non-performing party a final chance to resume performance. Additionally, CEB is restricted from terminating the agreement due to specific force majeure events listed in Article 6(a)(vii) and (viii), such as civil disturbances or governmental actions like nationalization or expropriation, providing further protection to the seller.

However, the Sri Lankan PPA does not clearly define what constitutes an Event of Default for both the buyer and seller, which could lead to ambiguities. Additionally, the force majeure events, especially those in Article 6(a)(vii) and (viii), need clearer definitions and mutual understanding to avoid potential disputes over their interpretation.

Arbitration and Dispute Resolution

Arbitration is a key mechanism in PPAs for resolving disputes that cannot be settled through informal or fast-track processes. If the PPA mandates arbitration, disputes are resolved outside of court, often under established procedural rules like those from the World Bank's International Centre for Settlement of Investment Disputes (ICSID). These rules cover important aspects such as the qualifications and appointment of arbitrators, the confidentiality of proceedings, and the enforceability of awards. One notable advantage of arbitration is its flexibility, allowing parties to tailor the process to the specific dispute.

Moreover, the "seat of arbitration" is crucial in arbitration proceedings, as it determines the legal framework that will govern the arbitration process and can impact the enforceability of the arbitral award. While host countries may prefer their own jurisdictions as the seat, international investors and lenders often push for neutral, third-party locations. The choice of governing law is also significant, as it can affect the interpretation of the PPA and the consolidation of disputes across various project agreements. The governing law is often chosen based on mutual agreement between the parties and may be tied to a neutral jurisdiction that is perceived as fair and stable. This choice can involve laws from countries with well-established legal frameworks for international finance and arbitration.

Compared to what is found under arbitration in international PPAs, the Sri Lankan PPA’s dispute resolution clause emphasizes a more tiered approach to dispute resolution, starting with mutual discussions within 30 days (or 14 days for disputes involving insurance or disputed amounts) and escalating to higher-level representatives from both sides within an additional 15 days (or longer if agreed) if necessary. If the parties agree, some disputes may be resolved by an Expert, as outlined in Part 1 of Schedule 15. If not, the dispute will be handled according to the procedure in Part 2 of Schedule 15. However, Schedule 15 titled Disputes Resolution Procedure is not clearly defined in the available wind PPA. Therefore, this approach may offer flexibility but lacks the clarity and robustness typically found in international agreements, potentially leading to uncertainties in the resolution process.

Regarding the governing law, the Sri Lankan PPA is explicitly governed by the Laws of Sri Lanka, which means that any interpretation or enforcement of the agreement must adhere to Sri Lankan legal principles and precedents. This potentially impact the perception of neutrality, especially for international investors who may prefer a more globally recognized legal system.

Regulatory and Legal Framework
A robust regulatory and legal framework for offshore wind PPAs is essential to address stakeholder concerns, streamline project approvals, ensure consistency and transparency, mitigate risks, promote sustainable development, and align with international best practices.

This topic is the key focus of the parallel study "Regulatory Gap Analyses" and is therefore not further detailed in this study.

Financing

Offshore wind projects are typically financed through a combination of debt and equity, often using a non-recourse or limited-recourse project financing structure. In this setup, lenders provide capital primarily secured by the project's future cash flows and assets, with little or no recourse to the developers' other assets. This means that if the project fails, lenders can only claim the project's assets and revenues, not the developers' broader holdings. The financing often involves creating a Special Purpose Vehicle (SPV) to isolate the project's risks and liabilities, making it more attractive to investors and reducing the developers' financial exposure.

Three major financing terms that can affect the project viability, such as interest rates, maturity and gearing (or sizing) are briefly elaborated below.

Interest Rates
The interest rate is the cost of borrowing capital, typically expressed as a percentage of the loan amount, and it reflects the risk level, project duration, and overall financial market conditions. As indicated in Section 3.6, the LCoE of offshore wind is highly influenced by the prevailing interest rates. While recent domestic interest rates are notably high, ranging from 8-10% and sometimes even reaching 18%, for LKR borrowings, their impact on major projects is limited. This is because most large-scale projects primarily secure debt in USD rather than LKR. Instead, accessing funds at lower rates from international banks become crucial to the viability of offshore wind project in Sri Lanka. A comprehensive feasibility and risk assessment of these projects is essential to address this need and ensure better chance of access to international funding.

Maturity
Maturity refers to the length of time until the final repayment of the loan or debt instrument used to finance the project. It is the period over which the project must generate sufficient cash flows to repay the principal amount borrowed, along with any interest. Maturity can range from short-term (a few years) to long-term (up to 20 years or more), depending on the financing structure and the project's expected revenue streams. Longer maturities are common in offshore wind projects due to their capital-intensive nature. The maturity period is a critical factor in determining the project's overall cost of financing, as longer maturities often come with lower annual payments but higher total interest costs.

Gearing
Gearing influences financing risks by determining the project's financial leverage; higher gearing (more debt relative to equity) increases the risk of financial instability and higher interest costs, especially if the project's revenue falls short of projections. This can lead to greater vulnerability to market fluctuations and operational challenges. Conversely, lower gearing (more equity relative to debt) reduces financial risk and interest burdens, providing a more stable financial foundation but

potentially requiring higher upfront investment from equity holders. Stable, contracted revenue, reflected in lower cover ratio requirements can improve gearing.

Domestic Financial Support

This section elaborates on several domestic financial support options for Sri Lankan offshore wind projects.

Local financing

The financing of offshore wind projects in Sri Lanka will undoubtedly require significant international capital, given the scale and complexity of these undertakings. However, the involvement of local banks will also be important, particularly in addressing currency concerns that arise when funding such large-scale projects.

One of the financial challenges in offshore wind projects is managing currency risk, which arises when project financing involves multiple currencies. In the case of Sri Lanka, much of the required capital will likely be sourced in foreign currencies such as the US dollar or Euro, given the need for international expertise and the large sums involved. However, despite most revenues from offshore wind projects in Sri Lanka likely being generated in USD, there may be a portion in the local currency, LKR[85]. This mismatch between the currency of revenue and the currency of debt can expose projects to exchange rate risks, potentially impacting their financial viability.

Local banks play an important role in mitigating these currency risks. By providing (a portion of) financing in LKR, local banks can help align the currency of the debt with the currency of the project's revenue streams. This alignment reduces the project's exposure to exchange rate fluctuations, thereby enhancing its financial stability. Furthermore, local banks have a deeper understanding of the domestic economic environment and can offer financing solutions that are more attuned to the local market conditions. Text box 11 provides an example of how local banks collaborate with international banks for offshore wind development in Taiwan. This cooperation allows local banks to learn from international banks and better support the projects while addressing the risk of currency exchange.

Text box 11 Financial support from local banks to offshore wind development – Example from the case of Taiwan

Synergies between local banks who understand Taiwanese context and international banks who are experienced in funding offshore wind projects

Taiwanese offshore wind projects are required to source at least 20% of their debt from local banks. This presents a major opportunity for local banks to learn from international collaborations and to benefit from lending to offshore wind projects. It will also benefit the emerging local supply chain if they choose to extend their credit to this field to deepen their understanding of the project risks associated with locally sourced goods and services.

A key example of a successful collaboration between local and international banks occurred in 2023, when funding was secured for the 1,022MW Hai Long wind project through joined efforts. This is the initial step where international lenders (i.e. 11 of them in this case) led most of the debt financing, incorporating local institutions (i.e. 4 Taiwanese institutions) into lending syndicates. From this first step, it is expected that local banks will become more familiar with offshore wind projects and develop their risk assessment capabilities, they will be able to play a more prominent role in financing future offshore wind projects. Additionally, local financiers are expected to play a substantial role in the refinancing of projects once they enter commercial operations.

[85] Current PPAs in Sri Lanka for larger power plants are denominated in USD, but some have a smaller LKR rupee component as well, typically the local maintenance cost component.

Grants

Grants can provide direct funding for specific projects or research. There are currently no national government funds available for offshore wind. Below are two examples of funds for energy efficiency projects.

One example is the Sustainable Guarantee Fund managed by SLSEA that provides guarantees for investors seeking loans for energy efficiency projects. The fund receives its starting capital from the consolidated fund and collects an annual premium and interest payments from the guarantees it provides[86].

There have been plans to establish the Sustainable Energy Guarantee Fund that will provide guarantees for small loans to energy service companies (ESCOs) for energy conservation projects[87]. The fund would start with an initial capital grant of fifty million rupees (approximately USD 0.5 million) and investors will pay an annual premium of at least 0.5% of the guaranteed amount[88]. Moreover, the fund also collects interest, service charges, and penalties from investors.

International Financial Support

There might be a need for international finance support, beyond regular non-recourse project financing, to ensure sufficient liquidity becomes available for the construction of offshore wind projects in Sri Lanka. This in addition to the previously described domestic financial support. This section will elaborate on several options for Sri Lankan offshore wind projects in this regard, their benefits and their adaptability to the Sri Lankan context.

ECA-covered loans

ECA-covered loans are a form of financing provided by commercial banks or financial institutions, but with backing from Export Credit Agencies. An Export Credit Agency (ECA), which can be an official agency in some countries, is a national government-owned or affiliated investment insurance agency that provides government-backed loans, insurance, or guarantees to help domestic companies engage in international trade and investment. These loans are crucial for facilitating international trade and large-scale, complex and multi-jurisdictional projects like offshore wind by reducing risks for both lenders and borrowers[89]. It also offers access to financing and facilitates international trade.

The ECA either lends a direct loan to the borrower (the developer) or provides a guarantee of loans made by commercial banks to the borrower (see Figure 99). This coverage assures the bank that it will be compensated by the ECA in case the borrower defaults on the loan. With ECA backing, the commercial bank disburses the loan to the borrower. The borrower uses the funds for their project or export deal, often involving the purchase of goods and services from the ECA's home country. After an agreed period, the borrower is to repay the loan. If the borrower fails to repay, the ECA steps in to cover the outstanding amount, thus mitigating the risks for the commercial bank. Usually, these risks (e.g. political instability, non-payment, bankruptcy, etc.) are much higher than commercial financiers would normally be able to absorb[89].

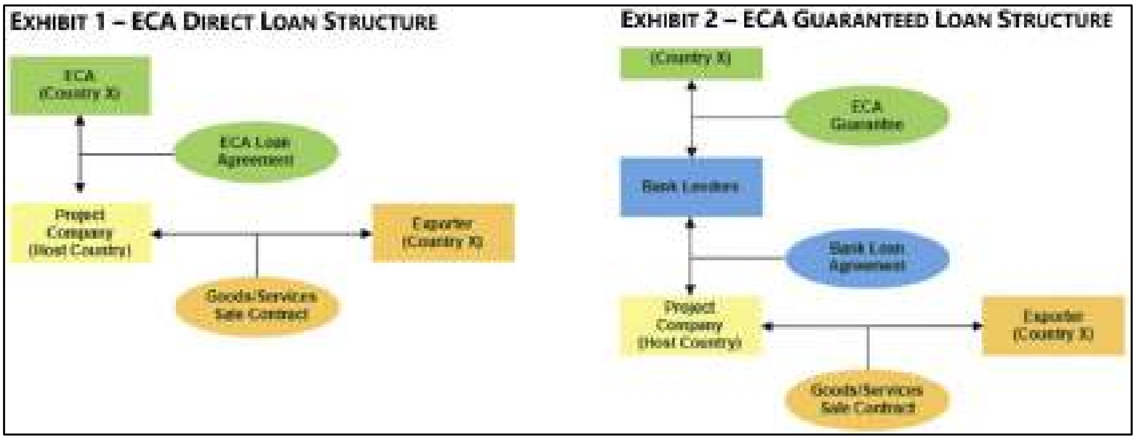
[86] SLSEA – Annual report 2021

[87] SLSEA – Corporate Plan 2021 – 2025

[88] ADB – Building the capacity of the sustainable energy authority (2011)

[89] Pwc – Export Credit Agency financing 2023

Figure 99 Structure of ECA-covered loans, direct and indirect



ECA-backed loans are beneficial to both lenders and borrowers. For borrowers, it offers larger amounts of financing and potentially better terms (like longer tenor and subsidized interest rates) because the ECA coverage enhances the creditworthiness of the loan. It also helps exporters by providing the necessary financial support to their international buyers, making it easier to close deals and expand into new markets. Broadly, ECAs support the home country's economy by promoting exports and encouraging international business relationships.

One recent successful example of offshore wind ECAs financing is the Hai Long project in Taiwan that is backed by seven ECAs from Japan, Canada, the UK, Australia, Belgium, and Norway. The project is owned by a joint venture between Northland Power and Mitsui & Co which required substantial financing. It was successful in mobilizing more than 15 international and local lenders provided the TWD 118 billion ($3.7 billion) needed, with the reassurance that the ECAs would cover potential defaults[90]. ECA backing has enabled the project to secure non-recourse financing (where lenders are repaid from the project's cash flow, not the borrower's other assets) for 20 years, ensuring the project's financial viability despite global economic pressures.

And as another example, in February 2022, India signed an agreement for the supply of petroleum products worth USD 500 million from the Indian Oil Company to help Sri Lanka overcome its fuel shortage. This was facilitated through a credit line backed by an ECA, allowing Sri Lanka to draw funds as needed for the purchase. In April 2022, the arrangement was expanded by an additional USD 200 million, further aiding Sri Lanka during its crisis.

However, it is important to note that ECA-backed loans are contingent upon the projects' risk profiles meeting acceptable criteria set by lenders. This means developers must adhere to specific requirements, including rigorous due diligence and reporting mandates imposed by individual ECAs. These requirements can be more demanding compared to those typically required by commercial financiers[89]. Additionally, transactions involving tied financing with ECAs covered by the OECD Arrangement must comply strictly with its regulations.

Sri Lanka has not seen any renewable projects been funded by ECA-backed loan from OECD countries. In 2010, JICA funded a 150 MW hydropower plant with OECD approval for the tied financing but only for Japanese contractor.

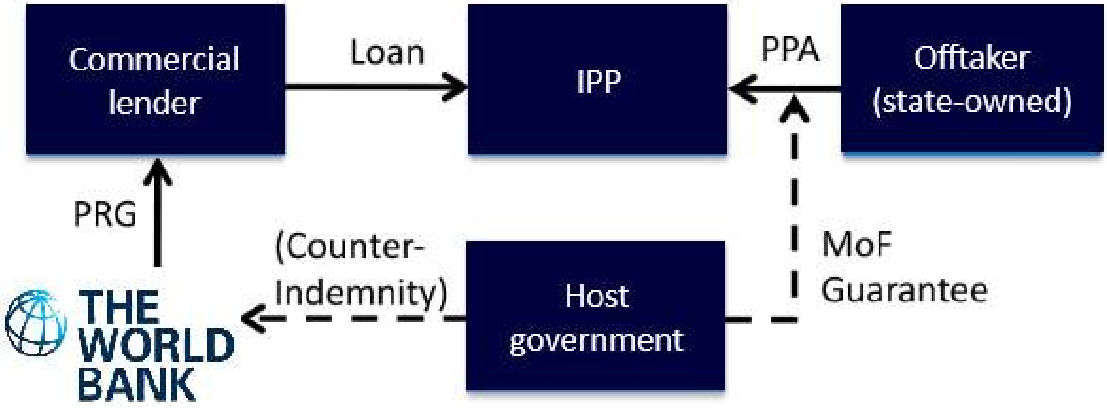
IFI guarantees and insurance

Guarantees and insurance offered by IFIs are designed to protect FDI against political (non-commercial) risks in developing countries, while also helping Borrowing Member Countries achieve their development goals. Major IFIs include the WB, the ADB, and the UN. The Multilateral Investment Guarantee Agency (MIGA), a member of the WB, is a prime example of an IFI that offers political guarantees and insurance.

[90] Global Trade Review – Hai Long scores bumper US$3.6bn ECA-backed facility

A guarantee involves a three-way relationship where the guarantor (IFI) provides assurance to one party (the commercial bank) against the risk that actions or behavior of a public entity could negatively affect the performance of the bank's borrower, such as an IPP. The guarantee protects the bank by ensuring that if the public entity's actions adversely impact the IPP's ability to meet its obligations, the IFI will step in to cover the potential losses (see Figure 100). Meanwhile, insurance is a two-way relationship between the insurer (in this case the IFI) and the insured (usually the entity providing finance), without requiring direct involvement from the developer[91].

Figure 100 Structure of IFI Guarantee, example of WBG providing Partial Risk Guarantee (PRG) [92]



These guarantees and insurance mechanisms are essential in reducing the risks associated with investing in developing countries. Political risks can include expropriation, political violence, currency inconvertibility, and breach of contract by the host government. Non-commercial risks involve regulatory changes or government interference that could negatively impact investments. Guarantees can also help address certain liquidity or creditworthiness concerns with a public off-taker or a public financial obligation. By providing protection against these risks, IFIs not only protect investments but also encourage more FDI into countries that need it for their development.

As an example, in 2018, MIGA's guarantee support the development of Noupoort, Khobab, and Loeriesfontein 2 wind farms in South Africa. The guarantee worth US$73 million offer coverage 90% for equity and shareholder loan investments made by the renewable energy company Lekela Power and its subsidiary, Lekela Power Intermediate Holdings[93]. It acts as a protector against risks such as expropriation, transfer restriction and inconvertibility, breach of contract, and war or civil disturbance for up to 15 years.

Sri Lanka also has an example of IFI guarantee dated back in 2009 with the IFC's PADGO (Portfolio Approach to Distributed Generation Opportunities) project that aided local banks in Sri Lanka in supporting renewable energy initiatives. By establishing a Risk-Sharing Facility (RSF), the project enabled the National Development Bank PLC to expand its lending capacity for renewable energy projects. The RSF functions as a financial safety net for banks, absorbing a portion of the losses should the renewable energy projects encounter difficulties or fail. This mechanism allows banks to free up capital, which can then be allocated to new renewable energy projects. Additionally, it encouraged banks to consider financing innovative renewable energy technologies in Sri Lanka, such as wind energy projects, in an era where no commercial wind power plants existed in Sri Lanka.

[91] World Bank – Financing renewable energy: Options for developing financing instruments using public funds
[92] ADB – Guarantees
[93] ESI Africa – World Bank's MIGA to support three wind farms in South Africa

However, it is unlikely that a similar project will be implemented for offshore wind, as the nature of RSF is designed to encourage banks to grow their portfolios of renewable energy projects, which is most beneficial when there are numerous projects to be financed. In the case of offshore wind, the focus is more on financing a few large-scale projects, and risk cover instruments are typically applied at the project level rather than across a portfolio.

Two significant drawbacks of guarantees involve the complexities of accounting for and approving contingent liabilities, as well as the potential for excessive use due to political reasons and preferences[91]. Guarantees require careful accounting and approval processes because they involve potential liabilities that may arise if the guaranteed party fails to meet obligations. Assessing these risks can be challenging, which complicates the financial management and decision-making process. Moreover, guarantees may be overused for political reasons, such as supporting projects favored by certain interests. This misuse may prioritize projects based on political considerations rather than their economic or strategic merits, potentially leading to inefficiencies in resource allocation.

One key challenge in securing insurance for renewable energy projects in emerging markets is the limited capacity of local insurers. These markets often lack the depth to handle risks associated with offshore wind, but IFIs like MIGA can help bridge this gap by facilitating access to local and international reinsurance. Assembling a comprehensive insurance package will require close collaboration with insurers, and while a well-developed financial market and project database are important, IFIs can play a critical role in overcoming local insurance limitations.[91].

In the context of Sri Lanka, there is a significant resource that addresses this need. The CEB publishes a report on sales and generation data, which provides valuable insights into the technical performance of all renewable energy projects in the country. This report can serve as a crucial tool for insurers, offering comprehensive data that can aid in the evaluation and pricing of insurance for renewable energy projects. An overview of the report's coverage is provided in Table 68 below.

Table 68 Contents covered in the Sales and Generation data book published by CEB in 2022

Data on sales	Historical behavior pattern
	Summary statistics on electricity sales
	Divisional & provincial electricity sales by tariff
	Electricity sales by province & division
	Provincial electricity sales by area
	Provincial electricity sales by tariff
	Electricity sales by area & tariff
	Monthly data on electricity sales by tariff
	Monthly data on electricity sales by province
Data on electricity generation	Year of commissioning of power station
	Summary statistics on electricity generation
	Data on power stations – CEB
	Monthly electricity generation by source & sectors
	Gross generation, auxiliary & net generation
	Monthly gross generation by power stations
	Monthly station consumption & net generation by power stations
	Fuel consumption & fuel cost power stations – CEB
	Coal shipment details
	Fuel cost by power stations – Private

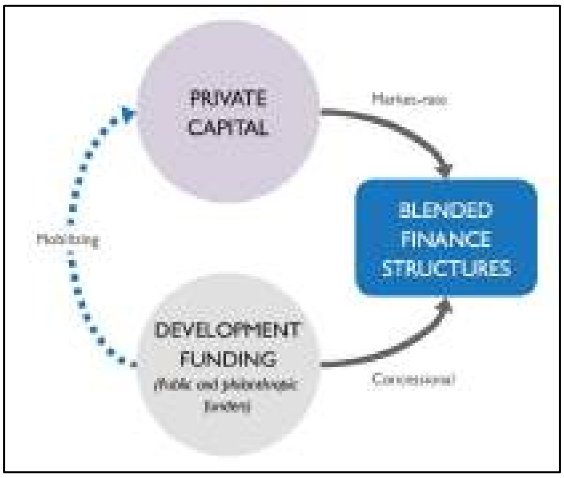
	Monthly system peak demand & load factor
	Reservoir operation data
	Daily & weekly load curves
	CEB tariff

Though not specific to (offshore) wind energy, in the context of hydro projects in South and Southeast Asia, IFI insurance mechanisms have played a critical role in mitigating risks and enhancing project bankability. A classic example is the Nam Theun 2 hydropower project in Laos, which employed a suite of instruments, including the MIGA Political Risk Insurance (PRI) and a World Bank Partial Risk Guarantee (PRG). At the time, these tools were highly innovative and became a case study for IFI involvement in large infrastructure projects. Another relevant example is the refinancing of the Asahan 1 hydropower project in Indonesia, where MIGA PRI was deployed to facilitate the project's financial restructuring. Similar instruments have been used outside the region, such as in the Nachtigal hydro project in Cameroon, which utilized both MIGA PRI and a World Bank PRG to extend local bank financing maturity. Guarantees have also been applied in other renewable energy initiatives like the Scaling Solar Programme in Zambia and Renovar in Argentina. Notably, the largest guarantee to date was issued for the Sankofa gas project in Ghana, with a $700 million guarantee. These examples demonstrate the ongoing relevance of IFI insurance in supporting infrastructure projects in developing markets.

Blended finance

Blended finance strategically uses public and private sector capital to bridge the risk gap in new investments and innovative business models, especially in sectors like energy transition in emerging markets. By leveraging public funds to reduce perceived risks, it attracts private investment into projects that might otherwise be considered too risky (see Figure 101).

Figure 101 Structure of blended finance[94]



Blended finance is particularly advantageous for renewable energy projects like offshore wind, which typically involve high upfront costs and extended payback periods. What sets blended finance apart is its ability to leverage (a small amount of) public donor funding to mitigate the risks associated with a project, while the majority of the funding comes from private sources. A key advantage in the context of offshore wind is that by reducing the LCoE through blended finance for the initial projects, these early ventures can successfully move forward. This, in turn, allows the supply chain to establish itself, which can lead to lower LCoE for subsequent projects. As a result, the need for blended finance diminishes over time, reducing the financial burden on the sector. The donor funding in blended finance is used to cover initial losses or guarantee returns, altering

[94] Convergence Finance

investors' perceptions of high risks and low returns, and thereby encouraging a flow of private capital into renewable energy projects, particularly in emerging economies like Sri Lanka.

However, determining the optimal timing and duration for concessional funds in a project can be challenging. This difficulty arises because local financial markets must be sufficiently developed and aligned with international standards for the market to become self-sustaining after the blended finance intervention. If the government sets prices rather than allowing market mechanisms to determine them, and if strict monopolies dominate the market, renewable energy business models may struggle to survive despite concessional finance. This is due to reasons such as distorted market signals in electricity tariffs and a dependence on subsidies. This should be taken into consideration when choosing either the government-led or the developer-led approach that have been discussed above.

In Sri Lanka, electricity prices are adjusted biannually; however, this adjustment does not affect renewable energy PPAs, as their pricing is fixed and all PPAs to date have followed a "must-run, must-take" policy. Fixed tariffs and "must-run, must-take" elements are important for securing concessional financing because they reduce risk and ensure predictable returns. However, for commercial investors, these elements might not be as attractive because they can limit the opportunity for higher, market-driven returns. The regulated market environment could impede the development of a self-sustaining market after the blended finance intervention.

While no offshore wind projects have been implemented in emerging markets to date, many renewable energy projects in these regions have benefited from blended finance approaches, combining donor funding with commercial investments. IFIs, such as the IFC, have established facilities in collaboration with donors, including the International Development Association (IDA), to blend concessional funds with their own financing. These blended finance mechanisms help de-risk projects and attract private sector investment. The listed facilities represent various climate-focused partnerships and programs supported by bilateral and multilateral donors in collaboration with the IFC to advance climate finance and renewable energy projects:
Bilateral

- IFC-BMWK Climate Facility (Germany)
- IFC-Global Energy Alliance for People and Planet Partnership
- IFC-Canada Climate Change Program
- Canada-IFC Renewable Energy for Africa Program
- Canada-IFC Blended Climate Finance Program
- Finland-IFC Blended Finance for Climate Program
- Korea Green Resilient and Innovative Development (K-GRID)
- UK-IFC Market Accelerator for Green Construction Program Multilateral
- Climate Investment Funds
- The Global Environment Facility
- The Green Climate Fund

The blended finance approach in these facilities is deployed in all kinds of situations. One example from the Green Climate Fund is the Renewstable Barbados Project, which illustrates how donor funding can be blended with IFC financing to promote renewable energy development.

Direct A/B loans and equity
A direct A/B loan structure involves collaboration between national or IFIs, such as National Investment Banks (NIBs) and Development Finance Institutions (DFIs), and private sector lenders to fund large projects. The "A loan" is the portion of the loan provided directly by the institution (e.g., NIBs, DFIs) from its own resources[95]. The institution holds the Lender of Record status, which means it is officially recorded as the lender for the entire loan amount. The "B loan" is the portion of the loan provided by private sector lenders[95]. These private lenders are brought into the deal through the mobilization efforts of the leading institution.
This structure is particularly beneficial for financing large infrastructure projects.

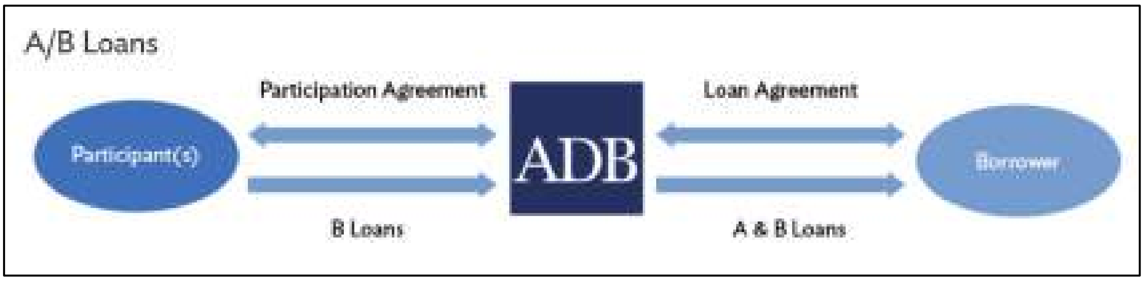
[95] ADB – Loan syndications and commercial cofinancing

The institution (NIB or DFI) not only provides its own capital but also acts as the facilitator, ensuring that the project meets required standards and managing the administrative aspects of the loan. Preferred Credit Status allows for tax benefits, making it more attractive for private sector lenders to participate and offer competitive financing rates. In case of default, all lenders, both public (A loan) and private (B loan), are equally impacted, as a default on one part of the loan results in a default on the entire facility.

A recent example of using A/B loans to finance wind projects include the case where the ADB and Monsoon Wind Power Company Limited (Monsoon) signed the largest syndicated renewable project financing transaction among ASEAN countries to date worth of $692.55 million to develop a wind power plant in Sekong and Attapeu provinces in the southern region of Laos. The package comprises a $100 million A loan from ADB's ordinary capital resources, a $150 million syndicated B loan, $50 million in concessional financing, $382.55 million in parallel loans, and a $10 million grant[96]. The B loan is a collaborative contribution of multiple commercial banks. This deal is designed to help mitigate key project risks, including potential curtailment risk, which is a key bankability issue for lenders.

The structuring of A/B loan can be complex and pose coordination challenges because of the splitting of the loan into two parts (see Figure 102). This complexity arises because each party may have different requirements, risk assessments, and expectations, necessitating extensive legal and financial structuring to align interests and manage relationships effectively. Most importantly, the mismatch in risk appetite can lead to negotiations over risk allocation and terms, potentially complicating the loan structuring process further. In such a way that the development institutions might be more willing to take higher risks compared to private investors, leading to potential mismatches in risk appetite and terms. Development institutions often have a higher tolerance for risk, driven by their developmental goals, whereas private investors typically seek lower risk opportunities with predictable returns. Additionally, efforts and costs are incurred in advertising the B-loan portion to private investors, as marketing and negotiating terms with multiple stakeholders can be time-consuming and resource-intensive.

Figure 102 Structure of A/B loans, example from ADB[95]

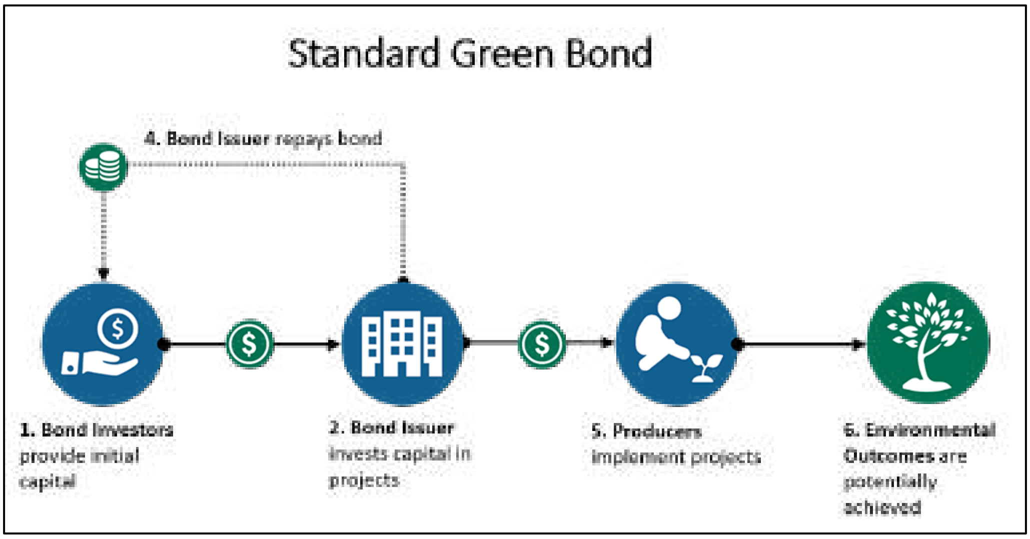


Green bonds

Green bonds are a type of debt issued by public or private institutions to finance environmental projects in Figure 103. These bonds help attract commercial investors and issuers into environmentally beneficial projects while encouraging local regulators, issuers, and investors to adopt international best practices. A bond differs from a normal loan in that it is a tradable debt security issued to multiple investors, while a loan is a direct borrowing arrangement with a single lender and is not tradable.

[96] ADB – ADB signs loan for first cross-border wind power project in Asia, first plant in Lao PDR and Largest in Southeast Asia

Figure 103 Structure of Green Bond[97]



Issuing green bonds signals a strong commitment to environmental priorities. This enhances budget stability and transparency, as it subjects all issuer activities to greater scrutiny. The commitment associated with green bonds helps garner additional support. Organizations like the World Bank find green bonds beneficial due to their alignment with thematic focuses, facilitating evaluation and accountability[98]. The rise of ESG-friendly investments has created a significant alternative funding source for projects aligned with environmental, social, and governance agendas. Since the establishment of the Principles for Responsible Investment, the number of global financial institutions adhering to ESG principles has surged, providing ample funding opportunities for compliant issuers.

There is an important distinction between corporate and project green bonds. Corporate green bonds are issued by a company, with the proceeds used to finance various green initiatives across the organization. These bonds are often on the balance sheet of large developers or corporations, which means the company's overall financial health backs them. In the context of offshore wind projects in Sri Lanka, it is possible that a large international developer might issue a corporate green bond to finance such a project. However, this would typically be on the company's balance sheet, with the developer providing the necessary financial guarantees.

Project green bonds, on the other hand, are specifically issued to finance a particular project and are usually secured by the project's assets and revenue streams. These bonds are less common in markets like Sri Lanka, especially for large-scale offshore wind projects, due to the higher risks associated with construction and the lack of a robust local bond market. It is highly unlikely to see a project bond issued for an offshore wind project in Sri Lanka without a corporate guarantee from an investment-grade developer. In such cases, the developer would need to wrap the construction risk to make the bond attractive to investors. An example of this is the project bond issued by Ørsted for the Hornsea One offshore wind farm, where the developer provided a construction wrap to mitigate risk and secure investor confidence.

In 2020, Pan Asia Bank became the first Sri Lankan bank to partner with Switzerland-based Symbiotics Group for a green bond issuance, successfully raising USD 7.75 million to promote indigenous crops and strengthen sustainable agricultural practices[99]. Building on this initiative, Symbiotics arranged a USD 15.1 million green bond for Seylan Bank PLC in 2021[99]. Seylan Bank committed to using the proceeds to finance renewable energy projects within Sri Lanka, including mini hydro power plants up to 25MW, as well as solar and wind power facilities.

[98] World Bank – Pros and Cons of Green Bond
[99] UNDP – Sustainable finance in Sri Lanka

In 2023, the Ministry of Finance, with support from the United Nations Economic and Social Commission for Asia and the Pacific (ESCAP), developed a Green Bond Framework to further support the development of green bonds and sustainable projects in Sri Lanka. ADB now continues to assist Sri Lanka in advancing its green bond framework and facilitating green bond issuances.

However, green bonds have drawbacks despite their benefits. First, contrary to common belief, green bonds do not offer a financial advantage over conventional bonds[98]. The interest rates are based on the issuer's credit rating rather than the purpose of the funds, so there is no guarantee that they will be cheaper. Second, although subjected to greater scrutiny, there is also no absolute guarantee that green bond proceeds will be used as intended. Even if earmarked for sustainable projects, issuers might redirect existing funds to other areas, potentially diluting the intended impact[98]. Thirdly, green bonds' commitment to specific expenditures might force cutbacks in other crucial areas due to fiscal constraints. Ideally, such trade-offs should be managed by legislative bodies rather than the financial markets. Finally, like other measures, uncertainty is a variable in deciding the success of a financial support mechanism. Measuring the true impact of green bonds is challenging and requires extensive, costly, and time-consuming evaluations. Uncertainty in proving that additional spending achieves the desired outcomes can deter future investment. Allocating bond proceeds to specific expenditures can complicate funding over time.

6.5.1 Environmental and Social

Sharing Maritime Space

A range of other stakeholders are using maritime space and developing offshore wind requires adequate engagement with those stakeholders. Failing appropriate solutions, the projects may face risks of delays, reduced available space, increased costs, reduced energy yield, or even project cancellations.

From the constraints assessment in Chapter 2, several potential competing interests have been identified, mainly related to fishing, ecology, shipping, military and tourism concerns, which can set preconditions. Further study and assessments are required to determine which measures are indeed necessary and recommended to be put in place. It is important that the bandwidth of possible measures and consequences is taken into account beforehand, and an assessment of the likelihood of occurrence is conducted. To avoid surprises, this should be incorporated into the business case with a large enough contingency budget. Environmental insurance can mitigate unforeseen risks.

In general, most environmental and social issues should be mitigated in the planning phase. By choosing the right location and size for the wind farm, many conflicting interests can usually be avoided or mitigated. Involving the right stakeholders in the planning process is essential to gain understanding and support for the wind farm. Finally, legal procedures, including public consultations, should ensure that decisions regarding spatial planning and permitting are well-balanced. However, certain impacts and some conflicts will always remain.

Examples of strategic engagements to share the maritime space with other interests are Marine Spatial Planning (MSP) and Environmental and Social Impact Assessments (ESIA), which help prevent commercial risks in offshore wind projects by optimizing site selection to avoid environmental risks and conflicts, ensuring regulatory compliance, and facilitating stakeholder engagement. A thorough ESIA will provide insights into the impacts and result in a proposal for the environmental and social monitoring program. The requirements for environmental & social safeguard from a lender’s standpoint are elaborated in the next section.

Lender E&S safeguard requirements

Lenders require Environmental and Social (E&S) safeguards for offshore wind projects to manage risks related to biodiversity, ecosystems, and communities. These safeguards aim to minimize project impacts and promote sustainable development goals. Concessional finance providers and commercial project finance lenders conduct due diligence on a project’s compliance with E&S

Performance Standards (PS). Not meeting these safeguards may limit financing options or preclude investment altogether. There is no fixed list of requirements from lenders on E&S factors, but several major institutions, including EP, IFC, ADB, and WB, provide their own specific criteria, which are briefly provided below and categorized into environmental and social aspects. These can be considered as Good International Industry Practices (GIIPs).

Environmental Requirements

Environmental and Social Impact Assessments (ESIA)
The Equator Principles (EP), IFC PS, and Asian Development Bank (ADB) safeguard policies all mandate Environmental and Social Impact Assessments (ESIAs) to manage environmental and social risks in project development. For high-risk Category A and appropriate Category B projects under the EP, comprehensive ESIAs are required to identify, mitigate, and compensate for adverse impacts, with a focus on climate change risk assessment based on project specifics. Similarly, IFC's PS 1 requires an Environmental Management System to manage risks and ensure continuous improvement through the mitigation hierarchy of avoiding, minimizing, mitigating, and compensating for residual impacts, guided by site-specific Environmental, Health, and Safety (EHS) Guidelines. The ADB's safeguard policy framework mandates early identification, assessment, and mitigation of environmental, social, and cultural impacts, with transparency and community engagement ensured through the disclosure of draft and final assessments. All frameworks emphasize thorough risk assessment, tailored mitigation measures, and ongoing monitoring to enhance environmental performance and accountability throughout the project lifecycle.

Biodiversity and Marine Conservation:
Biodiversity and marine conservation are crucial components of the "Environmental" aspect under the EP and IFC's PS 6. Both frameworks require comprehensive project assessments that prioritize the protection of biodiversity, particularly focusing on endangered species, sensitive ecosystems, and legally protected areas.

Pollution Prevention and Control:
The EP highlights the importance of pollution prevention and waste management in project assessments, recommending measures such as minimizing pollution, controlling liquid effluents and air emissions, and implementing effective waste management practices. In contrast, the IFC's PS 3 provides more detailed requirements, mandating projects to minimize pollution impacts on human health and the environment by adopting prevention strategies, stringent controls on emissions and effluents, and comprehensive waste management throughout the project lifecycle.

Climate Change Adaptation and Mitigation:
The EP, IFC, and ADB integrate climate change considerations into their project assessment frameworks, ensuring that projects are resilient to climate change impacts and contribute to mitigation efforts.

Social Requirements

Social Impact Assessment (SIA):
The Social Impact Assessment (SIA) for offshore wind projects evaluates the potential social impacts on local communities, stakeholders, and the broader social environment. This process is part of the ESIA, as described above, and is not elaborated upon further here.

Social Engagement:
Under Principle 5 of the EP, Category A and B projects must ensure effective Stakeholder Engagement, including an Informed Consultation and Participation (ICP) process for projects with significant impacts, with information disclosed in local languages. The IFC's PS 7 requires Free, Prior, and Informed Consent (FPIC) from indigenous peoples for projects affecting their lands,

relocation, or cultural heritage. In such cases, an independent consultant must confirm that the consultation meets host country laws and IFC standards.

Cultural Heritage:

The EP and IFC PS mandate the protection of cultural heritage and Indigenous Peoples' rights. Projects affecting Indigenous Peoples or their heritage must follow ICP and adhere to relevant laws. IFC PS 7 addresses Indigenous rights, while PS 8 requires developers to avoid or mitigate harm to cultural heritage, preserve non-replicable sites, and ensure community consultation and benefit-sharing. Projects impacting or commercializing cultural heritage must consult communities, integrate their views, and implement mitigation measures, including chance find procedures and compliance with local regulations.

Labor and Working Conditions:

The EP and IFC PS 2 require addressing labour issues, including core labour standards, occupational health and safety, and grievance mechanisms. Child and forced labour are prohibited. Occupational health and safety standards must follow good industry practices, as detailed in the World Bank's EHS Guidelines, which cover key areas to ensure safe workplaces, effective hazard communication, and proper training.

7.1 Preamble

Stakeholder engagement and capacity building is a crucial component to meet the project's objectives and plays an important role in all tasks and during the entire project timeline. It is important to engage with the stakeholders of the project throughout the project's life cycle, including pre-feasibility. This engagement should start early in the project development process. Since offshore wind development is a new concept for Sri Lankan community, it is necessary to build the capacity of government organizations and other relevant stakeholders about offshore wind development.

Two offshore wind sites studied in this pre-feasibility, Mannar and Puttalam in Sri Lanka, are areas where already onshore wind turbines are operating. The handling of environment and social impacts in setting these onshore wind projects can have a negative impact on offshore wind development in the country. Therefore, it is required to engage with stakeholders on a long-term basis to obtain consent and legitimacy for offshore wind exploration.

The aim of the stakeholder engagement is 1) to raise awareness, 2) to collect input and feedback, 3) to build knowledge & capacity, 4) to create widespread support to achieve consensus on the proposed offshore wind projects and, 5) agree on future development pathways. This chapter discusses identification, classification and involvement of stakeholders during the pre-feasibility study. Moreover, the various stakeholder engagement activities are elaborated, including meetings, workshops and site visits.

7.2 Overview of Previous Work

In the Roadmap, four main groups of stakeholders were identified: 1) Government 2) International non-governmental organizations 3) National non-governmental organizations and 4) Academia and civil society. Consultations were initiated with several identified stakeholders as presented in Table 69.

Table 69 Stakeholder consultations during Technical Assistance Phase I (source: Roadmap)

Stakeholder category	Stakeholder organization
Government Stakeholders	Ministry of Power and Energy (MoPE), Sri Lanka Sustainable Energy Authority (SLSEA), Ceylon Electricity Board (CEB)
Private sector stakeholders including project developers	Wind Force Ltd, LTL Holdings Ltd, Senok Wind Power Pvt. Ltd. Lanka Transformers, Celex Renewables (Pvt) Ltd, Chamber of Commerce (committee on renewable energy)
Domestic Financial Institutions	NDB Bank, DFCC Bank PLC, Commercial Bank of Ceylon PLC
International Financial Institutions	IFC, ADB, Japan International Cooperation Agency (JICA)

During the pre-feasibility study, the list of government stakeholders was broadened to include various government stakeholders that were not included in the Roadmap such as environment regulatory organisations, organisations related to the fisheries and tourism sectors, organisations related to ports related services, organisations related to security and access to the site and other organisations that have a stake for the offshore wind exploration in Sri Lanka. The national research organisation, namely National Aquatic Resource Research and Development Agency (NARA) was also consulted. In addition, regional-level stakeholders in Mannar and Puttalam districts were identified. The private sector stakeholders, domestic financial institutions and IFIs that were consulted in the Roadmap were not continued during pre-feasibility, as it is too early to have consultations with these stakeholders at this phase.

7.3 Identification and classification of stakeholders

This section provides the approach to stakeholder classification, the list of identified stakeholders and the RACI matrix.

7.3.1 Approach to stakeholder classification

Stakeholders are defined as organizations or groups or people that have direct or indirect involvement in the offshore wind development initiative. Stakeholders are identified and classified at the following three levels:

Level 1: National-level stakeholders

The national-level stakeholders are identified as government and private organizations, groups or persons that are important for offshore wind development in Sri Lanka. There are around 36 national level stakeholders that are identified at this pre-feasibility phase of the project (see Table 70). Some national level stakeholders such as National Institute of Occupational Safety and Health, trade unions, Ceylon Chamber of commerce, Embassies (e.g. from USA, UK, The Netherlands) and financing institutions (e.g. local banks, bilateral and multilateral banks) were not included at this pre-feasibility phase of the project as it is too early to consult these stakeholders at this phase.

Level 2: Regional-level stakeholders

This study focuses on two offshore project sites, namely coastal areas of Mannar and Puttalam. The prominent regional level government stakeholders are District Secretaries, Divisional Secretaries and representatives of local authorities. In addition, there are also non-government organizations working on environment and social safeguards and non-government organizations working in fisheries sector.

Level 3: Project affected stakeholders and Partner Organizations (local)

Several stakeholders are identified as potential project affected parties. These include organizations or groups or persons that are affected or likely to be affected by the project. These include the possibly affected fishing communities, people/organizations involved in tourism activities, and affected landowners (onshore activities). There are also affected maritime organizations, utility organisations, aviation authorities, project equipment suppliers etc. Some of these potentially affected organizations are already identified in level 1 and 2.

7.3.2 List of Stakeholders

The identified stakeholders are presented in Table 70 (level 1), Table 71 (level 2) and Table 72 (level 3).

Table 70 List of national level stakeholders

Number	Stakeholder organization or group or person	Description/ relation to offshore wind development
National level stakeholders		
Organizations/Commissions related to Power and Energy		
1	Ministry of Power and Energy (MoPE)	• Executing agency of the offshore wind
2	Sri Lanka Sustainable Energy Authority (SLSEA)	• Implementing agency for offshore wind projects • Facilitate and regulate development of Sri Lanka's renewable energy resources

Number	Stakeholder organization or group or person	Description/ relation to offshore wind development
3	Ceylon Electricity Board (CEB)	• Electricity transmission and distribution service provider in Sri Lanka • Off taker of power output from offshore wind
4	Petroleum Development Authority of Sri Lanka (PDA)	• Exploration and production of indigenous oil and gas resources • Exploration activities in selected project sites
5	Public Utilities Commission of Sri Lanka (PUCSL)*	• Economic, technical and safety regulator of the electricity industry, petroleum and water services in the country.
Environment Regulatory Organizations		
6	Department of Coast Conservation and Coastal Resource Management	• Interested in sustainable development and management of coastal resources • Provide necessary approvals for the project
7	Marine Environment Protection Authority (MEPA)	• Prevention, controlling and managing offshore pollution in Sri Lanka • Potentially a larger role with offshore permitting
8	Central Environmental Authority (CEA)	• Provide necessary environmental approvals for onshore activities of the project • Monitor environmental aspects of the onshore activities of the project
9	Geological Survey and Mines Bureau (GSMB)	• Issue permits for blasting quarrying rock, sand etc. for project activities
10	Department of Archaeology (Marine Archeology Unit)	• Exclusion of project activities from archeologically protected areas
11	Central Cultural Fund*	• Heritage management institution in the country • Carry out marine archaeological research
12	Ministry of Environment	• Framing policies for the protection of environment and wildlife resources
13	Department of Wildlife Conservation	• Exclusion of project activities from wildlife protected areas • Protection of sensitive flora and fauna species (even outside of protected areas)

Number	Stakeholder organization or group or person	Description/ relation to offshore wind development
Organizations related to fisheries sector		
14	Ministry of Fisheries and Aquatic Resources	• Issuing policy guidelines for fisheries and aquatic resources
15	Department of Fisheries and Aquatic Resources	• Concerns about impact to fisheries and aquatic resources in project sites
16	Ceylon Fishery Harbor Corporation (CFHC)	• Fishery harbor related services and providing the fishing community with modern infrastructure and facilities
Ports related services		
17	Ministry of Ports and Shipping	• Responsible for formulating and implementing national policy on ports and shipping
18	Sri Lanka Ports Authority	• To provide port facilities and logistics services to all stakeholders and contribute to national economic development
19	Merchant Fishing Secretariat*	• Shipping administration arm with the responsibility of overseeing maritime concerns in the country.
Organizations related to tourism sector		
20	Sri Lanka Tourism Development Authority	• Concerns about impact on tourism activities in the project sites
21	Ministry of Tourism	• Concerns about impact on tourism activities in the project sites
Organizations related to security and access to the site		
22	Ministry of Defence	• Formulating and executing strategic plans and policies for a secure, safe and sovereign country with territorial integrity
23	Sri Lanka Air Force	• Train, equip and deploy a professional air force exploiting core competencies to undertake air operations in support of national security
24	Sri Lanka Navy	• Maintain, train and equip a combat ready naval force capable of achieving national security objectives and safeguard Sri Lankas's maritime interest wiliest nurturing a stable environment at sea
25	Sri Lanka Army*	• Attending to national security of the country.

Number	Stakeholder organization or group or person	Description/ relation to offshore wind development
26	Sri Lanka Coast Guard	• Premier law enforcement force functioning under Ministry of Defense • Entrusted to assist vessels at sea, safety of life at sea, protect marine environment and prevent/combat marine disasters ensuring national security
Other Organizations/groups/persons		
27	Department of National Physical Planning	• Formulating physical policies, plans and strategies and monitor the implementation of such policies regarding economic, social, physical and environmental aspects of land and territorial waters of Sri Lanka
28	Civil Aviation Authority of Sri Lanka	• Operate safe and secure national civil aviation system • Impact on aviation systems in project areas
29	Telecommunication Regulatory Commission Sri Lanka	• Regulatory agency for telecommunications in Sri Lanka
30	Sri Lanka Telecom	• Service provider for information communication technology solutions
31	Department of Meteorology	• Provision of meteorological and climatological services
32	National Building Research Organization (NBRO)*	• Leading research and development institution and technical service provider in the field of geotechnical engineering, land slide risk management, environment monitoring, engineering project management
NGOs working in environment/social safeguards		
33	Groups studying on migratory birds and environment safeguards in Sri Lanka (Ceylon Bird Club, Wildlife and Nature Protection Society, Environmental Foundation (Guarantee) Limited etc.)	• Safeguarding bird life in the region and conservation • Environmental safeguards in the country
Marine Research/Education/Service Organizations		
34	National Aquatic Resource Research and Development Agency (NARA)	• Principal research institute to carry out and coordinate research, development, and management activities on aquatic resources in Sri Lanka

Number	Stakeholder organization or group or person	Description/ relation to offshore wind development
35	Lanka Hydraulic Institute Ltd.*	• Engineering consultant in ocean, coastal and inland water in Sri Lanka
Academics		
36	Academics attached to main universities in Sri Lanka (University of Moratuwa, University of Peradeniya, University of Jaffna etc.)	• Interested in technical information and environment/social impacts of offshore wind projects

** These stakeholders were not identified during the initial stakeholder engagement plan. They were identified later and have been invited to, and attended, the workshops.*

Table 71 List of Regional level stakeholders

Number	Stakeholder organization or group or person	Description/ relation to offshore wind development
1	District Secretaries– Puttalam/Mannar and relevant staff (Ex: Staff attached to Planning division)	• Administers the project areas • Attend to environmental and social issues of the offshore wind project
2	Divisional Secretaries of coastal areas of Mannar District (Manthai West DSD, Mannar Town DSD, Nanadan DSD, Musali DSD) and Puttalam District (Vanathavilluwa DSD, Puttalam DSD, Kalpitiya DSD, Mundel DSD, Arachchikattuwa DSD, Chilaw DSD, Mahawewa DSD, Naththandiya DSD and Wennapuwa DSD)	• Administers the project areas • Attend to environmental and social issues of the offshore wind project
3	Secretaries of coastal Urban councils (UCs) and Pradeshiya Sabhas (PSs) (Local Authorities) of Mannar District (Mannar UC, Mannar PS, Manthai West PS, Musali PS, Nanattan PS) and Puttalam District (Vanathavilluwa PS, Puttalam PS, Kalpitiya PS, Arachchikattuwa PS, Chilaw PS, Naththandiya PS and Wennapuwa PS)	• Political administration of the project area • Collects taxes, provide approvals for buildings, responsible for waste collection and disposal etc.
4	Non-government organizations working on environment/social safeguards	• Environment and social impacts of offshore wind project
5	Non-government organizations working in the fisheries sector	• Concerns about impact to the fisheries sector from project activities
6	Mannar and Puttalam district representatives of national level stakeholders (Ex: Central Environment Authority, Department of Wildlife Conservation, Department of Archaeology etc.)	• Attending to environment/social matters in Mannar and Puttalam areas under the national level authority

Table 72 List of Project affected stakeholders and Partner Organisations (Local)

Number	Type of Impact	Stakeholder Group
1	Social	Affected Fishermen/fisheries societies in or around respective project sites

2	Social	Affected people or organizations engaging in tourism activities in or around respective project sites
3	Social	Affected landowners (onshore activities)
4	Social	Affected project workers including construction workers
5	Social	Affected persons (temporary disturbance) during equipment transport, construction and commissioning activities
6	Technical	Affected existing wind power plants (potential impacts on energy yield)
7	Technical	Affected maritime activities including Sri Lanka Navy and Sri Lanka Coastguard
8	Technical	Affected aviation activities
9	Partners	Project investors or co-investors
10	Partners	Project equipment suppliers
11	Partners	Project construction and maintenance service providers

7.3.3 RACI Matrix

The identified stakeholders are engaged in the study according to the following four levels:
1. Responsible: Stakeholders who are responsible for identified tasks;
2. Approve: Stakeholders who need to approve identified tasks;
3. Consulted: Stakeholders who should be consulted for identified tasks;
4. Informed: Stakeholders who should be informed about identified tasks.

The RACI Matrix prepared for the pre-feasibility study tasks is attached as Appendix B.

7.4 Overview of meetings, workshops and seminars

This section provides an overview of meetings, workshops and seminars.

7.4.1 Inception mission

The inception mission of the study was held from 6 to 10 November 2023. The project team (Pondera and RMA Energy) and WB had various one-on-one discussions with identified stakeholder organizations and started the process of making stakeholders aware of the offshore wind development. On a very general level, the team had the following (positive) observations:

- All parties met and showed great interest in the project and had a supportive attitude;
- For each stakeholder, the project team obtained a single focal point for further contact, data and knowledge sharing and follow-up;
- There is ongoing debate between two regulatory organisations, CEA and MEPA, on which authority will be responsible for regulatory and permitting matters related to offshore wind development;
- No showstoppers for offshore wind development were identified, but several specific points of attention to be considered with care: biodiversity, fishery, hydrocarbon exploration;
- There is a current period of significant regulatory change within the Sri Lankan energy system with the new Energy Act;
- Offshore wind continues to be widely supported by the government at very senior levels.
- Ongoing initiatives to enhance awareness, support, and capacity among management and senior management of government authorities.

The stakeholder organizations visited and the outcome of the engagement are presented in Table 73.

Table 73 Stakeholder organizations visited during inception mission and outcome

Date	Name of the Stakeholder/ Organization	Objective of the meeting	Outcome
06.11.2023	Ministry of Power and Energy (MoPE)	Kick-off of the assignment.	• Agreement on the methodology and the work plan. • Updates were provided for regulatory gap analysis and offshore wind resource assessment planning • Requested relevant data and information from relevant SL authorities • Coordinators appointed from the MoPE, CEB and SLSEA. • Need for extensive stakeholder engagement mentioned and Secretary of MoPE agreed to support stakeholder engagements.
06.11.2023	Marine Environment Protection Authority (MEPA)	To explain the upcoming project and understand MEPA's role in environmental clearance for offshore wind.	• Revisions of MEPA regulations mentioned • Interested in supporting the project and potential future responsibility of regulatory matters • Contacts were developed with MEPA for future offshore wind development activities.
07.11.2023	Sri Lanka Sustainable Energy Authority (SLSEA)	To discuss SEA's perspective and mandate related to onshore and OWP development.	• SLSEA mentioned the plan for extending energy permitting for offshore wind • Discussion about wind data collection and possible sites for Dual Scanning Lidar (DSL) • Discussion on onshore wind projects in Mannar
07.11.2023	UK Consulate, UK FCDO, Blue Planet	To discuss various workstreams	• Further funding availability for FCDO • Making contact to share information about Blue planet
07.11.2023	Petroleum Development Authority (PDA)	To provide an introduction to planned offshore wind development work and understand potential offshore oil and gas exploration zones, results obtained so far, and future plans to explore and monetize. The approval process for potential offshore wind sites.	• Supportive of Offshore wind development • Oil and gas exploration and offshore wind coexistence discussed • Agreed to share details on offshore oil and gas zones and geographic information upon submission of a letter through MoPE/SLSEA. • Main points of contact were developed.

Date	Name of the Stakeholder/ Organization	Objective of the meeting	Outcome
08.11.2023	Central Environmental Authority (CEA)	To introduce planned offshore wind development work and discuss the environment approval process related to offshore wind development and what the project approving organization will be.	• Mentioned the Strategic Environment Assessments • Mentioned the issue of onshore renewable projects permits requests and not delivering projects • A follow-up meeting will be held with officers to fully assess the approval process. • The point of contact at CEA for this study mentioned.
09.11.2023	National Aquatic Resources Agency (NARA)	To introduce planned offshore wind development work and discuss about information available with NARA and services available with them.	• Obtained a good understanding of the information available and what services NARA can provide for future offshore wind development. • Mentioned the importance of fisheries sector • Information and studies available with NARA will be listed later. • Discussed idea to combine future NARA surveys with required studies for offshore wind development. • Main points of contact were developed.
09.11.2023	Sri Lanka Ports Authority (SLPA)	To introduce planned offshore wind development work and discuss the operational limitations and availability of the ports in Sri Lanka. To explain the specifics of offshore wind equipment delivery and servicing needs.	• Discussed about capacities of ports in Sri Lanka and the limitations associated with them. • Mentioned the possibility of developing a port in Mannar in two years which can be used for operations • Main points of contact were developed.
10.11.2023	National Physical Planning Department (NPPD)	To discuss the role of NPPD in the context of offshore and onshore wind infrastructure.	• NPPD provided the draft national physical plan. • Mentioned about preparation of a detailed plan for Northwestern province which will include the offshore wind in Puttalam • Main points of contact were developed.
10.11.2023	Ceylon Electricity Board (CEB)	To discuss the updated transmission plan of CEB. To discuss any indicative	• RMA will work directly with CEB to analyze grid interconnection options. • CEB will share the network data files for modelling.

Date	Name of the Stakeholder/ Organization	Objective of the meeting	Outcome
		developments in the coastal areas of Mannar and Puttalam.	• Main points of contact were developed.

7.4.2 Workshops for national and regional stakeholders

After the inception mission, RMA Energy continued discussions with the executing agency, MoPE. In January 2024, an introductory letter was sent by the ministry to District Secretary Mannar, District Secretary Puttalam, coastal Divisional Secretaries of Mannar and Puttalam districts and 17 identified government organizations to request their assistance for future activities. Capacity building workshops were arranged for regional and national stakeholder organizations. This series of workshops were held between 26 February and 5 March. The various workshops will be explained in more detail below.

Regional Workshops

Two regional workshops were planned in the potential offshore wind areas, Mannar and Puttalam. The district secretariat offices in respective districts were selected as the location to have regional workshops and discussions were initiated with relevant district secretaries from December 2023. A letter was sent to district secretaries by Ministry of Power and Energy officially requesting their support for the workshops.

The participants for the regional workshops were identified early through contacting relevant stakeholder organizations. Same as district secretaries, divisional secretaries also play an important role in handling administrative, social and environment issues in the division. Therefore, identified divisional secretaries in coastal divisions were invited to the workshop. The participants from regional level offices of respective regulatory and partner organizations were also invited.
The organizers selected participants with special care to include participants with required subject knowledge and experience working in the district, who can contribute to the workshop actively. Participation of women was promoted and encouraged (further explained in section Cultural Inclusivity and Gender below). Personal invitations were sent to relevant participants through MoPE. In addition to the government organizations, participants from academia were also invited in order to have a fruitful discussion. After sending invitation letters, the attendance of participants to the workshop was confirmed through several rounds of follow up calls.

With regard to the agenda, both regional workshops were inaugurated by respective District Secretaries with a welcome speech and each workshop included four presentations. The first presentation by WB provided introduction to the offshore wind program activities in Sri Lanka including the Roadmap. The second presentation was on offshore wind energy development, construction and impact in a global context followed by a third presentation on scope of works of the current study presented by Pondera. The final presentation by RMA Energy included stakeholder engagement with necessary approvals for environment and social safeguards. These presentations included videos, maps and pictures making the audience to understand the concept of offshore wind energy development. Furthermore, translations were provided in Tamil language in the Mannar workshop and in Sinhala language in the Puttalam workshop. Participants were encouraged to ask questions in the language they prefer and relevant translations were provided by the organizers.

Both the Mannar and the Puttalam workshops are described in more detail below.

Mannar Workshop

Mannar workshop was successfully held on 27th February 2024 at the Mannar District Secretariat. The workshop was chaired by District Secretary Mannar and Director General of SLSEA. A total of 37 participants from different stakeholder organizations attended the workshop. Participants from University of Jaffna also attended the workshop.

A template invitation letter including the agenda, participant list, detailed Q&A session, and selected captured moments are attached in Appendix C. A brief summary of the outcome of the workshop is provided in the next paragraph.

The topics discussed during the Q&A session were mainly two-fold. The first aspect pertained to the questions and clarifications on technical and environment safeguards about offshore wind energy development that were addressed by the WB and Pondera, drawing international experiences to local context. The second aspect involved addressing the environmental and social concerns raised by the fishing community, with the knowledge sharing of both the study team as well as the academics. In addition, the benefits to local communities and the need for identification of skill gaps of young people for capacity building on technical aspects of renewable energy projects were discussed in detail. Finally, all participants agreed the need for continuous awareness and consultation presenting scientific evidence for the community to make them understand the real potential impacts and possible mitigation measures in wind energy development in the project area.

Puttalam Workshop

The Puttalam workshop was held on 29th of February 2024 at the Puttalam District Secretariat Office. This workshop was chaired by District Secretary Puttalam and Director General of Sri Lanka Sustainable Energy Authority. The total number of participants attended the workshop was recorded as 32.

A template invitation letter including the agenda, participant list, detailed Q&A session, and selected captured moments are attached in Appendix C. A brief summary of the outcome of the workshop is provided in the next paragraph.

The discussion at Puttalam workshop highlighted the importance of the Kalpitiya area with regard to tourism activities and environmental resources. Navy officers highlighted the issue of poaching happening in the area as a major concern. Further, the requirement of getting approvals from local authority and Urban Development Authority for any onshore developments in Kalpitiya area was pointed out. The representatives from regulatory agencies such as Coast Conservation and Department of Archaeology highlighted the need for getting necessary approvals for the project. In addition, information on fishing harbours in the project area and Airforce activities taking place in the project area was shared by the participants.

National Workshops

Two Colombo workshops were organized for regulatory organizations and partner organizations for offshore wind development. The Colombo workshops were held at BMICH as it is convenient for the stakeholders to locate and attend.

The participants for the Colombo workshops mainly included higher management officials of respective stakeholder organizations. The participants were selected with special care. Prior to sending invitations, organizers contacted respective stakeholder organizations and inquired about most relevant divisions and officials for the study. Then, personal invitations were sent to relevant stakeholders through MoPE. Participation of women was promoted and encouraged (further explained in section Cultural Inclusivity and Gender below). Participants from University of Sri Jayewardenepura, University of Moratuwa, University of Peradeniya and University of Ruhuna were also invited for the workshops. After sending invitation letters, the attendance of participants to the workshop was confirmed through several rounds of follow up calls.

The Colombo workshops had the same four presentations as the regional workshops. In addition, a presentation on grid interconnection and approvals, permits and agreements for renewable energy projects by RMA Energy was added to both workshops. The workshop for regulatory organizations had an additional presentation on legal and regulatory considerations for the development of offshore wind in Sri Lanka by Tiruchelvam Associates.

Both workshops, for regulatory organizations and partner organizations, are described in more detail below.

Workshop for Regulatory Organizations

The workshop for regulatory organizations was held on 4th March 2024 at BMICH. The welcome speech for the workshop was given by the Secretary Ministry of Power and Energy. A total of 42 participants attended the workshop. The participants from University of Sri Jayewardenepura also attended the workshop.

A template invitation letter including the agenda, participant list, detailed Q&A session, and selected captured moments are attached in Appendix C. A brief summary of the outcome of the workshop is provided in the next paragraph.

The Q&A session included various questions and clarifications. The main questions were raised on the areas of private investments, environment and social impacts, issue of poaching, cost for logistical infrastructure, levy for windmills, marine conditions etc. Participants also shared information on their expertise areas.

Workshop for Partner Organizations

The workshop for the partner organizations was held on 5th March 2024 at BMICH. The workshop was inaugurated by Chairman of SLSEA. Around 33 participants attended the workshop. Participants from University of Moratuwa, University of Peradeniya and University of Ruhuna attended the workshop representing the academia.

A template invitation letter including the agenda, participant list, detailed Q&A session, and selected captured moments are attached in Appendix C. A brief summary of the outcome of the workshop is provided in the next paragraph.

The discussion mainly consisted of clarifications and international experience sharing. The questions raised were on the areas of environment issues, managing prioritizing the project with oil and gas exploration, business model for the project etc. The information on underwater cultural heritage, marine ecology, ways of managing social impacts, providing alternative livelihoods for fishing community was shared by participants.

Cultural Inclusivity and Gender

In Mannar district, 80.4% of the population is Tamil and 16.5% comprise of Moor (DCS, 2012). The main language used in the district is Tamil. In contrast, in Puttalam district, 79.7% of the population is Sinhalese and 14.6% of the population is Moor while there is 5.1% of Tamil population (DCS, 2012). The predominant language used in the district is Sinhala. The regional workshops arranged in Mannar and Puttalam included participants from all ethnicities. Considering this cultural diversity, organizers took special measures to provide translations of presentations in Tamil language in Mannar workshop and Sinhala language in Puttalam workshop.

With regard to gender, workshop organizers identified the low representation of females in all four workshops early as the higher management positions in the country are mainly held by men. During the planning phase there were only 2 female officers expected in the Mannar workshop and around 5-6 officers expected in the Puttalam and Colombo workshops. Therefore, a decision was taken to invite the second level of officials and selected females in higher management positions to participate in the workshops and personal invitations were sent to identified female participants. The female representation target was set as 20 – 25 percent. The actual share of females in the workshops varied between 26 and 41% (see Table 74). Moreover, the female contribution to the discussion was especially noticed in Puttalam and Colombo workshops.

Table 74 Representation of females in the first series of workshops

Workshop	Participants		Total	% of Females	Study Team		Total	% of Females
	Male	Female			Male	Female		
Mannar Workshop	26	11	37	30	6	1	7	14
Puttalam Workshop	19	13	32	41	7	1	8	13
Workshop for Regulatory Organizations	31	11	42	26	11	4	15	27
Workshop for Partner Organizations	23	10	33	30	9	2	11	18

7.4.3 Parties met during site visits

Table 75 provides information about the stakeholders visited during the project team visit to Sri Lanka in February and March 2024.

Table 75 Stakeholder organizations visited during project team visit to Sri Lanka in Feb/Mar 2024

Date	Name of the Stakeholder/ Organization	Objective of the meeting	Outcome
21.02.2024	NARA	Obtain data for constraint assessment	• NARA will share information about various constraint items to the project team.
26.02.2024	Mannar onshore wind project	Get presentation and tour on site	• Got a presentation about the project history and operation. Special attention was given to the bird radar. A tour on site showed the storage area for spare compartments and the wind turbines.
28.02.2024	Mannar Navy	Visit various naval facilities	• Visited the Thalaimannar Pier This is an old pier; a ferry service began operations in 1914 as a joint effort between the Sri Lankan and Indian governments. Thalaimannar railway station, a Naval base and the light house are located here. • Visited the Thalvupadu Naval Deployment The jetty managed by Sri Lanka Navy deploy the offshore patrol vessels in the high seas to carry out surveillance on a wide area of maritime activities.
01.03.2024	Coal Fired Power Plant	Get presentation and tour on site	• Got a presentation about the coal fired power plant. Visited several on site facilities, including the coal jetty and a smaller jetty located to the south.
04.03.2024	Petroleum Development Authority (PDA)	Obtain data/information for assessments	• Information on seabed composition in Mannar and Puttalam areas was gathered to take decision on foundations. • Historical data of PDA was also obtained.

04.03.2024	Sri Lanka Navy	Obtain data/information for assessments	• Agreed to provide data on unexploded ordnances, shipwrecks etc. and extended their support for survey activities of Mannar and Puttalam marine areas after receiving a formal request through Ministry of Defence.

7.4.1 Online meeting with environment and social Non-Government Organisations

An online meeting was arranged on 13th of June 2024 with relevant environment and social non-governmental Organizations (NGOs) to inform them about the pre-feasibility, to get their feedback and also to obtain relevant data for the analyses. Out of the eight NGOs invited, participants from the following six NGOs attended the meeting:

1. Ceylon Bird Club;
2. Wildlife and Nature Protection Society;
3. Environmental Foundation (Guarantee) Limited;
4. Centre for Environmental Justice;
5. Federation of Environmental Organizations;
6. Sarvodaya Shramadana Movement.

The participants of the online meeting were welcomed by the Director of SLSEA. The meeting was then followed by three presentations, starting from WB explaining the ongoing support to Sri Lanka for offshore wind development and then Pondera presenting the ongoing study. Final presentation was done by RMA Energy on stakeholder engagements.

A template invitation letter including the agenda, participant list and detailed Q and A session are attached in Appendix C. A brief summary of the outcome of the meeting is provided in the next paragraph.

During Q & A session, participants highlighted the importance of Mannar area for birds as there is the Central Asian Flyway and mentioned their concerns for the project due to this. The non-availability of sufficient data was highlighted and participants requested to do detailed studies in advance before moving to project phase. Further, participants agreed to share available data/information with the study team and extended their support in shaping Phase 3 TA.

7.4.2 Final Stakeholder Engagement Activities

Disclosure of draft report findings
Concluding workshop for official stakeholders (the same group of participants who attended the workshop held in February/March 2024) were held in same locations in March 2025 to disclose the draft report. The NGOs that attended the online meeting were also invited to the Colombo workshop. The workshops mainly focused on presenting a summary of the chapters of the draft report & feedback/discussion of participants was recorded. Table 76 shows the representation of females in the last series of workshops.

Table 76 Representation of females in the last series of workshops

Workshop	Participants		Total	% of Females	Study Team		Total	% of Females
	Male	Female			Male	Female		
Mannar Workshop	25	11	36	31	4	3	7	43
Puttalam Workshop	20	13	33	39	6	3	9	33
Workshop for Regulatory Organizations	44	18	62	29	9	6	15	40

The invitation letter including the agenda, participant list, detailed Q&A, and selected captured moments of the final workshops in Mannar, Puttalam and Colombo are attached in Appendix C.

8 List of Abbreviations

OWP – Offshore Wind Power
CEB – Ceylon Electricity Board
SLSEA – Sri Lanka Sustainable Energy Authority
IPP – Independent Power Producer
PPA – Power Purchase Agreement
PUCSL – Public Utilities Commission of Sri Lanka
MoPE – Ministry of Power and Energy
FiT – Feed-in Tariff
LCoE – Levelized Cost of Energy
DEVEX – Development Expenditure
FIMOI – Financial Modelling for Offshore Investments
O&M – Operations and Maintenance
SOV – Service Operation Vessel
CTV – Crew Transfer Vessel
GEBCO – General Bathymetric Chart of the Oceans
ESIA – Environmental and Social Impact Assessment
MPA – Marine Protected Area
IMMA – Important Marine Mammal Area
EBSA – Ecologically or Biologically Significant Area
ISRA – Important Shark and Ray Area
CfD – Contract for Difference
IFI – International Financial Institution
PRG – Partial Risk Guarantee
PRI – Political Risk Insurance
MIGA – Multilateral Investment Guarantee Agency
RSF – Risk-Sharing Facility
ADB – Asian Development Bank
NTSO – National Transmission System Operator

APPENDIX A – POWER FLOW ANALYSES CONDUCTED TO SELECT GRID CONNECTION ARRANGEMENT OF OFFSHORE WIND FARMS

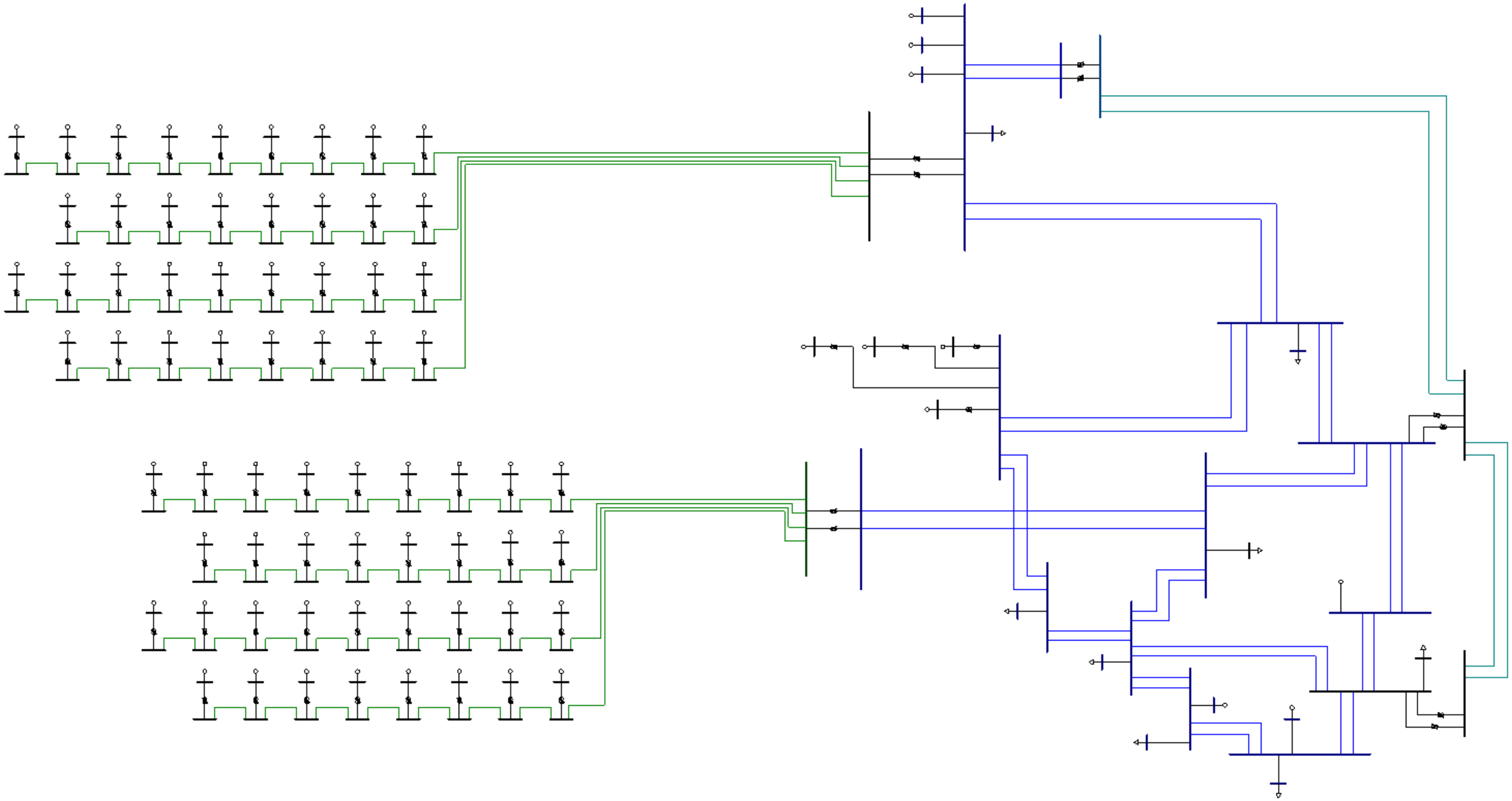


Figure A.1: Network Model used for the Power Flow Analyses

A1. Grid Interconnection of Puttalam Offshore Wind Farm

A1.1. Puttalam Offshore Wind Farm Connected with Wariyapola Grid Substation

Grid Substation	Voltage (kV)	Generation MW	Generation MVar	Load MW	Load MVar
Puttalam PS	220	1385	+213.11	-	-
New Chilaw	220	-	-	250	120
Veyangoda	220	-	-	700	320
Kotugoda	220	300	+739.53	900	440
Biyagama	220	400	+649.23	1,000	500
Kirindiwela	220	-	-	150	80
Kotmale	220	850	-55.69	-	-
New Habarana	220	-	-	-	-
Wariyapola	220	-	+234.48	-	-
New Anuradhapura	220	-	-	200	150
Mannar	220	520	-119.2	70	60
HVDC SS	220	-	-	-	-
Total		**3,455**	**+1,661.46**	**3,270**	**+1,670**

Load Flow Study Results

		Onshore SS - Wariyapola	Wariyapola – New Habarana	Wariyapola – Veyangoda	Puttalam – New Chilaw	New Chilaw - Veyangoda	Veyangoda – Kotugoda	Kotugoda – Biyagama	Biyagama – Kirindiwela
Maximum Power (MVA)		666	966	966	828	594	571	342	609
Maximum Current (A)		1,750	2,535	2,175	2,175	1,560	1,500	900	1,600
Normal Operation	Loading (%)	38	4	30	40	35	57	5	53
	Voltage	ok	ok	ok	ok	ok	ok	ok	ok
Operation under (N-1) Contingency	Loading (%)	38	9	35	44	41	52	26	65
	Voltage	ok	ok	ok	ok	ok	ok	ok	ok

A1.2. Puttalam Offshore Wind Farm Connected with Norochcholai Power Station

Grid Substation	Voltage	Generation		Load	
	(kV)	MW	MVar	MW	MVar
Puttalam PS	220	1385	+441.96	-	-
New Chilaw	220	-	-	250	120
Veyangoda	220	-	-	700	320
Kotugoda	220	300	+830.28	900	440
Biyagama	220	400	+685.25	1,000	500
Kirindiwela	220	-	-	150	80
Kotmale	220	850	-21.11	-	-
New Habarana	220	-	-	-	-
Wariyapola	220	-	-	-	-
New Anuradhapura	220	-	-	200	150
Mannar	220	520	-65.79	70	60
HVDC SS	220	-	-	-	-
Total		**3,455**	**+1,870.59**	**3,270**	**+1,670**

Loading levels based on CEB Long Term Transmission Development Plan 2018-2027

Load Flow Study Results

		Onshore - Puttalam PS	Puttalam PS - New Anuradhapura	Puttalam - New Chilaw	New Chilaw - Veyangoda	Veyangoda - Kotugoda	Kotugoda - Biyagama	Biyagama - Kirindiwela	Kirindiwela - Kotmale
Maximum Power (MVA)		666	571	828	594	571	342	609	609
Maximum Current (A)		1,750	1,500	2,175	1,560	1,500	900	1,600	1,600
Normal Operation	Loading	38	37	60	60	6	55	59	38
	Voltage	ok	ok	ok	ok	ok	ok	ok	ok
Operation under (N-1) Contingency	Loading	38	45	53	105	59	8	57	61
	Voltage	ok	ok	ok	ok	ok	ok	ok	ok

A1.3. Puttalam Offshore Wind Farm Connected between Norochcholai Power Station and New Chilaw Grid Substation

Grid Substation	Voltage (kV)	Generation		Load	
		MW	MVar	MW	MVar
Onshore SS	220	510	+255.91	-	-
Puttalam PS	220	875	+190.17	-	-
New Chilaw	220	-	-	250	120
Veyangoda	220	-	-	700	320
Kotugoda	220	300	+792.79	900	440
Biyagama	220	400	+669.27	1000	500
Kirindiwela	220	-	-	150	80
Kotmale	220	850	-35.10	-	-
New Habarana	220	-	-	-	-
Wariyapola	220	-	-	-	-
New Anuradhapura	220	-	-	200	150
Mannar	220	520	-84.28	70	60
HVDC SS	220	-	-	-	-
Total		**3,455**	**+1,788.76**	**3,270**	**+1,670**

Loading levels based on CEB Long Term Transmission Development Plan 2018-2027

Load Flow Study Results

Line		Onshore SS – Puttalam PS	Onshore SS – New Chilaw SS	Puttalam PS - New Anuradhapura	New Chilaw - Veyangoda	Veyangoda - Kotugoda	Kotugoda - Biyagama	Biyagama - Kirindiwela	Kirindiwela - Kotmale
Maximum Power (MVA)		828	828	571	594	571	342	609	609
Maximum Current (A)		2,175	2,175	1,500	1,560	1,500	900	1,600	1,600
Normal Operation	Loading (%)	39	77	31	66	59	4	54	57
	Voltage	ok	ok	ok	ok	ok	ok	ok	ok
Operation under (N-1) Contingency	Loading (%)	32	**142**	39	59	60	7	55	59
	Voltage	ok	ok	ok	ok	ok	ok	ok	ok

A2. Grid Interconnection of Mannar Offshore Wind Farm

A2.1. Mannar Offshore Wind Farm Connected with Mannar Grid Substation

Grid Substation	Voltage (kV)	Generation		Load	
		MW	MVar	MW	MVar
Puttalam PS	220	875	240.21	-	-
New Chilaw	220	-	-	200	120
Veyangoda	220	-	-	700	300
Kotugoda	220	300	806.22	900	420
Biyagama	220	400	696.22	1,000	500
Kirindiwela	220	-	-	150	80
Kotmale	220	850	-5.63	-	-
New Habarana	220	-	-	-	-
Wariyapola	220	-	-	50	40
New Anuradhapura	220	-	-	200	150
Mannar	220	1,030	10.43	70	60
HVDC SS	220	-	-	-	-
Total		**3,455**	**+1,747.45**	**3,270**	**+1,670**

Loading levels based on CEB Long Term Transmission Development Plan 2018-2027

Load Flow Study Results

Line		Mannar – HVDC SS	Mannar -New Anuradhapura	New Anuradhapura – New Habarana	New Chilaw - Veyangoda	Veyangoda – Kotugoda	Kotugoda – Biyagama	Biyagama – Kirindiwela	Kirindiwela - Kotmale
Maximum Power (MVA)		666	465	365	594	571	342	609	609
Maximum Current (A)		1,750	1,220	960	1,560	1,500	900	1,600	1,600
Normal Operation	Loading (%)	53	28	30	45	57	11	58	60
	Voltage	ok	ok	ok	ok	ok	ok	ok	ok
Operation under (N-1) Contingency	Loading (%)	**104**	29	31	45	57	11	58	60
	Voltage	ok	ok	ok	ok	ok	ok	ok	ok

A3 Puttalam and Mannar Offshore Wind Farms Operating Together

Grid Substation	Voltage (kV)	Generation		Load	
		MW	MVar	MW	MVar
Puttalam PS	220	875	245.16	-	-
New Chilaw	220	-	-	250	150
Veyangoda	220	-	-	800	350
Kotugoda	220	300	876.12	900	500
Biyagama	220	400	762.92	1,100	550
Kirindiwela	220	-	-	200	100
Kotmale	220	850	-4.21	-	-
New Habarana	220	-	-	-	-
Wariyapola	220	510	241.26	100	-
New Anuradhapura	220	-	-	200	150
Mannar	220	1,030	-19.40	88	50
HVDC SS	220	-	-	-	-
Total		**3,965**	**+2,101.9**	**3,638**	**1,850**

Loading levels based on CEB Long Term Transmission Development Plan 2018-2027

Load Flow Study Results

		Mannar – HVDC SS	Mannar – New Anuradhapura	New Anuradhapura –	Onshore SS - Wariyapola	Wariyapola - Veyangoda	Puttalam – New Chilaw	New Chilaw - Veyangoda	Veyangoda - Kotugoda	Kotugoda - Biyagama	Biyagama - Kirindiwela	Kirindiwela - Kotmale
Maximum Power (MVA)		666	465	365	666	966	828	594	571	342	609	609
Maximum Current (A)		1,750	1,220	960	1,750	2,175	2,175	1,560	1,500	900	1,600	1,600
Normal Operation	Loading	52	27	28	38	30	45	42	62	1	61	54
	Voltage	ok	ok	ok	ok	ok	ok	ok	ok	ok	ok	ok
Operation under (N-1) Contingency	Loading	52	27	28	39	39	45	42	**128**	6	**114**	54
	Voltage	ok	ok	ok	ok	ok	ok	ok	ok	ok	ok	ok

APPENDIX B – RACI MATRIX

RACI Matrix

Responsible	Stakeholders who are responsible for the identified tasks
Approval	Stakeholders who need to approve identified tasks
Consulted	Stakeholders who need to be consulted for identified tasks
Informed	Stakeholders who need to be informed about identified tasks

Consultancy Team: 0 Ramboll Team. National Level Stakeholders: 1 Ministry of Power and Energy; 2 Sri Lanka Sustainable Energy Authority (SLSEA); 3 Ceylon Electricity Board (CEB); 4 Petroleum Development Authority of Sri Lanka (PDA); 5 Public Utilities Commission of Sri Lanka (PUCSL); 6 Department of Coast Conservation and Coastal Resource Management; 7 Marine Environment Protection Authority (MEPA); 8 Central Environmental Authority (CEA); 9 Geological Survey and Mines Bureau (GSMB); 10 Department of Archaeology (Marine Archaeology Unit); 11 Central Cultural Fund; 12 Ministry of Environment; 13 Department of Wildlife Conservation; 14 Ministry of Fisheries and Aquatic Resources; 15 Department of Fisheries and Aquatic Resources; 16 Ceylon Fishery Harbour Corporation; 17 Ministry of Ports and Shipping; 18 Sri Lanka Ports Authority; 19 Merchant Shipping Secretariat; 20 Sri Lanka Tourism Development Authority; 21 Ministry of Tourism; 22 Ministry of Defence; 23 Sri Lanka Air Force; 24 Sri Lanka Navy; 25 Sri Lanka Army; 26 Sri Lanka Coast Guard (SLCG); 27 Department of National Physical Planning; 28 Civil Aviation Authority of Sri Lanka; 29 Telecommunications Regulatory Commission of Sri Lanka; 30 Sri Lanka Telecom; 31 Department of Meteorology; 32 National Building Research Organisation (NBRO); 33 [illegible]; 34 National Aquatic Resources Research and Development Agency (NARA); 35 SL Hydraulic Institute; 36 Academic Institutes (Universities in SL). Regional Level Stakeholders: R1 District Secretariats - Puttalam/Mannar; R2 Divisional Secretariats of Puttalam/Mannar Districts; R3 Pradeshiya Sabha / Local Authorities - Puttalam/Mannar; R4 Non-governmental organizations working for environment and social safeguards.

Tasks	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	R1	R2	R3	R4
Task 1: Constraints Assessment																																									
1. Assess and confirm the presence and location of all exclusion areas, 2. Assess restriction areas, identify environment and social data evidence gaps, 3. An indicative scope of work identifying key areas of bio diversity and social analysis	R	A	A	C	C	I	A	A	A	A	A	I	A	A	C	C	C	C	C	I	C	C	C	C	C	I	C	C	C	C	C	C	I	C	C	I	I	C	C	C	C
Task 2: Project Concepts																																									
1. Study fixed bottom offshore wind areas (Mannar and Puttalam)	R	A	A	C	C	I	C	C	C	C	C	I	C	C	C	C	C	C	C	I	C	C	C	C	C	I	C	C	C	C	C	C	I	C	C	I	I	C	C	C	C
2. Identify limitations or uncertainties based on data gaps	R	A	A	C	C	I	C	C	C	C	C	I	C	C	C	C	C	C	C	I	C	C	C	C	C	I	C	C	C	C	C	C	I	C	C	I	I	C	C	C	C
3. Characterise feasible options for wind farm capacity, foundation type, preliminary layouts, yields, cost estimates, export cable routes to onshore grid connections	R	A	A	C	C	I	C	C	C	C	C	I	C	C	C	C	C	C	C	I	C	C	C	C	C	I	C	C	C	C	C	C	I	C	C	I	I	C	C	C	C
4. Characterise and select the best sites within higher potential areas, export cable and onshore infrastructure	R	A	A	C	C	I	A	C	A	A	A	I	A	A	C	C	C	C	C	I	C	C	C	C	C	I	C	C	C	C	C	C	I	C	C	I	I	C	C	C	C
Task 3: Port Appraisal																																									
1. Deep study on port infrastructure of Sri Lanka, 2. Study interaction with Indian offshore wind market, 3. Study wider socio economic risks and benefits of port development	R	A	A	I	I	I	I	I	I	I	I	I	I	I	I	I	I	C	C	I	C	C	C	C	C	I	C	C	C	C	C	C	I	C	C	I	I	C	C	C	C
Task 4: Onshore Infrastructure																																									
1. Review of infrastructure needs and design options for exporting power from Mannar and Puttalam areas, 2. Consider optimised onshore infrastructure options for potential interconnector with India	R	A	A	A	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I
Task 5: Commercial risk and bankability																																									
1. Undertake detailed work to estimate development costs, capital expenditure, operation expenditure, relevant for procuring turbines and balance of plant in SL, 2. Review and assess Sri Lanka specific and project specific commercial risks, 3. Comment on lender E&S safeguard/performance requirement, 4. Produce an overview of financial support mechanisms considered necessary to establish developer interest/a viable market, based on the economic analysis	R	A	A	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I
Task 6: Stakeholder Engagement and Capacity Building																																									
Prepare Stakeholder Engagement Plan (SEP), have one on one discussions with identified key stakeholders, arrange national and regional workshops to assess stakeholders & disclosure of draft report to all identified stakeholders.	R	A	C	C	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	C	I	I	I

APPENDIX C – ADDITIONAL INFORMATION FROM STAKEHOLDER SESSIONS

Appendix C1: Stakeholder Workshop Mannar (Feb 27th, 2024) – Invitation Letter/ Agenda, Attendance Sheet, Q&A, Photos

Ministry of Power and Energy
Offshore Wind Power Technical Assistance Phase II: Pre-feasibility Assessment
Stakeholder Workshop

Date : Tuesday, 27 February 2024
Time : 9:30 am to 12:45 pm
Venue : District Secretary's Office, Mannar.
Chaired by: District Secretary, Mannar

The Background: The government has received technical assistance from the World Bank to conduct preliminary studies toward developing offshore wind power. A road map of activities was prepared in 2023, and presently, pre-feasibility studies are being conducted. Mannar and Puttalam are two locations where offshore wind power possibilities are good.

The Workshop: Study, design, construction, and operation of offshore wind power plants requires careful consideration of oceanography, marine biology and several other stakeholder interests both onshore and offshore. Power transfer would require laying submarine cables, new onshore substations, and transmission lines. Government officials would be called upon to review different types of designs and studies, and to monitor implementation social and environmental safeguards regulations and best practices. The objective of the workshop is to explain to officials about the process of designing, building and operating an offshore wind park. At the workshop, officials from The World Bank, and their consultants Pondera of the Netherlands and RMA of Sri Lanka, will explain the planning process and their experience with such projects actually implemented in other countries.

Agenda

9.30 – 10.00	Registration of participants and tea
10.00 – 10.15	Speech by the District Secretary
10.15 – 10.45	Presentation by the World Bank on the Sri Lanka Off-shore Wind Roadmap
10.45 – 11.15	Presentation by Pondera on offshore wind development in other countries (including several videos)
11.15 – 11.30	Presentation by Pondera on the current study and the approach and methodology
11.30 – 11.45	Presentation by RMA on approvals and clearances anticipated
11.45 – 12.45	Stakeholder feedback session

Tea and lunch will be provided.

"This attendance list together with your contact details will be included in the pre-feasibility study report. The World Bank may contact you during subsequent studies related to offshore wind power development in Sri Lanka."

Offshore Wind Power Technical Assistance Development Phase II: Pre-feasibility Assessment Stakeholder Workshop – Mannar, 27th February 2024

Attendance Sheet

	Stakeholder Agency	Reg. No	Name	Contact	Email	Signature
1	District Secretary - Mannar	1	Mr. K. Kanekeshwaran District Secretary Mannar District Secretariat	077 239 5900 023 2222235 023 2222232		
		2	Mr. H Haleemden ~~Deputy~~ Director Planning Mannar District Secretariat	077 5005330 074 0625430 070 385 4054	hhdeen1974@gmail.com	
		3	Mrs. Premaranjani Assistant Director Planning Nanattan	077 017 2115 023 2050672	ranjiniranjini1967@gmail.com	
2	Divisional Secretaries of Coastal DSDs					
	1 Manthai West DSD	4	Mr. D.C. Aravintharaj Divisional Secretariat	023 205 0862 077 224 9825		
		5	Ms. N. Emalda Jojini Development Officer	023 205 0862		
		6	Ms. M. Calista Shiromi Development Officer	023 205 0862		
	2 Mannar Town DSD	7	Mr. M. Piratheep Divisional Secretariat	023 222 2012	dsmannartn@gmail.com	
		8	Ms. T. Thivakary Assistant Director of Planning	076 195 2519	tthiva199220@gmail.com	
		9	Ms. S. S. M. Joseph Development Officer	077 744 1244	susanavijayanathan@gmail.com	

"This attendance list together with your contact details will be included in the pre-feasibility study report. The World Bank may contact you during subsequent studies related to offshore wind power development in Sri Lanka."

Offshore Wind Power Technical Assistance Development Phase II: Pre-feasibility Assessment Stakeholder Workshop – Mannar, 27th February 2024

Attendance Sheet

	Stakeholder Agency	Reg. No	Name	Contact	Email	Signature
3	Nanaddan DSD	10	Mrs K Sivasambu Divisional Secretariat	023 205 0673 023 205 1873 077 227 1069		[signature]
4	Musali DSD	11	Mr. S. Rajeev Divisional Secretariat Musali	077 798 5422	dsmusali@yahoo.com	[signature]
		12	Ms. N.G. Thiviya Soasai Woman Development Officer	077 323 7398	noyal1984@gmail.com	[signature]
		13	Ms. D. Densila Early Childhood Development Officer	770 879 699		[signature]
~~3~~	~~Sri Lannka Navy~~	~~14~~		~~011 719 2000~~		
4	Sri Lanka Air Force	15	Flt Lt Hitibandara	011 249 5495	afhq@airforce.lk chathura.hiti2@gmail.com	[signature]
5	Department of Fisheries and Aquatic Resources	16	Mr. V. Kalistan Assistant Director District Office Mannar.	023 222 2173		V. Kal[signature]

"This attendance list together with your contact details will be included in the pre-feasibility study report. The World Bank may contact you during subsequent studies related to offshore wind power development in Sri Lanka."

Offshore Wind Power Technical Assistance Development Phase II:
Pre-feasibility Assessment Stakeholder Workshop – Mannar, 27th February 2024

Attendance Sheet

	Stakeholder Agency	Reg. No	Name	Contact	Email	Signature
6	Central Environmental Authority	17	Mr. R. Mahesh Jaltota Director Northern Provincial Office Kilinochchi	021 787 7277 071 818 8658	rmjaltota@cea.lk rmjaltota@yahoo.com	[signature]
		18	Ms Mary Anterida Head, Mannar	0777485354	ceamdodeo@gmail.com	[signature]
7	Ceylon Electricity Board	19	Mrs Maithiliee Thayaparan CE, Wind PP	071 839 7115	maithiliee.thayaparan@ceb.lk	[signature]
		20	Mr Selvarajah Prabaharan DGM(NP)	077 297 9737	ksprabaharan66@gmail.com	[signature]
		21	Mr J A P Rajkumar EE(Vavuniya)	077 3657 074	Ajith.Rajkumar@ceb.lk	[signature]
8	**Secretaries of Local Authorities**					
	1 Mannar Urban Council	22	Mr Logeswaran Administrative officer	776235858		S. Logeswaran
	2 Mannar Pradeshiya Sabha	23	Mr ML Selvaraj Croos Secretary Mannar Pradeshiya Sabah Pesalai.	023 205 0002	jathusan@yahoo.com	[signature]
	3 Manthai West Pradeshiya Sabha	24	Mr Densil Fernando Secretary	023 205 1854	densil551@gmail.com	[signature]

"This attendance list together with your contact details will be included in the pre-feasibility study report. The World Bank may contact you during subsequent studies related to offshore wind power development in Sri Lanka."

Offshore Wind Power Technical Assistance Development Phase II: Pre-feasibility Assessment Stakeholder Workshop – Mannar, 27th February 2024

Attendance Sheet

	Stakeholder Agency	Reg. No	Name	Contact	Email	Signature
4	Musali Pradeshiya Sabha	25	Secretary MR. A. C. NAJEEB Musali Pradeshiya Sabah Silawathura.	023 205 1672		
5	Nanattan Pradeshiya Sabha	26	E Sahayanadan Crooze Chief-Management Services	077 143 2859	nanattanpsabha@gmail.com	
9	Department of Wildlife	27	Mr. W.M.C.K. Chandraratne Asst. Director Regional Wildlife office Madu	071 442 9618 077 060 2083	keerthi_chandraratne@yahoo.co.in. T.Jathavan (Ranger)	T.Jr.
10	Geological Survey and Mines Bureau	28	Mr RR Kulas Regional Mining Engineer District Secretariat Office Mannar	077 073 8472 023 225 0611	rohansharn05@gmail.com	
11	Department Archaeology	29	Mr. Chaminda Silva Regional Officer Mannar	071 727 5345		
12	Department of Coast Conservation	30	Mr. Joseph Daniel District Secretariat Mannar	077 840 5250	anujo1984@gmail.com	
13	Sri Lanka Sustainable Energy Authority	31	Mr JM Athula, DG	0715344167	athula@energy.gov.lk	

"This attendance list together with your contact details will be included in the pre-feasibility study report. The World Bank may contact you during subsequent studies related to offshore wind power development in Sri Lanka."

Offshore Wind Power Technical Assistance Development Phase II: Pre-feasibility Assessment Stakeholder Workshop – Mannar, 27th February 2024

Attendance Sheet

	Stakeholder Agency	Reg. No	Name	Contact	Email	Signature
14	University of Jaffna, Faculty of Technology	32	Prof. Arulampalam Atputharajah Department of Electrical and Electronic Engineering	077 737 9164	atpu@eng.jfn.ac.lk	
		33	Dr. Sivakumar Gowthaman Department of Engineering Technology	077 291 1120	gowtham@tech.jfn.ac.lk	
		34	Ms. Saikrisha Kaneswaran Department of Engineering Technology Faculty of Technology University of Jaffna	0715443243	saikrisha@tech.jfn.ac.lk	
15	Pondera Team	35	Joost Starmans	0031 62420 9385	J.starmans@pondera consult.com	
		36	Eric Arends	+31 6533721 30	e.arends@ponderaconsult.com	
16	World Bank	37	Chris Lloyd	+44 07739117670	clloyd@worldbank.org	
		38	Jari Vayrynen			
		39	Mark Leybourne			
	Stakeholder Agency	Number of Participants	Name	Contact	Email	Signature

"This attendance list together with your contact details will be included in the pre-feasibility study report. The World Bank may contact you during subsequent studies related to offshore wind power development in Sri Lanka."

Offshore Wind Power Technical Assistance Development Phase II:
Pre-feasibility Assessment Stakeholder Workshop – Mannar, 27th February 2024

Attendance Sheet

17	RMA Study team	40	Dr. Tilak Siyambalapitiya			
		41	Mr. Swetha Perera	0772253304	swetha@rmaenergy.lk	
		42	Prof. Singhakumara	0714439300	balangodasinghe@gmail.com	
		43	Mr. Jeyakumar Birannaa	0772885448	birannaa@rmaenergy.lk	
		44	Ms. Lakmali Liyanage	571-7703836	sepali12@yahoo.com	
03	Sri Lanka Navy	14	Mr. R.A.K. Dharmawikrama	0710930725	rammengamila@gmail.com	
			~~[illegible]~~.			
	Sri Lanka Navy	45	Mr. I.D.D. Nishanka	0763657762	nishanka2322@gmail.com	
		46	O. Prabaharan	0777188747	prabaharan@gmail.com	
	CEB	47	S. Gobinath	0701922382	gobinath.ceb@gmail.com	
	Sri Lanka Air Force	48	WO Kumara	0768942340	thushithakumara@gmail.com	
		49	Cpl Godamanne	0778499516	samanabandara20@gmail.com	

World Bank Technical Assistance for Sri Lanka: Offshore Wind Power Development Phase II

Detailed Q&A session in Mannar Regional Workshop

Date: 27.02.2024

Time: 10.00 a.m. – 1.00 p.m.

Stakeholder Agency/Group	Questions Raised	Responses Provided
Navy	What is the distance from the shore? The grid needs to be strengthened. Will the area be ban for fishing? And will the fishing activities will be affected? It is better to avoid heavy fishing areas. Can there be floating type?	Distance from shore is 15-30km Can't be floating type. There can be issues for fishing during construction period. Ground vibration at operation phase is low. Studies have been conducted in South Korea and Netherlands. Detailed feasibility studies will include necessary studies. The designs will be done considering to minimize livelihood impacts.
	What are the onshore activities of the project? It is important to get necessary approvals for the onshore activities.	There will be export cables, land filling, transformers for the connection to the grid. The necessary approvals will be taken for the onshore activities.
	Bird radar? Is it applied in western and other countries?	When large flocks appear, the turbine can be stopped. The migratory paths of birds will be studied.
Navy	Coastal surveillance. Will there be any disturbance to sealine communications?	The level of disturbance can be calculated. Have to look in to it closely in future studies.
Academics from University of Jaffna, District Secretary and Divisional Secretaries	What are the opportunities available for locals? There is lack of skilled labour. Majority of people engage in fishing. There need to be technical knowledge through technical colleges. Students study up to NVQ levels. Electrical, education courses need to be promoted in the project area. If the project comes in 8 years.	WB mentioned that skill training can be added to the scope of works. Training is needed and skill gaps need to be identified. DG SLSEA: Two days training program can be arranged for (young) people who have completed NVQ level 3 and 4 for solar installation. There need to be awareness program for the community on this as well.
	Do birds migrate at night time? Are there any studies?	
Divisional Secretary	In Mannar, there are already established wind power plants. There are onshore facilities needed for this	The land acquisition for onshore infrastructure will be low. When we have data for this, we can decide.

Stakeholder Agency/Group	Questions Raised	Responses Provided
	project as well. How much land is required for grid connection?	
Navy	There is poster outside saying “Say no to wind power”. It is important to educate regional people. This renewable energy project is important.	There will be continuous consultation on this project.
	Consultation is important. The community need to be aware with scientific evidence. This is a national level project. It is important to educate and aware the people.	There will be continuous consultation on this project.
Fisheries Officer	Thalpadu community mentioned that the fish catch has been reduced. People think there is an impact from onshore wind projects.	This issue has been raised earlier also. NARA did a report and according to them, fishing has increased. Fishermen need to be educated
	Does ongoing onshore activities have an impact on fishing?	A group of academics from University of Jaffna did a study on this. During construction period of the project, there is pile driving and there’s vibration. And the culverts in the area is blocked due to siltation. These activities have an impact on fishing. However, after construction activities, the there is no issue reported.
Divisional Secretary	For onshore projects, the land is a problem. Therefore, we need to convince the community on this project. There need to be field level awareness. Bird studies also need to be conducted.	There will be continuous consultation on this project.
Navy	The navigation charts are important. Therefore, navigations charts need to be updated.	This will be studied.
DGM - CEB	It is important that District Secretary give a media briefing. Otherwise, people misunderstand this meeting as there is ongoing protest to onshore wind power project.	Agreed.

Captured moments from Mannar Regional Workshop on 27th February 2024

Appendix C2: Stakeholder Workshop Puttalam (Feb 29th, 2024) – Invitation Letter/ Agenda, Attendance Sheet, Q&A, Photos

Ministry of Power and Energy
Offshore Wind Power Technical Assistance Phase II: Pre-feasibility Assessment
Stakeholder Workshop

Date: Thursday, 29 February 2024
Time: 9:30 am to 12:45 pm
Venue: District Secretary's Office, Puttalam.
Chaired by: District Secretary, Puttalam

The Background: The government has received technical assistance from the World Bank to conduct preliminary studies toward developing offshore wind power. A road map of activities was prepared in 2023, and presently, pre-feasibility studies are being conducted. Mannar and Puttalam are two locations where offshore wind power possibilities are good.

The Workshop: Study, design, construction, and operation of offshore wind power plants requires careful consideration of oceanography, marine biology and several other stakeholder interests both onshore and offshore. Power transfer would require laying submarine cables, new onshore substations, and transmission lines. Government officials would be called upon to review different types of designs and studies, and to monitor implementation social and environmental safeguards regulations and best practices. The objective of the workshop is to explain to officials about the process of designing, building and operating an offshore wind park. At the workshop, officials from The World Bank, and their consultants Pondera of the Netherlands and RMA of Sri Lanka, will explain the planning process and their experience with such projects actually implemented in other countries.

Agenda

9.30 – 10.00	Registration of participants
10.00 – 10.15	Speech by the District Secretary
10.15 – 10.45	Presentation by the World Bank on the Sri Lanka Off-shore Wind Roadmap
10.45 – 11.15	Presentation by Pondera on offshore wind development in other countries (including several videos)
11.15 – 11.30	Presentation by Pondera on the current study and the approach and methodology
11.30 – 11.45	Presentation by RMA on approvals and clearances anticipated
11.45 – 12.45	Stakeholder feedback session

Tea and lunch will be provided.

"This attendance list together with your contact details will be included in the pre-feasibility study report. The World Bank may contact you dur subsequent studies related to offshore wind power development in Sri Lanka."

Offshore Wind Power Technical Assistance Development Phase II: Pre-feasibility Assessment Stakeholder Workshop – Puttalam, 29th February 2024

Attendance Sheet

Stakeholder Agency	Reg No	Name	Contact	Email	Signature
District Secretary - Puttalam	1	Mr. H.M.S.P. Herath District Secretary District Secretariat Puttalam	032 2265335 032 2265235 (direct) 032 2265543	disputtalam@yahoo.com	
	2	Mr. N.H.S.K. Rathnayake Director Planning District Secretariat Puttalam	032 2265690	Sarath525@yahoo.com 0719766150 (whatsapp)	
Divisional Secretaries of Coastal DSDs					
1 Vanathavilluwa DSD	3	Mr. S.M.P. Nandasena Divisional Secretariat Vanathavilluwa (Handling Kalpitiya DSD as well)	032 493 4202 032 226 0274 032 226 0275 071 343 7548	milanga377@gmail.com	
	4	Mrs. A.D.M. Attanayake Assitant Director Planning Vanathavilluwa, (working as ADP at DS Puttalam)	071 5465403	aththanayakamadhu@gmail.com	
2 Puttalam DSD	5	Mr. S.P. Weerasekara ~~Assistant~~ Assistant Divisional Secretary (Covering up duties of DS) Divisional Secretariat Puttalam	0713913451 dsputtalam@gmail	dsputtalam@gmail	
4 Mundel DSD	6	Mr. M.S.B.W.T.M.S.B. Malvila Assistant Divisional Secretary	032 205 2271 071 930 4707 071 297 5400	saliyam93@gmail.com	

"This attendance list together with your contact details will be included in the pre-feasibility study report. The World Bank may contact you dur subsequent studies related to offshore wind power development in Sri Lanka."

Offshore Wind Power Technical Assistance Development Phase II:
Pre-feasibility Assessment Stakeholder Workshop – Puttalam, 29th February 2024

Attendance Sheet

	Stakeholder Agency	Reg No	Name	Contact	Email	Signature
5	Arachchikattuwa DSD	7	T. A. K. Chandrika ~~Mrs. E.A.D.M. Athukorala~~ (ADS) Divisional Secretariat Arachchikattuwa	077-9040384 (AD.S) 0322 259 709 032 225 9780 032 493 4343	chandrikayrt@gmail.com	
6	Chilaw DSD	8	Ms NRA Jayawickrama ~~(Acting DS)~~ ADS Divisional Secretariat Chilaw	032 222 2138 071 578 7990	nra.jaya@gmail.com	
7	Mahawewa DSD	9	Ms. M.A. Emasha H. Perera Additional Divisional Secretary Mahawewa	071 4279883	dsmahawewa@yahoo.com adsmahawewa@gmail.com	
		10	Ms. Vayomi Bhupa Jayalath Landuse planning Officer Divisional Secretariat Mahawewa	070 3240765	vayomijayalath@gmail.com	—
8	Nattandya DSD	11	Mrs. W.A.S.C.G. Janza, Divisional Secretariat Nattandiya	0716358945	cgjanza@gmail.com	
9	Wennapuwa DSD	12	Mrs. H.M. N. Herath Divisional Secretariat Wennapuwa	077 3901272	herathnadeeja@gmail.com	
		13	Assistant Divisional Secretary Divisional Secretariat Wennapuwa	703 590001	achinipushpa@gmail.com	
	Sri Lanka Navy	14	TCD Galgodella Commander	011 719 2000	chandrakumaradias1983@gmail.com	
		15	EMMBP Ekanayake Lieutenant Commander	076-3480808	nojitha.ekanayake@gmail.com	

"This attendance list together with your contact details will be included in the pre-feasibility study report. The World Bank may contact you dur subsequent studies related to offshore wind power development in Sri Lanka."

Offshore Wind Power Technical Assistance Development Phase II: Pre-feasibility Assessment Stakeholder Workshop – Puttalam, 29th February 2024

Attendance Sheet

Stakeholder Agency	Reg No	Name	Contact	Email	Signature
Sri Lanka Air Force	16	Wg Cdr Pavan Dharmapala	011 249 5495 032-2229235	afhq@airforce.lk	
Department of Fisheries and Aquatic Resources,	17	Mr. I.M.G.S. Chandranayake Assistant Director Puttalam	032 - 2265295	Sarath3622@gmail.com	
	18	Mr. S.P. Wickramarachchi Assistant Director Mahawewa.	077 401 7127 032 - 2054330	suminprabath@gmail.com	
Central Environmental Authority	19	Mr. K.P. Welikannage	037-7877277/ 78/79/80 Mobile 0718168337		
Ceylon Electricity Board	20	Mr Malraj Fernando, DGM	071 429 8901	malraj123.mf@gmail.com	
	21	Mr Ramal Amadoru, EE (commercial)	071 429 8908	Ramal.Amadoru@ceb.lk	
	22	Mr AMMD Arampath, CE	071 429 8844	mahindarampath@gmail.com	
Secretaries of Local Authorities					
1 Kalpitiya Pradeshiya Sabha	23	Mr. R.M. Ramanayake Kalpitiya Pradeshiya Sabah Kalpitiya	0777 365020	KalpitiyaPS@gmail.com	

"This attendance list together with your contact details will be included in the pre-feasibility study report. The World Bank may contact you dur subsequent studies related to offshore wind power development in Sri Lanka."

Offshore Wind Power Technical Assistance Development Phase II: Pre-feasibility Assessment Stakeholder Workshop – Puttalam, 29th February 2024

Attendance Sheet

	Stakeholder Agency	Reg No	Name	Contact	Email	Signature
2	Vanathavilluwa Pradeshiya Sabha	24	Secretary	032 56 77052 071 058 9337		
3	Puttalam Pradeshiya Sabha	25	Ms. Mangalika Senevirathne	076 7649303		
4	Wennapuwa Pradeshiya Sabha	26	Mr. Asela Gunarathna	031 225 5276 076 391 6015 (whatsapp no)	ranjanasela@ymail.com	
5	Chilaw Pradeshiya Sabha	27	R Pradeep Chandana	032 224 7675 WhatApp No 0717934328	pradeepchandana@1133@gmail.com chillaw[illegible]yahu.com	
6	Nattandya Pradeshiya Sabha	28	Mrs. W.A.S.D. Wasalaarahchi	032 225 4276	[illegible]@[illegible]gmail.com	
7	Arachchikattuwa Pradeshiya Sabha	29	Mrs. Shirani Abeysingha	032 225 9780	071-6007343 (Whatsapp).	
Sri Lanka Tourism Development Authority		30	Manoj Ratnayaka, SLTDA Resort Officer - Kalpitiya	076 766 6995	manojr@srilanka.travel	
Department of Wildlife		31	Mr. Eranda Gamage Asst. Director Regional Wildlife office-Puttalam	71 446 5420		

"This attendance list together with your contact details will be included in the pre-feasibility study report. The World Bank may contact you dur subsequent studies related to offshore wind power development in Sri Lanka."

Offshore Wind Power Technical Assistance Development Phase II:
Pre-feasibility Assessment Stakeholder Workshop – Puttalam, 29th February 2024

Attendance Sheet

Stakeholder Agency	Reg No	Name	Contact	Email	Signature
Geological Survey and Mines Bureau	32	Mr. Tharindu Warnasooriya Regional Mining Engineer Chilaw.	070 341 2505		
Department Archeology	33	Mr. Y. W. U. M. Ananda District Office Kurunegala	071 493 4056 037-222 0475	1. ~~[illegible]~~ Anandawithanage1970 @gmail 2. northpadunuwasnuwara @gmail.com.	[signature]
Department of Coast Conservation	34	Ms. Maduni Fernando Assistant Director Area Office Chilaw	076 277 6084 032 2224225	madunitharangaf@gmail.com.	[signature]
SLSEA	35	Mr JM Athula, Director General	0715344147	athula@energy.gov.lk	[signature]
Marine Env. Protection Authority	36	Ms HMP Samarasekara Chilaw	HO 011 255 4006 011 255 4373 Chilaw office: 032 22 22 865 071 140 6600	~~[illegible]~~ chomepa@gmail.com	[signature]
Pondera Team	37	Joost Starmans	0031629209385	j.starmans@ponderaconsult.com	[signature]
	38	Eric Arends	+31 653372130	e.arends@ponderacult.com	[signature]

"This attendance list together with your contact details will be included in the pre-feasibility study report. The World Bank may contact you dur subsequent studies related to offshore wind power development in Sri Lanka."

Offshore Wind Power Technical Assistance Development Phase II:
Pre-feasibility Assessment Stakeholder Workshop – Puttalam, 29th February 2024

Attendance Sheet

Stakeholder Agency	Reg No	Name	Contact	Email	Signature
World Bank	39	Chris Lloyd			
	40	Jari Vayrynen			
	41	Mark Leybourne			
RMA Study Team	42	Dr. Tilak Siyambalapitiya			[signature]
	43	Mr Sunith Fernando			[signature]
	44	Mr. Swetha Perera			[signature]
	45	Prof. BMP Singhakumar			[signature]
	46	Mr. Bhasara Sirisinghe			[signature]
	47	Ms. Lakmali Liyanage			[signature]
	48	Ms. S.P.T. Priyadarshani	070 5253457		[signature]
	49.	M.N.M.M. Fahmy	0711766717	mmfahmy@gmail.com	[signature]

World Bank Technical Assistance for Sri Lanka: Offshore Wind Power Development Phase II

Detailed Q&A session in Puttalam Regional Workshop

Date: 29.02.2024

Time: 10.00 a.m. – 1.00 p.m.

Stakeholder Agency/Group	Questions Raised	Responses Provided
Coast Conservation Department (CCD)	Around 2km of the sea comes under the purview of CCD. Therefore, the erosion and other impacts need to be considered and necessary approvals need to be taken.	The project will come in 8 years. The studies will be conducted. Necessary approvals will be taken. It is important to have baseline studies before the project.
Secretary, Kalpitiya Pradeshiya Sabah (PS) – Local Authority	Kalpitiya area is gazette as a tourist area. Onshore activities are planned by Urban Development Authority (UDA) and UDA need to be consulted for zoning activities. There is already established planning committee consisting PS and UDA to provide approvals.	The planned location in Puttalam is 5km away from the shore.
Planning Director, District Secretariat	This area is a marine mammal area. A special study needs to be carried out for tourism related activities.	This will be considered
Department of Fisheries and Aquatic Resources	There are 3 fishing harbors in the project area. 1) Chillaw 2) Wellamankara 3) Kalpitiya. Chillaw harbor will not be suitable as there are sand banks. Wellamankara harbor will be suitable and the depth is around 8m. The jetty at Norochcholai can serve for service vessels.	These locations will be studied.
Tourism Development Officer	There are coral reefs in Kalpitiya. Kalpitiya is a Tourism development zone gazette in 2007. This area is an environmentally sensitive area and military training also take place in the area. The main tourism activity is kite surfing and there are also camping sites. It is important to implement this project making tourism industry more attractive. Most of the tourist activities take place in the lagoon and close to the shore.	Kalpitiya coral reefs will not be affected. Tourist activities will be considered.

Stakeholder Agency/Group	Questions Raised	Responses Provided
Secretary, Kalpitiya Pradeshiya Sabah (PS) – Local Authority	Will the kite surfing activities be affected by the project?	There is no impact for kite surfing from the project.
Archeology Department	There is a feasibility study done on archeology sites focusing Kalpitiya Dutch fort. The proposed project area needs to be inspected. There can be archeologically important relics. It is important to contact the head office regarding Archeology Impact Assessments.	Necessary procedures will be followed.
Airforce - Palavi	There are helicopter operations, security operations and joint operations taking place in the area. Therefore, Airforce need to be informed about project plans early.	This will be considered.
Department of Fisheries and Aquatic Resources	The Fisheries Act No. 2 of 1996 lay out the legal framework for activities taking place in the sea. There is beach seine fishing and small scale and large scale fishing activities taking place in this area. It is important to inform fisheries community in the project area about the project. It is better to carry out consultations with fishing community through Department of Fisheries. There are fisheries societies in the project area and it is important to educate community leaders and connect with these societies. Also, engage with respective fisheries officers and the provisions of the act can also be used.	The suggestions are useful to the study.
Marine Environment Protection Authority (MEPA)	The permits have been issued for oil and gas exploration activities. It is important to connect with head office.	The necessary discussions are ongoing and there is also a legal advisor.
Secretary, Kalpitiya Pradeshiya Sabah (PS) – Local Authority	It is important to get necessary approvals for onshore activities from PS and UDA as mentioned earlier.	This will be considered.
Mr. Sunith from RMA team	The impacts of this type of new projects cannot be identified before the project. People visualize some impacts and its difficult to make them realize when there's lack of data. Therefore, I suggest government agencies to collect available baseline data. It will be important for the future.	
Ceylon Electricity Board (CEB)	It is important to identify how the power will be connect to the grid.	This will be presented in Colombo workshops.

Captured Moments from Puttalam Regional Workshop on 29th February 2024

Appendix C3: Stakeholder Workshop for Regulatory Agencies Colombo (March 4th,2024) – Invitation Letter/ Agenda, Attendance Sheet, Q&A, Photos

Ministry of Power and Energy
Offshore Wind Power Technical Assistance Phase II: Pre-feasibility Assessment
Stakeholder Workshop for Regulatory Agencies

Date : Monday, 4th March 2024
Time : 8:30 am to 1.00 pm
Venue : Orchid Room, BMICH, Colombo 7.

The Background: The government has received technical assistance from the World Bank to conduct preliminary studies toward developing offshore wind power. A road map of activities was prepared in 2023, and presently, pre-feasibility studies are being conducted. Mannar and Puttalam are two locations where offshore wind power possibilities are good.

The Workshop: Study, design, construction, and operation of offshore wind power plants requires careful consideration of oceanography, marine biology and several other stakeholder interests both onshore and offshore. Power transfer would require laying submarine cables, new onshore substations, and transmission lines. Government officials would be called upon to review different types of designs and studies, and to monitor implementation social and environmental safeguards regulations and best practices. The objective of the workshop is to explain to officials about the process of designing, building and operating an offshore wind park. At the workshop, officials from The World Bank, and their consultants Pondera of the Netherlands and RMA of Sri Lanka, will explain the planning process and their experience with such projects actually implemented in other countries. This workshop will also focus on the legal and regulatory procedures and relevant institutions.

Agenda

8.30 – 9.00	Registration of participants
9.00 – 9.15	Opening remarks and purpose of the workshop
9.15 – 9.45	Presentation by the World Bank on the Sri Lanka Off-shore Wind Roadmap
9.45 – 10.15	Presentation by Pondera on offshore wind development in other countries (including several videos)
10.15 – 10.45	Tea break
10.45 – 11.15	Presentation by Pondera on the current study, the approach and methodology
11.15 – 11.45	Presentation by Thiruchelvam Associates on legal and regulatory provisions and gaps
11.45 – 12.15	Presentation by RMA on approvals and clearances anticipated
12.15 – 13.00	Stakeholder feedback session

Tea and lunch will be provided.

This attendance list together with your contact details will be included in the pre-feasibility study report. The World Bank may contact you during subsequent studies related to offshore wind power development in Sri Lanka

Offshore Wind Power Technical Assistance Development Phase II: Pre-feasibility Assessment Stakeholder Workshop for Regulatory Institutions - 4th March 2024

Attendance Sheet

Opening remarks by : Dr. Sulakshana Jayawardena - the Secretary to the Ministry of Power and Energy

S. No	Organisation	Reg. No	Name & Address	Contact	email	Signature
1	Central Environmental Authority	1	Mr. N.S. Gamage Deputy Director General (EMA) Central Environmental Authority 104, Denzil Kobbekaduwa Mawatha Battaramulla.	071 818 8654	gamage@cea.lk	
		2	Ms. Nilmini Attanayake Director (EIA) Environment Impact Assessment Unit Central Environmental Authority 104, Denzil Kobbekaduwa Mawatha Battaramulla.	071 818 8648	nilmini@cea.lk	
2	Ceylon Electricity Board	3	Dr. Narendra De Silva General Manager	071 533 7601	Narendra.DeSilva@ceb.lk	
		4	Ms. W G Pavithra Electrical Engineer (TP)	071 125 7396	Pawithra.Gamage@ceb.lk	
		5	Mr. D R K Bowatte, Electrical Engineer (TP)	077 235 2784	Darshana.Bowatte@ceb.lk	
		6	Mr. K A M N Pathirathne Electrical Engineer (GP)	071 875 5949	Mevan.Pathiratne@ceb.lk	
		7	Ms. M D V Fernando Electrical Engineer (GP)	071 123 5751	Dilini.Fernando@ceb.lk	
		8	Mr. Dulan Lakshitha Project Manager (Siyambalanduwa Project)	071 687 6177	Dulan.Lakshitha@ceb.lk	
		9	Mr. Randula Wijeratne Chief Engineer (Monitoring) - REDB		Randula.Wijeratne@ceb.lk	
		10	Mr. Manuj Wijerathne Electrical Engineer (REP)	071 606 1764	Manuj.Wijayaratne@ceb.lk	
		11	Mr. Pushparuban Panchadcharam	071 568 3384	pushparubanp2@gmail.com	P. Push
		12	Ms. Chathuri Rajapaksa	077 266 1566	chathurir@yahoo.com	
		13	Mr D. A. A. K. Niranjana			

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Offshore Wind Power Technical Assistance Development Phase II: Pre-feasibility Assessment
Stakeholder Workshop for Regulatory Institutions - 4th March 2024

Attendance Sheet

3	Civil Aviation Aithority	14	~~Mr. P.A. Jayakantha~~ Amila Fernando ~~Director General and CEO~~ Civil Aviation Inspector Civil Aviation Authority of Sri Lanka No.152/1 Minuwangoda Road, Katunayake	011 235 8802 0770275734	Cai'ao@caa.lk ~~eldgca@caa.lk~~ dgcaoffice@caa.lk, dae@caa.lk	
4	Department of Coast Conservation and Coastal Resource Management	15	~~Eng. R.A. Ranawaka~~ Sakuntha Pathmasiri ~~Director General~~ Chief Engineer. 4th Floor, Ministry of Fisheries Building New Secretariat Maligawatta, Colombo 10	0716417083	sakunthadeepal@gmail.com dgcaoffice@caa.lk	
		16	Mr. K.H.R. Sriyantha Asst. Director (Coastal Resource Management) 4th Floor, Ministry of Fisheries Building New Secretariat Maligawatta, Colombo 10	0718100339	sriyanthakhr@yahoo.com	
5	Department of Fisheries and Aquatic Resources	17	~~Mr. S.J. Kahawatta~~ M. K. H. [illegible] ~~Director General~~ D. D New Secretariat Building [illegible] Maligawatta, Colombo 10	112 446 183 [Ext: 200]	dgdfar@gmail.com	
		18	Mr. Buddhika Abeyarathna Director Fisheries Development Division New Secretariat Building Maligawatta, Colombo 10	112 472 199 Ext: 271 0714 969 572	buddhikamgt@gmail.com	
6	Department of Wildlife Conservation	19	Mr. Chandana Sooriyabandara Director General Department of Wildlife Conservation 811A, Jayanthipura Battaramulla	0112 888 585	dg@dwc.gov.lk wadawijesooriya@gmail.com	
		For 20	Mr. Manjula Amararathne Director PA Management Department of Wildlife Conservation 811A, Jayanthipura Battaramulla		manjulaamararathna@yahoo.com manjulawildlife@gmail.com	

Hashani Samarathne.
AD (NRM)

hashanidwc@gmail.com

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Offshore Wind Power Technical Assistance Development Phase II: Pre-feasibility Assessment
Stakeholder Workshop for Regulatory Institutions - 4th March 2024

Attendance Sheet

7	Geological Survey and Mines Bureau	21	Prof. H.M. Ranjith Premasiri Director General Geological Survey and Mines Bureau 569, Epitamulla Mawatha Pitakotte.	011 288 6271	dg@gsmb.gov.lk	
		22	Ms. Deepani Weerakoon Senior Geologist Geological Survey and Mines Bureau 569, Epitamulla Road Pitakotte.	011 288 6289 / 886 290 077 757 7337	dpoweerakoon@gmail.com	
8	Marine Environment Protection Authority	23	Mr. Jagath Gunasekara General Manager Marine Environment Protection Authority 177, Nawala Road Colombo 05	071 810 0818	jagathg@mepa.gov.lk	
		24	Mr. H.T.N. I. Piyadasa Manager Operations Marine Environment Protection Authority 177, Nawala Road Colombo 05	071 818 1430	nilantha@mepa.gov.lk	
9	Ministry of Defence	25	Lt. Col I.P. Hettiarachchi Engineer Advisor	077 363 3444 071 263 3444	hipriyantha@yahoo.com	
10	Petroleum Development Authority	26	Mr. Surath Ovitigama Chairman Petroleum Development Authority Level 6, Ceylinco House 69, Janadhipathi Mawatha Colombo	077 0734922	chairman@pdasl.gov.lk	
		27	Mrs. Saumya Wijesinghe Legal Officer Petroleum Development Authority Level 6, Ceylinco House 69, Janadhipathi Mawatha Colombo	071 289 4544	saumya@pdasl.gov.lk	

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Offshore Wind Power Technical Assistance Development Phase II: Pre-feasibility Assessment Stakeholder Workshop for Regulatory Institutions - 4th March 2024

Attendance Sheet

11	PUCSL	28	~~Mr. Damitha Kumarasinghe~~ ~~Director General - PUCSL~~ 6th Floor, BOC Merchant Tower St. Michael's Road Colombo 3 S. Krishananth	0779900344	damitha@pucsl.gov.lk krishananths@pucsl.gov.lk	
12	Sri Lanka Air Force	29	Wing Commander P.G.U.N. Dharmapala			
		30	Fg Officer G.R.K. Somarathna			
		31	D.L.J.R.K. Dodamgoda	0773713443	janakakumu21@gmail.com	
		32	R.T. Lokuliyana	0779585239	rlokuliyana@yahoo.com	
13	Sri Lanka Navy	33	Y. D. Jayawardene Commander	0712994439	rivithyd@gmail.com	
14	Sri Lanka Army	34	Lt. Col P.D.S. de Alwis RSP USP psc	076 690 7278	Suranjanadealwis@gmail.com	
15	Sri Lanka Sustainable Energy Authority	35	Mr J.M. Athula Director General			
		36	Mr. Harsha Wickramasinge Deputy Director General (S.S.M)	0712308907	harshawk@gmail.com	
		37	Mr. Chamila Jayasekera Director (R&D)	0715344201	chamila.slsea@gmail.com	
		38	Ms. Poornima Kalhari Deputy Director	0710790258	poornimakalhari@gmail.com	
		39	Mr. Kankeyan Thurairaja Assistant Director	0716413444	kankeyan.slsea@gmail.com	
16	Telecommunications Regulatory Commission	40	Mr. S.E. Wakista Director/Information Technology, Telecommunications Regulatory Commission 276, Elvitigala Mawatha Colombo 08	071 447 3137	wakista@trc.gov.lk	

This attendance list together with your contact details will be included in the pre-feasibility study report. The World Bank may contact you during subsequent studies related to offshore wind power development in Sri Lanka

Offshore Wind Power Technical Assistance Development Phase II: Pre-feasibility Assessment
Stakeholder Workshop for Regulatory Institutions - 4th March 2024

Attendance Sheet

17	University of CMB	41	Prof. Devaka K. Weerakoon Dept. of Zoology and Environment Sciences Faculty of Science University of Colombo Thurstan Road Colombo	077 615 0184	head@zoology.cmb.ac.lk	
18	University of Sri Jayewardenepura	42	Prof. R.R.M.K.P. Ranatunga Head, Department of Zoology University of Sri Jayewardenepura Gangodawila Nugegoda	071 446 3970	ranatunga@sjp.ac.lk/ kamal.ranatunga@gmail.com	
19	World Bank	43	Christopher John Lloyd		clloyd@worldbank.org	
		44	Sonali Singhal		ssinghal@ifc.org	
21	Pondera	45	Joost Starmans		j.starmans@ponderaconsult.com	
		46	Eric Arends		E.Arends@ponderaconsult.com	
22	RMA	47	Dr. Tilak Siyambalapitiya	077 741 2269	tilak@rmaenergy.lk	
		48	Dr Amila Wicramasinghe	071 481 0281	amila@rmaenergy.lk	
		49	Mr. Swetha Perera	077 225 3304	swetha@rmaenergy.lk	
		50	Prof. BMP Singhakumar		balangodasinghe@gmail.com	
		51	Ms. Lakmali Liyanage		sepali12@yahoo.com	
		52	Mr. Bhasara Sirisinghe	077 046 2984	bhasara@rmaenergy.lk	
		53	Mr. Jeyakumar Birannaa	077 288 5448	biranna@rmaenergy.lk	
		54	Ms. Thirasara Gunaruwan	077 756 3185	thirasara@rmaenergy.lk	
		55	Mr. Sulekha Abeyrathne	076 549 8989	sulekha@rmaenergy.lk	
		56	Mr. Menura Shaveen		menurar@gmail.com	
		57	Ms. Niwddry Fernando	077 030 1295	niwddry99@gmail.com	

This attendance list together with your contact details will be included in the pre-feasibility study report. The World Bank may contact you during subsequent studies related to offshore wind power development in Sri Lanka

Offshore Wind Power Technical Assistance Development Phase II: Pre-feasibility Assessment
Stakeholder Workshop for Regulatory Institutions - 4th March 2024

Attendance Sheet

23	SL Navy	58	LCdr (H) BMGK Jayawardhana	0714544[illegible]	gayan.k.jayawardhana@gmail.com	
	TIRUCHELVAM ASSOCIATES	59	LAILA NASRY			
		60	Nirosha Peiris			
		61	Athulya [illegible]			
	PUCSL	62	Sameera Adikaram			
	PUCSL	63	Ramesh Chandala.	0769709372	rameshc@pucsl.gov.lk	
	SLSEA	64	B.L.P.M. Balasooriya	0701511120	madhusanka.slsea@gmail.com	

World Bank Technical Assistance for Sri Lanka: Offshore Wind Power Development Phase II

Detailed Q&A session in Colombo Workshop 01

Date: 04.03.2024

Time: 9.00 a.m. – 1.00 p.m.

Stakeholder Agency/Group	Questions Raised	Responses Provided
IFC	How do you see private involvement? Is there any efforts been made to develop private sector to get ready with offshore wind?	Supply-chain and local ports, construction and operation are some ways to get private party involvement. For the first project we need to get international experience with SL counterparties so that this is a joint approach.
Ministry	Out of three locations, why is the North-Western part been selected for the prefeasibility study?	North has the lowest wind speed and south-east has technical constraints. To start off with, NW locations are having the best mix with strong winds shallow sea, the ground condition.
	In the pre-feasibility will you identify the necessary infrastructure in the ports? Will you collect baseline data on fishing activities during pre-feasibility rather than going to feasibility study? It is important to handle social impacts	The port of Colombo will be useful for construction, for OnM we can use a smaller port. Coal power plant Jetty might be very sufficient too. Regarding fishing, when we have a draft report, we will go again and talk to the communities, and get them.
Participant	Fishermen in Mannar island claim that fishers are declining with the impact of Thambapawani power plant	Ministry: although there is a claim, it is very hard to conclude on the impact after comparing the historical data and present data. During construction we have to prevent fishermen entering that area and to compensate them adequately. Therefore, baseline data is very important to mitigate the impact during construction period as well as the operating period. Study team: Issue is not limited to SL. Dealt in mature markets as well.
CEA	Based on the prefeasibility study what are the pros and cons of fixed support type and floating type in the area of Puttalam and how far those potential sites available from the shoreline?	Floating type are under development, and not economically attractive at the moment. Therefore, we are looking for the fixed bottom foundation type. In Puttalam we are planning to use the area between 5-15km from the shoreline, In Mannar, starting from 15km ahead of the shoreline.
GSMB	Comment: North-west sea is shallow and the seabed consists of limes stones (Jurassic sand stone) and very thick sedimentary basins. As per the onshore experience, this limestone has lot of cavities and is very soft. Lot of work has been done by PDA (surveys and drilling) those data will be useful.	
Participant	Impact on marine life during construction and operational phases due to acoustical changes in marine water with higher sound propagation velocity in water than in air.	Special methods and devices are used to reduce noise and to prevent fish entering during construction period. During operation the impacts are much lower and not harmful Suggestion: to collect baseline acoustic data in the water for later comparison.

Stakeholder Agency/Group	Questions Raised	Responses Provided
Participant	Compared with onshore the capital cost will be high, but wind speed and plant factor are beneficial. Any indication on the expenses against energy?	Capital expense likely to be twice when compared to onshore. But produces more energy. It depends on the characteristics of onshore plant and offshore plant. In recent auctions in mature countries difference between onshore and offshore are very less, and sometimes offshore winds are much cheaper.
Participant	whether the Interconnection between India and SL is Overhead/submarine?	Submarine. The idea was to have 500MW initially and extend it up to 1000MW
Participant	Is there any levies scheme for issuing provisional approval or energy permit? What are the criteria?	SLSEA: Application fee (when submitting the application)- Rs. 100,000 for each 1MW. There is no fee apart from application fee for Provisional approval. Permit fee - for the 1st MW: Rs.100,000 and for the balance, Rs. 50,000 per 1MW. There is a royalty fee involved. But so far not charged
SLSEA	Comment: Initiatives for declaring offshore wind will be taken soon.	Currently only onshore areas are declared as energy dev areas. But there is an amendment in the pipeline to extend.
CEA	Comment: CEA has initiated an action to develop a strategic EIA according to National Physical Plan 2048. We will invite MoPE and their agencies to discuss plans	
	Environmental user fee scheme levied for windmills? Suggestion: add a fee scheme for using wind and to have a fund to safeguard the environment.	For using it is royalty fee. In SL we have not charged so far For decommissioning there are financial considerations in other countries. Monitoring and regulation are important. When charging royalty fee, should be very careful. The electricity price will increase. It can be counterproductive.
Participant	Difference between state policy and govt. policy	Answer was provided by Ms. Laila (part of the presentation)
Navy	South of Mannar critical for poaching. What should security forces do?	Constant activities with people working there. Fix additional radars. Ms. Laila: Defense is usually dealt with marine spatial planning
Air force	Resource searching such as oil and natural gas. Need to reach, search and rescue in that area there by helicopters. Sufficient space to reach (low level helicopter operation) required	Offshore are bigger. Therefore, 1-2km spacing in between to access
Participant	Fishing community oppose due to noise generated from turbine. What are the solutions?	Livelihood impact – compensation package NARA study results are opposite to fishing community complaint. Baseline data are required.
Marine Ecologist	Comment: Vibration will be there and there will be an impact. Should seriously consider. There will be a lot of resistance from the fishermen. Fish catch has increased. More and more finishing boats are added, and individual income is going down.	Should bring them in to seeing the benefits of the project.
CEB	What is the extent wind measurements are being considered at Pre-feasibility and what is the best	Currently collecting existing data. During feasibility - placing measuring equipment in offshore (laser-based detection systems) and get the support of wind resource expert.

Stakeholder Agency/Group	Questions Raised	Responses Provided
	approach in collecting more accurate data for feasibility?	
	Who will bear the cost of developing logistical infrastructure (small ports)? Govt or developer?	Cost of O&M ports is mostly borne by the developer. Construction ports – depends. Different countries have done it in different ways. For SL should consider carefully. Expect developer to invest.
Participants	EIA process. What are the shortcomings/differences? How to overcome?	Answer was provided by Ms. Laila (part of the presentation)

Captured moments from Colombo Workshop for regulatory agencies on 4th March 2024

Appendix C4: Stakeholder Workshop for Implementing Partner Agencies Colombo (March 5th,2024) – Invitation Letter/ Agenda, Attendance Sheet, Q&A, Photos

Ministry of Power and Energy

Offshore Wind Power Technical Assistance Phase II: Pre-feasibility Assessment Stakeholder Workshop for Implementing Partner Agencies

Date : Tuesday, 5th March 2024
Time : 8:30 am to 1.00 pm
Venue : Orchid Room, BMICH, Colombo 7.

The Background: The government has received technical assistance from the World Bank to conduct preliminary studies toward developing offshore wind power. A road map of activities was prepared in 2023, and presently, pre-feasibility studies are being conducted. Mannar and Puttalam are two locations where offshore wind power possibilities are good.

The Workshop: Study, design, construction, and operation of offshore wind power plants requires careful consideration of oceanography, marine biology and several other stakeholder interests both onshore and offshore. Power transfer would require laying submarine cables, new onshore substations, and transmission lines. Government officials would be called upon to review different types of designs and studies, and to monitor implementation social and environmental safeguards regulations and best practices. The objective of the workshop is to explain to officials about the process of designing, building and operating an offshore wind park. At the workshop, officials from The World Bank, and their consultants Pondera of the Netherlands and RMA of Sri Lanka, will explain the planning process and their experience with such projects actually implemented in other countries. This workshop will also focus on the regulatory procedure and relevant institutions as well as different studies, investigations and services required to establish feasibility of projects and in their actual implementation.

Agenda

8.30 – 9.00	Registration of participants
9.00 – 9.15	Opening remarks and purpose of the workshop
9.15 – 9.45	Presentation by the World Bank on the Sri Lanka Off-shore Wind Roadmap
9.45 – 10.15	Presentation by Pondera on offshore wind development in other countries (including several videos)
10.15 – 10.45	Tea break
10.45 – 11.15	Presentation by Pondera on the current study, the approach and methodology
11.15 – 11.45	Presentation by Thiruchelvam Associates on legal and regulatory provisions and gaps
11.45 – 12.15	Presentation by RMA on approvals and clearances anticipated
12.15 – 13.00	Stakeholder feedback session

Tea and lunch will be provided.

This attendance list together with your contact details will be included in the pre-feasibility study report. The World Bank may contact you during subsequent studies related to offshore wind power development in Sri Lanka

Offshore Wind Power Technical Assistance Development Phase II: Pre-feasibility Assessment Stakeholder Workshop for Implementing Partner Agencies- 5th March 2024

Attendance Sheet

S. No	Organisation	Reg. No	Name & Address	Contact	email	Signature
1	Central Cultural Fund	1	Ms. Nisanthi Wilfred Director (Admin) Central Cultural Fund Colombo Head Office 212/1, Bauddhaloka Mawatha Colombo 07	071 4421 490	~~gamage@ceb.lk~~	
2	Ceylon Electricity Board	2	Mr Ronald Comester Additional General Manager (Tr-NWO)			
		3	Mr S A D A Peiris Additional General Manager (DD 1)			
		4	Dr. H M Wijekoon Deputy General Manager (TGP)	071 411 5592	Wijekoon.Banda@ceb.lk	
		5	Mr K Ramjee Chief Engineer (TP)	071 874 0954	Ramjee.Kuberalingam@ceb.lk	
		6	Mr Eranga Jayarathna Chief Engineer (GP)	071 162 9429	Eranga.Jayarathna@ceb.lk	
		7	Ms D P Liyanage Electrical Engineer (GP)	071 830 5004	Dilini.Liyanage@ceb.lk	
		8	Mr. Sachitra Peiris, Chief Engineer (REP)	071 490 8906	Sachitra.Peiris@ceb.lk	
		9	Mrs. Tharanga Wickramarathne, Project Manager (Mannar & Pooneryn Projects)	071 832 3384	Tharanga.Wickramarathna@ceb.lk	
		10	Mr Ajith Alwis	071 415 0639	amaawpsm@gmail.com	
		11	Mr Asela Jayasinghe	071 536 0306	Asela.Jayasinghe@ceb.lk	
		12	Mr. Chinthaka J Dissanayake		chindissa@gmail.com	

This attendance list together with your contact details will be included in the pre-feasibility study report. The World Bank may contact you during subsequent studies related to offshore wind power development in Sri Lanka

Offshore Wind Power Technical Assistance Development Phase II: Pre-feasibility Assessment Stakeholder Workshop for Implementing Partner Agencies- 5th March 2024

Attendance Sheet

3	Ceylon Fishery Harbor Corporation	13	Mr. M. Janaka Prasanna General Manager No. 15, Rockhouse Lane Colombo 15	077 718 7995	gmcfhc@gmail.com	
4	Department of Archaeology	14	Ms. Udeni Wickramasinghe Department of Archeology Sir Marcus Fernando Mawatha Colombo 7.	011 269 2840	udeni.rupicka @yahoo.com	
5	Department of Meteorology	15	Dr. K D Sujeewa Deputy Director Department of Meteorology 383, Baudhaloka Mawatha Colombo 7	071 055 0551	kndderg@yaho.com	
6	Lanka Hydraulic Institute Ltd	16	Dr. Sanjeewa Wickramaratne Senior Specialist Coastal/ Water Resources Engineering Lanka Hydraulic Institute Ltd 177, John Rodrigo Mawatha Moratuwa	077771 2914	sanjeewa@lhi.lk	
7	Merchant Shipping Secretariat	17	Mr. Pradeep Chandana Director (engineering)	0112 441429	pvtpchandana@yahoo.com	
8	National Aquatic Resources Agency	18	Dr. Geevika J. Ganegama Arachchi Deputy Director General National Aquatic Resources Agency Crow Island Colombo 15.	011 313 1344	janadari1@yahoo.com	
		19	Dr. R.P. Prabath Jayasinghe Head, Marine Biological Resources Division National Aquatic Resources Agency Crow Island Colombo 15.	011-2521914	prabath_jayasinghe@yahoo.com	
		20	Dr. K.A.W.S. Weerasekara Head, Environmental Studies Division National Aquatic Resources Agency Crow Island Colombo 15.	94 719353169	shyamalikaww@nara.ac.lk	
9	National Building Research Organization	21	Ms. Narmada Indeewari Liyanage Scientist (Geologist) National Building Research Organization 99/1, Jawatte Road Colombo 05	071862 7018	Narmada.ged@gmail.com	

This attendance list together with your contact details will be included in the pre-feasibility study report. The World Bank may contact you during subsequent studies related to offshore wind power development in Sri Lanka

Offshore Wind Power Technical Assistance Development Phase II: Pre-feasibility Assessment Stakeholder Workshop for Implementing Partner Agencies- 5th March 2024

Attendance Sheet

10	National Physical Planning Department	22	Mr. Gamini Hewage Director General National Physical Planning Department 5th Floor, Sethsiripaya Battaramulla	077-7308008	Hewage.gamini@yahoo.com	
		23	Additional Director General (Planning) National Physical Planning Department 5th Floor, Sethsiripaya Battaramulla			
11	Petroleum Development Authority	24	Mr. Surath Ovitigama Chairman Petroleum Development Authority Level 6, Ceylinco House 69, Janadhipathi Mawatha Colombo	077 0734922	chairman@pdasl.gov.lk	
		25	Mr. Chaminda Kularathna Geologist Petroleum Development Authority Level 6, Ceylinco House 69, Janadhipathi Mawatha Colombo	071 3246836	kularathna@pdasl.gov.lk	
12	Sri Lanka Ports Authority	26	Mr. J. A. Chandrarathne Acting. AMD - Technical Sri Lanka Ports Authority Colombo 10			
13	Sri Lanka Sustainable Energy Authority	27	Mr Ranjith Sepala Chairman	0710550057		
		28	Mr. Anuruddha Kariyawasam	0711694984 ~~077 228 7095~~	anuruddha@energy.gov.lk ~~prasad@srilanka.travel~~	
		29	Mr. B.W.A. Bulathgama	0711021692	sulathgama71@gmail.com	
		30	Ms. Vaithehi Seynulabdeen	0772408065	vaithehi.slsea@gmail.com	
		31	Mr. Chathura Wanniarachchi	0771873851	chathura.slsea@gmail.com	

This attendance list together with your contact details will be included in the pre-feasibility study report. The World Bank may contact you during subsequent studies related to offshore wind power development in Sri Lanka

Offshore Wind Power Technical Assistance Development Phase II: Pre-feasibility Assessment Stakeholder Workshop for Implementing Partner Agencies- 5th March 2024

Attendance Sheet

14	Tourism Development Authority of Sri Lanka	32	Mr. B.H.R Sarifoo Deen Director General Sri Lanka Tourism development Authority No. 80, Galle Road Colombo 03			
		33	Dr. Prasad Jayasooriya Director Tourism Planning and Development Sri Lanka Tourism development Authority No. 80, Galle Road Colombo 03	0772267-095	prasadj@srilanka.travel	
15	Tiruchelvam Associates	34	Laila Nasry Attorney-at-Law		lnasry@tiruchelvam.com	
		35	Nirosha Peiris Attorney-at-Law		npeiris@tiruchelvam.com	
		36				
16	University of Moratuwa	37	Dr. Thusitha Sugathapala Senior Lecturer Department of Mechanical Engineering Faculty of Engineering University of Moratuwa	077 731 3439	agtsugathapala@gmail.com	
		38	Ms N.W.A.M.S.H. Adikaram Temporary Lecturer, Department of Mechanical Engineering Faculty of Engineering University of Moratuwa	713824860	adikarams@uom.lk	
		39	Prof. Anura Wijayapala Head - Department of Electrical Engineering Faculty of Engineering University of Moratuwa	071 817 8975	anuraw@uom.lk	
		40	Prof. W.D.A.S. Rodrigo Department of Electrical Engineering Faculty of Engineering University of Moratuwa	077 795 8976	asanka.rodrigo@gmail.com	

This attendance list together with your contact details will be included in the pre-feasibility study report. The World Bank may contact you during subsequent studies related to offshore wind power development in Sri Lanka

Offshore Wind Power Technical Assistance Development Phase II: Pre-feasibility Assessment Stakeholder Workshop for Implementing Partner Agencies- 5th March 2024

Attendance Sheet

17	University of Peradeniya	41	Dr. Jagath K. Gunatilake Department of Geology Faculty of Science University of Peradeniya	077 731 3063		
		42	Prof. Prasanna Gunawardane Department of Mechanical Engineering Faculty of Engineering University of Peradeniya	077 409 4561	sdgspg@eng.pdn.ac.lk	
18	University of Ruhuna	43	Dr. Lishani Wijewardene Senior Lecturer Department of Limnology and Water technology Faculty of Fisheries and Marine Sciences & Technology University of Ruhuna	0701399701	nisansalaw@fish.ruh.ac.lk nisansalawijewardene@gmail.com	
19	World Bank	44	Christopher John Lloyd		clloyd@worldbank.org	
		45	Sonali Singhal		ssinghal@ifc.org	
21	Pondera	46	Joost Starmans		j.starmans@ponderaconsult.com	
		47	Eric Arends		E.Arends@ponderaconsult.com	
22	RMA	48	Dr. Tilak Siyambalapitiya	077 741 2269	tilak@rmaenergy.lk	
		49	Dr Amila Wicramasinghe	071 481 0281	amila@rmaenergy.lk	
		50	Mr. Swetha Perera	077 225 3304	swetha@rmaenergy.lk	
		51	Prof. BMP Singhakumar	0714439360	balangodasingha@gmail.com	BM
		52	Ms. Lakmali Liyanage		sepali12@yahoo.com	
		53	Mr. Bhasara Sirisinghe	077 046 2984	bhasara@rmaenergy.lk	
		54	Mr. Jeyakumar Birannae	077 288 5448	biranna@rmaenergy.lk	
		56	Ms. Thirasara Gunaruwan	077 756 3185	thirasara@rmaenergy.lk	

This attendance list together with your contact details will be included in the pre-feasibility study report. The World Bank may contact you during subsequent studies related to offshore wind power development in Sri Lanka

Offshore Wind Power Technical Assistance Development Phase II: Pre-feasibility Assessment
Stakeholder Workshop for Implementing Partner Agencies- 5th March 2024

Attendance Sheet

	Preeri Withanage	57	PDASC - Director	0718001813	preeri@pdasl.gov.lk	
	~~Maritime A~~					
	Central Cultural Fund	58	Rasika Muthucumarana	0718100698	muthurasika@gmail.com	

World Bank Technical Assistance for Sri Lanka: Offshore Wind Power Development Phase II

Detailed Q&A Session in Colombo Workshop 02

Date: 05.03.2024

Time: 9.00 a.m. – 1.00 p.m.

Stakeholder Agency/Group	Questions Raised	Responses Provided
Participants	What is meant by 'Sri Lanka is a priority'? is it about availability of wind? Or need of power?	It is a little bit of everything. From the limited resources we have we are supporting a few countries. SL is one of them
University of Moratuwa	Compared to the studies on other countries, in terms of implementation where do we stand?	Hard to compare. Generally, total capacity is smaller, and the demand is smaller. Off-shore can make a difference and help to reach net zero target.
NBRO	Whether you have finalized the locations and distance from shoreline, depth of water secured?	Currently, no project designed but data are being collected.
CEB	During pre-feasibility why have you selected NW?	Initially, wanted to investigate the best location.
PDA	Do you consider vertical type turbines as well?	There are different types which are still developing. Not used for commercial wind farms.
Participant	How long will a wind turbine last?	Designed to last 20-30 years. Sometimes 40 years even. Effective to be replaced within 20-25 years.
Participant	Comment: Lots of env. disturbances will happen during construction. It is important to do a good feasibility study. Further, these places are good fishing grounds and lot of complaints from fishermen on onshore plants due to vibration & sound. Baseline data collection is vital. Changes in the composition of species can also be analyzed with baseline data. Q: is it economically feasible?	More understanding required. But can be done economically.
University of Moratuwa	Do you cover how the project is responding to climate change?	Not the main activity. But we investigate that by getting data.
	Can we identify this project as a project to be prioritized? Or is it not ready yet? Can offshore wind come as an option in next NDC revision?	If the timeline you are looking at is 2025-35, then offshore wind should be considered. 8 years is a target. But achievable. Different source of power.
PDA	Vital to identify a mechanism to have multiple projects in the same area. There will be high oil and gas potential, minerals in the same area. How would you prioritize? How to manage? Before provisional approval at which stage do you identify other projects in the same area?	For now, can go in parallel. If a project starts, then we need to think more carefully. In different countries the mechanism is different. In UK, more priority to oil/gas. Leasing of sea of offshore wind area is an option. Former SLSEA: Project approval committee should go through it. If there is a requirement for additional authority to come in, we invite them for the approval process. There are provisions in the framework.

Stakeholder Agency/Group	Questions Raised	Responses Provided
		Suggestion: to have a stirring committee when the feasibility begins. To make sure that other projects will not be interrupted by this. Former SLSEA: Once there was an idea that it is SLSEA's duty to get the approvals and hand it over to developer, so that developer is not too late. SLSEA: When application for a new RE project is received, we do an initial screening. During that we check this.
University of Moratuwa	How reliable to use onshore wind measurement data to be used for offshore?	There are changes in the characteristics of offshore, and need to understand them
	How are you planning to connect to the national grid? How much capacity required? Are you going to consider cross border interconnections?	Altogether 1000MW capacity. With a strong interconnection with India, Mannar can go up to even 1000MW. Puttalam has difficulties in expanding. CEB comment: We have identified the location of HVDC station in Mannar. He explained the proposed transmission network upgrades.
	Are you looking at Micro siting? And the impact of proposed plant to the existing one?	Micro siting will come in the feasibility study and during detailed procurement. With regards to the impact, not in the scope directly but considering when assessing the areas (deciding the distance to shoreline)
participant	Do you have any data/stats on inland power plants? Are the Projects going on successful? How many plants are there? One decommissioned?	Yes. Expected results are received from wind. In Mannar, the project is highly successful. In Mannar itself there will be more large-scale projects. CEB comment: Mannar onshore plant is performing well. When considering the geographical location offshore will not have much difference compared to onshore. Either side of Mannar, vast ocean. Should not be overconfident. Yes. Hambantota PP decommissioned after operating its full lifetime. Total 18 projects are running. Profitable to the developers. Even economically viable for the country. The best example is Mannar.
University of Peradeniya	There is a possibility to shift the entire project into a different location. More flexible. Feasibility should be done for a wider area before micro siting	Pondera: Yes. We are looking into a wider area. WB: For the detailed env, assessments you don't have to define the project area. Even outside the area is assessed.
NARA	When selecting the locations, priority was given to wind availability. Ecological things are investigated now. Is that correct? Suggestion: in SL, marine parks are not sufficiently maintained. Some data are outdated. Better do a comprehensive survey. Fishery management areas has been gazetted. Please look into it.	We looked at a range of things but not in detail. Now we are looking at wider range of things in more detail.

Stakeholder Agency/Group	Questions Raised	Responses Provided
Central Cultural Fund	Comment: Underwater cultural Heritage. Should go through an Archeological Impact Assessment. Existing data on the underwater cultural heritage & shipwrecks can be accessed online (National Shipwreck data base of SL). From Puttalam to Mulativ (clockwise) need to be explored. Under the law of the sea, Mannar area is considered as historical water. Please consider.	
Participant	Please consider seismicity as well	
PDA	Do we expect feasibility to done by the developer?	No. Hopefully be funded by WB. WB: funding should be secured once we have an agreement on the approach.
Merchant Shipping Secretariat	Suggestion: Please consider commercial activities such as port and shipping activities when setting up the sites.	One of the advantages of the site we selected (Mannar) is having less shipping activities when compared to South East.
PDA	Oil and gas exploration we have fine-tuned business model. When it comes to wind it is more or less tariff based. If one developer wants a turn-key project, will you look into such business models in the future?	At the moment we consider bankability. Model established is tariff-based system. We will be interested in exploring other opportunities.
CEB	Lot of fishing in these areas. There can be huge protests. The design is also changing from box shape to circular one. People are diving for fishing, there are tide surfing, there are three growing coral reefs, there is a bomb blasting area. We will have to consider these.	
University of Peradeniya	After implementing the farm if the fishermen feel that it has become breeding ground it will be a plus point. Comment: PDA explained their experience with fishing community in explorations.	
University of Ruhuna	Comment: Aqua cultural options will give fishermen another source of income	

Captured moments from Colombo Workshop for partner agencies on 5th March 2024

Appendix C5: Online Workshop for NGOs (June 13th,2024) - Invitation Letter/ Agenda, Attendance Sheet, Q&A

Online meeting to explain offshore wind pre-feasibility studies to NGOs

Invitation

Aligning with the targets of the government to increase the renewable energy capacity addition, Sri Lanka Sustainable Energy Authority (SLSEA) has taken different initiatives in renewable energy development. Wind power is one of the key renewable energy sources under this, and off-shore wind power development is focused attention based on the high off-shore wind power potential in the country, especially in the northern and north-western coastal regions.

The Word Bank has provided technical assistance to carry out pre-feasibility studies for offshore wind power projects in the Mannar and Puttalam areas, with the involvement of consultant groups from Pondera and RMA. They have completed the studies and the findings of the studies have already been presented to the SLSEA and other related institutions. Now it is expected to present the study scope to NGOs.

Accordingly, the consultant group has made arrangements to conduct an online meeting in connection with the subject. It will be held on 13th June 2024 at 5.00 p.m., and the details are as follows.

On-line Meeting to Describe on-going Pre-feasibility Studies toward Developing Offshore Wind Potential in Sri Lanka
Date: Thursday 13th June 2024
Time: 5.00 pm to 6.30 pm
Mode: On-line (a MSTeams link will be sent to all participants responding to the meeting invitation)

Sri Lanka Sustainable Energy Authority

Agenda

4.50 – 5.00	Admitting participants to the online meeting
5.00 – 5.05	Welcome and purpose of the meeting, SLSEA
5.05 – 5.15	Introduction of Participants
5.15 – 5.25	The World Bank’s ongoing support for offshore Wind Power Development in Sri Lanka, World Bank
5.25 – 5.35	Scope of ongoing Pre- feasibility studies and the timeline, Pondera
5.35 – 5.45	Stakeholder Engagement at the Regional Level, RMA Energy
5.45 – 6.30	Stakeholder feedback session

Invited List of Participants and Attendance

	Organization	Participants
01	Field Ornithology Group of Sri Lanka, Department of Zoology and Environment Sciences, University of Colombo,	Didn't attend the meeting.
02	Ceylon Bird Club	Name: Uditha Hettige Designation: Chairman,Conservation and Action Committee Email: udithabirder@gmail.com
03	Wildlife and Nature Protection Society	Name: Revan Weerasinghe Designation: Lawyer & a member of the general committee Email : info@wnpssl.org
04	Environmental Foundation (Guarantee) Limited	Name: Manori Gunawardena Designation: Director/ Wildlife Scientist Email: manorig07@gmail.com Mobile Number: +94773017199 Name: Hettiarachchige Chandula Janith Designation: Senior Science Officer Email: chandula@efl.lk Mobile Number: +94771173960
05	Center for Environmental Justice	Name : Indika Rajapaksha Designation : Environmental Officer Email address : indikasamanr@gmail.com
06	Federation of Environmental Organizations	Name: Keith Wijesuriya Designation: Chair Email: keith@omnicommediagroup.lk Mobile number: 0777349880
07	Centre for Poverty Analysis	Didn't attend the meeting.
08	Sarvodaya Shramadana Movement.	Name: D.H. Sanjeewa Illangakoon Designation: Director, Sarvodaya Rural Technical Services Email: sanjeewa@sarvodaya.org Mobile: +94- 718-663477

World Bank Technical Assistance for Sri Lanka: Offshore Wind Power Development Phase II

Online meeting to explain offshore wind pre-feasibility studies to NGOs

Q&A session

Date: 13.06.2024

Time: 5.00 p.m. – 6.30 p.m.

NGO	Questions Raised/ Comments received	Responses Provided
Environmental Foundation (Guarantee) Limited	Have you done a strategic assessment of the spread of existing wind power in that geography when you selected these sites for this project? We don't want a ring fencing of the project and would like to see a strategic overview of the environment and social impacts of that geography. If this has not done, it will be very limited in environment and social safeguards when leading to project phase. This includes onshore wind power as well as offshore wind power as those are interconnected and cumulative. This is important as this development is new in Sri Lanka. There need to be strategic EIA as project based EIAs are insufficient to reflect the strategic and cumulative impacts in a small geography. Although there are project based EIAs, the WB Environment and social safeguards do not prevent you from doing a strategic environment assessment on wind power in that region. Recommend WB to consider this before moving forward and committing to the sites. Assessment should be done before committing, at the early stage before moving to EIA stage of the project. And there is also other infrastructure connected to the project such as transmission lines, etc.	SLSEA: The main potential areas were identified as Mannar, Poonaryn areas during the ADB master study approx. 10 years back. SLSEA approach is to take these high potential areas to large scale projects. And for each project we carried out EIA as the general approach. As Mannar is an Avifauna hotspot, in Mannar phase II consultations mainly, the request was made for a strategic bird study. Now, SLSEA initiated this study. This is a strategic bird study for Northern region. WB: There is lot of development going on specially in Mannar and Puttalam as well. The assessments of cumulative impacts are important. These two areas have been selected as priority areas for development. This is a very early stage and there had been a process of assessing whole of Sri Lanka. This process is documented in the road map. There is no project yet, just an initial planning of opportunity. Now we are checking in detail whether there is a realistic project in these good potential areas, to have a concept design of the project. There need to be project details like size turbines etc. for a cumulative impact assessment. Currently the need is to develop a concept for 500mw projects. And then to understand the constraints. This is needed for a strategic assessment. Still its early and not at the project. These are basic steps for future assessments.

NGO	Questions Raised/ Comments received	Responses Provided
Ceylon Bird Club	Environmentalists protested the first wind power project in Bundala. Recently, windmills are planned in Mannar. This is an important bird area. The central Indian bird migratory route funnel into SL through that narrow strip. In bad weather conditions, birds hop in Adam's bridge islands. There are windmills in this area. Ceylon Bird Club involved and asked to remove some. When the windmills are placed in Mannar, what will be the accumulate impact and how it will affect the bird migratory path? Still must analyze existing data and see the effect of windmills. It is too early to comment. When we do a project like this, it is important study these aspects. Have to study these in detail. It is important to study wildlife in this area. There are already planted windmills in Silavathurai, Thalai Mannar, Poonaryn…etc. The accumulated impact of these windmills needs to be studied. There is an annual bird count bird club is getting. In month of February, island wide bird count is taken. And Mannar is one of the important study areas. Have accumulated data for decades. Our long-standing data apart from wetland bird survey data in Mannar area (spend 3-5 days in Mannar area), are based on opportunistic observations. Can use the data to get an idea, but this should not be your study. Previous windmills developments in Mannar area, the data is not adequate. If you plan studies, we also can input. In previous studies, there are no migratory routes, no nocturnal observations…etc. We are not against the development but try to minimize the harm.	Pondera: It seems that the Ceylon Bird Club is involving in several studies in Mannar area. The study team would like to have one -one-discussion to discuss about this. Ceylon Bird Club: Agreed to have a discussion
Environmental Foundation (Guarantee) Limited	The NGOs and scientists have data. Marine mammal data are hard to find. Data are scattered and insufficient. Birds have been extensively studied. There is a data deficiency in every realm to make a decision. It is therefore important for project proponent to do proper studies. As there is the timeframe, the studies need to start immediately. SL has an international commitment, as we are a signatory to the convention on migratory species and there is reinstate to the Central Asian Flyway, there is an action plan (Delhi agreement) under which we are bound to protect the habitats of migratory species. This is a national commitment. There are multiple studies. Central Asian flyway is now adopted by all	WB: We are not avoiding the requirement of surveys, data collections. We are trying to understand what is known at the present, to define future studies appropriately. Any data is valuable. One part of the TA is to develop scope of works for future surveys. Acquiring high quality data is important. The existing data will help the future data collection campaigns.

NGO	Questions Raised/ Comments received	Responses Provided
	countries that are parties to the convention on migratory species. Strongly suggest to look in to this. Therefore, it is important to do studies. USAID has commissioned a Bat study and a bird study in Northern province. Have to do these in large scale as the areas that looking at is large. Hotspot is closer to Mannar island. The area is almost an exclusion zone. This need to be in the exclusion area in the study. Around 5km buffer will be inadequate. Happy to help in drafting good Scopes of works to reflect what is required in decision making	
Wildlife and Nature Protection Society	Millions of birds pass through Central Asian Flyway. And they congregate via Adam's bridge as there are landing sites. Somehow, this is the hot spot for wind farms. Not against the wind farming projects. In the presentations, Mannar is also a one site. Are there any equally good sites apart from Mannar? There are projects, that are already taking place in Mannar.	WB: Roadmap published last year considers whole of SL. Considering all aspects, Mannar and Puttalam are best areas. Not all SL has high wind speed. Northern was focused due to wind speed. The 3rd best area is South east coast. It is in 3rd place due to environmental sensitivity. There is national parks and offshore areas are also sensitive. The 3rd best area is worse than Mannar and Puttalam. When selecting sites for offshore wind projects, none are perfect. In concept designs, there are risks in projects. Pondera: Mannar site area is a large area. There is space to shift in that space.

Appendix C6: Stakeholder Workshop Mannar (March 18th, 2025) – Invitation Letter/ Agenda, Attendance Sheet, Q&A, Photos

Ministry of Power and Energy

Offshore Wind Power Technical Assistance Phase II: Pre-feasibility Assessment
Stakeholder Workshop - II

Date : Tuesday, 18th March 2025
Time : 9:30 am to 12.45 pm
Venue : District Secretary's Office, Mannar.
Chaired by: District Secretary, Mannar

The Background: The government has received technical assistance from the World Bank to conduct preliminary studies toward developing offshore wind power. A road map of activities was prepared in 2023, and presently, pre-feasibility study has been conducted. Mannar and Puttalam are two locations where offshore wind power possibilities are good.

The workshop: Developing offshore wind power projects requires careful planning to balance environmental considerations and stakeholder interests while ensuring efficient power transmission. Engaging with government officials is crucial, as they oversee project assessments, feasibility studies, and compliance with social and environmental safeguards. Continuous stakeholder engagement and transparent communication are essential for addressing concerns, and facilitating smooth project implementation.

Building on the first workshop held in February 2024, which introduced officials to the process of designing, building, and operating an offshore wind park, this session serves as a follow-up to present the findings of the pre-feasibility study and discuss the next steps for offshore wind power development. Experts from The World Bank, along with consultants from Pondera (Netherlands) and RMA (Sri Lanka), will share key insights from the study, covering technical, economical, regulatory, environmental and social aspects and guide the next phases of implementation.

Agenda

9.00 – 9.30	Registration of participants and tea
9.30 – 9.35	Opening remarks
9.35 – 9.45	Speech by the District Secretary
9.45 – 10.00	Introduction and context by the World Bank
10.00 – 11.30	Presentation by Pondera and RMA on the study findings
11.30 – 12.30	Stakeholder feedback session
12.30 – 12.45	Presentation by the World Bank on Key Takeaways and Next Steps

Tea and lunch will be provided.

The attendance ... together with ... contact details will be ... [illegible] ... offshore wind power development in Sri Lanka

Offshore Wind Power Technical Assistance Development Phase II: Pre-feasibility Assessment

Stakeholder Workshop - II

Regional Workshop (Mannar) - 18th March 2025

Attendance Sheet

Stakeholder Agency		Reg No	Name	Contact	Email	Signature
District Secretariat - Mannar		1	Mr. K. Kanakeshwaran District Secretary Mannar District Secretariat	077 239 5800 023 2222235 023 2222232		Attended
		2	Director Planning, Mr. H. Haleemdeen Mannar District Secretariat Medawachchiya – Thalaimannar Highway Mannar	077 5000030 074 0625400 070 365 4354	hlideen1974@gmail.com	S.J.P. ADP - C
		3	Mrs. Premaranjani Assistant Director Planning Nanattan	077 017 2115 023 2050872	ranjiniepremaranjini1967@gmail.com	[illegible]
Divisional Secretariats of coastal DSDs						
1	Manthai West DSO	4	Mr. Dilakshan, ADS Divisional Secretariat Manthai West Manthai West	023 205 0832 077 224 9825		[illegible]
		5	Ms. N. Emalda Joyni Development Officer Divisional Secretariat Manthai West Manthai West	023 205 0852		[illegible]
		6	Ms. M. Caleste Shiromi Development Officer Divisional Secretariat Manthai West Manthai West	023 205 0852		[illegible]
2	Mannar Town DSO	7	Mr. M. Pratheep, Divisional Secretariat Mannar Town Mannar Town	023 222 2236		
		8	Assistant Director of Planning Divisional Secretariat Mannar Town Mannar Town	[illegible]		[illegible]
		9	Ms. S. S. M. Joseph Development Officer, Divisional Secretariat Mannar Town Mannar Town	077 744 1744	[illegible]	[illegible]

L. J. Rohan Croos

Deputy director of plann...

3	Nanaddan DSD	10	Mrs K Sivasambu Divisional Secretariat Nanaddan Nanaddan	023 205 0673 023 204 1873 077 227 1065	[illegible]	
4	Musali DSD	11	Mr. S. Rajees Divisional Secretariat Musali Chilawathurai Musali	077 798 5422	dsmusali@yahoo.com	
		12	Ms. N.S. [illegible] Women Development Officer Divisional Secretariat Musali Chilawathurai Musali	077 [illegible]	[illegible]1984@gmail.com	
		13	Ms. [illegible] Early Childhood Development Officer Divisional Secretariat Musali Chilawathurai Musali	[illegible]		
Secretaries of Local Authorities						
1	Mannar Urban Council	14	Mr Logeswaran Secretary Mannar Urban Council	778235858		
2	Mannar Pradeshiya Sabha	15	Mr ML Selvaraj Crons Secretary Mannar Pradeshiya Sabah A14 Pesalai	023 205 2022	jarhuson@yahoo.com	
3	Manthai West Pradeshiya Sabha	16	Mr Gerald Fernando, Secretary Manthai Pradeshiya Sabah, Uyilankulam Adampan Road Adampan Mannar	023 205 1854	dens 2551@gmail.com	
4	Musali Pradeshiya Sabha	17	Secretary Musali Pradeshiya Sabah Silawathura	023 205 1679		
5	Nanattan Pradeshiya Sabha	18	F Sahayanadan Crooze, Chief Management Services Officer Nanattan Pradeshiya Sabah	077 143 2859	nanattanpsabha@gmail.com	
Regional CEA officers Northern Provincial Office		19	Mr. R. Mahesh Jalfela Director Northern Provincial Office Ariviya Nagar Kilinochchi	0212872277 071 818 8659	rmjalfela@cea.lk rmjalfela@yahoo.com	
		20	Ms Mary Amanda Head Mannar	077 1425554 023 2224 [illegible]	ceamdodes@gmail.com	
Coast Conservation Department		21	Mr Joseph Danie Coast Conservation Development Officer Area Office Coast Conservation Department	077 840 5250	amjos1984@gmail.com [illegible]	

Regional Officers of CEB	22	Mr Selvarajah Prabaharan, DGM(NP)	077 237 5737		
	23	Eng. W G J Kumara (EE-TWPS)	0717659 2469	[illegible]	
	24	Mr J A P Rajkumar EE(Vavuniya)	071 110 5221		
	25	S Gobinath EE (NP)	070 190 2382		
Department of Fisheries and Aquatic Resources	26	Mr V Kalistan Assistant Director, Department of Fisheries and Aquatic Resources District Office Pallimunai Road Mannar	023 222 2173 0701710501		
Department of archaeology regional office	27	Mr Chaminda Silva Regional Officer Mannar	071 727 5345		
GSMB regional office	28	Mr S Kosala Kumar Regional Mining Engineer Geological Survey and Mines Bureau No 64 24, District Secretariat Office Mannar	077 257 1409 023 225 0611	[illegible]	
Department of Wildlife regional office	29	Mr W M K S Chandrarathne Asst. Director Regional Wildlife office (Anuradhapura Area)	071 442 4618 077 860 20283	keerthi_chandrarathne@yahoo.co.in	
SLSEA	30	Mr Chathura Wanniarachchi Assistant Director	0404755766	chathura.slsea@gmail.com	
		[illegible]	[illegible]	[illegible]	
University of Jaffna	31	Dr Hiranya Navarathna Department of Engineering Technology Faculty of Technology University of Jaffna	077 501 7656	hiranya@tech.jfn.ac.lk	
	32	Mrs. Saikrisha Koneswaran Department of Engineering Technology Faculty of Technology University of Jaffna		saikrisha@tech.jfn.ac.lk	
	33	Mr N Kapilsankar Faculty of Engineering University of Jaffna	077 737 9184		
Navy officer in charge for the district	34	[illegible]	[illegible]	[illegible]	
	35	Lieut (S) DSM Rodrigo	0763572465	[illegible]@gmail.com	

Airforce officer in charge for the district	36	Squadron Leader CAK Rasinath	0768190346	Kanishkarasinath3@gmail.com	[illegible]
	37	Captain [illegible]	0117430?5	[illegible]@yahoo.com	N/3
World Bank	38	Christopher John Lloyd			Attended
ORE Catapult	39	Brijesh Suryawanshi			Attended
HiDef	40	Jess Harvey			Attended
Pondera	41	Joost Starmans			Attended
RMA	42	Lakmal Liyanage			Attended
	43	Jeyakumar Eranmas			Attended
	44	Thirasara Gunawardan	[illegible]	[illegible]	[illegible]
[illegible]	45	[illegible]	[illegible]	[illegible]	[illegible]

World Bank Technical Assistance for Sri Lanka: Offshore Wind Power Development Phase II

Detailed Q & A session in Final Regional Workshop – Mannar

(Draft final report was disclosed to Stakeholders)

Date: 18.03.2025

Time: 9.30 a.m. – 12.45 p.m.

Stakeholder Agency/Group	**Questions Raised**	**Responses Provided**
Central Environment Authority (CEA)	People in the project area oppose development projects. Therefore, the awareness programs are needed to educate them. There need to be baseline studies to aware the people. Its good if this project is materialised.	There is no project yet. This is a very early stage & this early stakeholder engagements are planned to aware the key stakeholders. The project is 10 years away from the operational stage. There need to be baseline studies on fishing, birds etc. These studies need to be carried out in next phases. There are lot of studies in mature markets.
Assistant Divisional Secretary, Manthai West	Do you have any experience in similar geographical conditions? Is mining required in implementing the project? Mannar island is small, therefore, there is risk & danger.	North Sea is a geographical condition. However, every environment is unique. There will be different species & fishing practices…etc. There is not much information about SL yet. Not really. One type of foundation is gravity-based foundation. For these, little mining activities are required as there is no need of

Stakeholder Agency/Group	Questions Raised	Responses Provided
		piling. The project developer will consider all aspects required.
Central Environment Authority (CEA)	Blades makes noises? Will there be same structure & design for turbines? Is it possible to reduce the noise?	The project is offshore. Therefore, there will be no issue. The operational noise can be significant for the marine species. Underwater noise & vibration surveys need to be done.
Coast Conservation Department (CCD)	Who will be the project approving agency?	New jurisdiction and regulatory system is required. MoPE, SLSEA & CEB are leading the current assessments. There is not a project yet.
Dr. Hiranya, University of Jaffna	Out of two locations, Mannar & Puttalam, what site was selected?	The assessments have been carried out for both sites. As per the assessments, the Mannar site seem more suitable.
Navy	There is concern for the height of the turbines & location. These seem not yet finalised. Better to consult the Navy before finalising these in future.	Noted.
University of Jaffna	SL need to take this project. The current environmental & social issues such as fish & noise, birds…etc. can be mitigated with measures like bird radar implemented in Thambapavani. Project has a 25 years lifetime. If its not feasible, then SL can stop future projects. And, its good if corporate funding can be arranged. SL universities would	Have time to do capacity building later as this is not the project phase yet. Operational period of the project is further away.

Stakeholder Agency/Group	Questions Raised	Responses Provided
	also like to work with foreign companies like Catapult & Hi Def. Will WB do the capacity building? University also can assist.	
Study Team	Can there be a pilot project?	Lot of investment is needed for a pilot project. 500 MW is an optimal scale. Globally also countries are moving away from pilot projects.
Ceylon Electricity Board (CEB)	What is the cost for onshore Vs offshore?	In mature markets the cost reduced. This will not be the case for SL. There is lot of cost uncertainties. It is expected that there will be a cost reduction in offshore as currently it is higher.
Airforce	Is there a maintenance cost? Do we have that technology?	When the projects are 50km away, day boats can do maintenance as a day shift. When close to the shore, SL operation & maintenance of ports can do the job. 2-10 years of maintenance will be done by the company.

Captured moments from Mannar Regional Workshop on 18th March 2025

Appendix C7: Stakeholder Workshop Puttalam (March 19th, 2025) – Invitation Letter/ Agenda, Attendance Sheet, Q&A, Photos

Ministry of Power and Energy

Offshore Wind Power Technical Assistance Phase II: Pre-feasibility Assessment Stakeholder Workshop – II

Date : Wednesday, 19th March 2025
Time : 9:00 am to 12.15 pm
Venue : District Secretary's Office, Puttalam
Chaired by: District Secretary, Puttalam

The Background: The government has received technical assistance from the World Bank to conduct preliminary studies toward developing offshore wind power. A road map of activities was prepared in 2023, and presently, pre-feasibility study has been conducted. Mannar and Puttalam are two locations where offshore wind power possibilities are good.

The workshop: Developing offshore wind power projects requires careful planning to balance environmental considerations and stakeholder interests while ensuring efficient power transmission. Engaging with government officials is crucial, as they oversee project assessments, feasibility studies, and compliance with social and environmental safeguards. Continuous stakeholder engagement and transparent communication are essential for addressing concerns, and facilitating smooth project implementation.
Building on the first workshop held in March 2024, which introduced officials to the process of designing, building, and operating an offshore wind park, this session serves as a follow-up to present the findings of the pre-feasibility study and discuss the next steps for offshore wind power development. Experts from The World Bank, along with consultants from Pondera (Netherlands) and RMA (Sri Lanka), will share key insights from the study, covering technical, economical, regulatory, environmental and social aspects and guide the next phases of implementation.

Agenda

8.30 – 9.00	Registration of participants and tea
9.00 – 9.05	Opening remarks
9.05 – 9.15	Speech by the District Secretary
9.15 – 9.30	Introduction and context by the World Bank
9.30 – 11.00	Presentation by Pondera and RMA on the study findings
11.00 – 12.00	Stakeholder feedback session
12.00 – 12.15	Presentation by the World Bank on key takeaways and next steps

Tea and lunch will be provided.

Offshore Wind Power Technical Assistance Development Phase II: Pre-feasibility Assessment
Stakeholder Workshop - II
Regional Workshop (Puttalam) - 19th March 2025

Attendance Sheet

Stakeholder Agency		Reg No	Name & Address	Contact	Email	Signature
District Secretariat Puttalam		1	Mr. H M S P Herath, District Secretary District Secretariat, Puttalam	032 2265335, 032 2265235 (direct) 032 2265543	disputtalam@yahoo.com	
		2	Mrs. V D.C N Vithana Director Planning, District Secretariat, Puttalam	032 2265690	chinthavithana12@ gmail.com	
		3	Mrs. A D M Atapayake Assistant Director District Secretariat Puttalam	071 56 5403		
Divisional Secretariats of Coastal DSDs						
1	Wanathavilluwa DSD	4	Mr. S M P Nandasena Divisional Secretariat Vanathavilluwa, Wanathavilluwa	94 713437548	mi.anga377@gmail.com	
2	Puttalam DSD	5	Mr. S P Weerasekara ~~Assistant~~ Divisional Secretary (Covering up duties of DS) Divisional Secretariat Puttalam		dsputtalam@gmail.com	
3	Kalpitiya DSD	6	Divisional Secretary, Divisional Secretariat Kalpitiya, Kalpitiya. [illegible] (ADS)	032 493 4202, 032 226 0274, 032 226 0275 071 343 7648	[illegible]	

4	Munde. DSD	7	Mr. M.S.B.W.T.M.S.B. Malvila Assistant Divisional Secretary. (Covering up duties of DS) Divisional Secretariat Mundel Colombo Road, Mundel	032 205 2271, 071 930 4707, 071 2975400	[illegible]@gmail.com	
5	Arachchikattuwa DSD	8	Mrs. TAK Chandrika A. Divisional Secretariat Arachchikattuwa Arachchikattuwa	0322 259 709, 032 225 9760 032 4934343		
6	Chilaw DSD	9	Ms NRA Jayawickrama ADS, Divisional Secretariat Chilaw	032 222 2138 071 678 7990		
		10	Mr. A.M.C.M. ~~Premasoorya~~ [illegible] Divisional Secretary, [illegible] Chilaw [illegible]	[illegible] 705253457 [illegible]		
7	Divisional Secretary Mahawewa	11	Ms. D.W.M.M.S. Bandara Divisional Secretary Mahawewa	~~071 4279883~~ [illegible]	dsmahawewa@yahoo.com	
		12	Ms. M.A. Emasha H. Perera, Assistant Divisional Secretary Divisional Secretariat Mahawewa, Mahawewa	[illegible]		
8	Divisional Secretariat Nattandiya	13	Mrs. W.A.S.C.G. Janza, Divisional Secretariat Nattandiya, Nattandiya	[illegible]	[illegible]	
9	Divisional Secretariat Wennapuwa	14	Mrs. H.M. N. Herath Divisional Secretariat Wennapuwa, Wennapuwa	077 3901272		
		15	Ms YAC Pushpananda Assistant Divisional Secretary Divisional Secretariat Wennapuwa Wennapuwa	070 350 0001	achinipushpa@gmail.com	
Secretaries of Local Authorities						
10	Kalpitiya Pradeshiya Sabha	16	Mr. R.M. Ramanayake Kalpitiya Pradeshiya Sabha Kalpitiya	[illegible]	[illegible]	
11	Puttalam Pradeshiya Sabha	17	Ms. Mangalika Senevirathne Puttalam Pradeshiya Sabha Madurankuliya	076 7549303		

12	Wennapuwa Pradeshiya Sabha	18	Mr. Asela Gunarathna Technical officer Wennapuwa Pradeshiya Sabha Wennapuwa	031 225 5276 076 391 6015	[illegible]	
13	Chilaw Pradeshiya Sabha	19	Mr R M P N Ranathunga, Secretary, Chilaw Pradeshiya Sabha Chilaw	071 4094083		
14	Nattandya Pradeshiya Sabha	20	Ms. W A H Dilrukshi, Secretary, Nattandya Pradeshiya Sabha, Nattandya	032 225 4276	[illegible]	
15	Arachchikattuwa Pradeshiya Sabha	21	Mrs. Shirani Abeysingha Arachchikattuwa Pradeshiya Sabha Arachchikattuwa	032 225 9780		
16	Wanathawilluwa Pradeshiya Sabha	22	Secretary Wanathawilluwa Pradeshiya Sabha Wanathawilluwa	071 0569337		
	CEB	23	Mr. Krishantha Hemarathna DGM	071 429 8901	[illegible] mahesj123 mf@gmail.com	
		24	A M M D Arampath, CE	071 429 8844	mahindarampath@gmail.com	
		25	Ramal Amadoru ,CE (commercial)	071 429 8908	Ramal Amadoru@ceb.lk	
	Coast Conservation Department	26	Ms. Maduni Fernando Assistant Director, Area Office Coast Conservation Department Kakapalliya Chilaw [illegible]	076 2776084 032 2224225 [illegible]	[illegible]	
	Department of Fisheries	27	Mr. I M G S Chandranayake, Assistant Director Department of Fisheries and Aquatic Resources, District Office Puttalam	032 - 2265295 0769933193	sarath3022@gmail.com	
			Mr. S P Wickramarachchi Assistant Director Mahawewa	077 401 7 127 032 - 2054330		

Department of Archeology	28	Mr. M.G. Rathnapala, Assistant Director, District Office, Department of Archeology, Maliga Place, Kurunegala [illegible]	077 575 8219 [illegible]		[illegible]
GSMB regional office	29	Mr. Tharindu Warnasooriya, Regional mining Engineer, Chilaw	070 341 2505		
Marine Environmental Protection Authority Regional Office-Puttalam	30	Ms HMP Samarasekara [illegible] Manager Marine Environmental Protection officer, Marine Environmental Protection Authority Regional Office-Puttalam	HO 011 255 4000, 011 255 4373 Chilaw office: 032 22 22 865, 071 140 6600	[illegible]	[illegible]
SLTDA Resort Officer Kalpitiya	31	Manoj Ratnayaka, SLTDA Resort Officer, Kalpitiya	767606990		[illegible]
Regional wildlife office puttalam	32	Mr. Eranda Gamage, Assist Director, Regional wildlife office-puttalam			
SLSEA	33	Mr Chathura Wannearachchi, Assistant Director	[illegible]	chathura.slsea@gmail.com	[illegible]
		[illegible] Assistant Director	[illegible]	[illegible]	[illegible]
Navy officer in charge for the district	34	[illegible]	[illegible]	[illegible]	[illegible]
	35	[illegible]	[illegible]	[illegible]	[illegible]
Airforce officer in charge for the district	36	Sqn Ldr SAK Rashantha	0766804914	kavindurashantha3@gmail.com	Kavinda
	37	Sqn Ldr [illegible]	[illegible]	[illegible]	[illegible]

World Bank	38	Christopher John Lloyd		Attended
ORE Catapult	39	Brijesh Suryawanshi		Attended
HiDef	40	Jess Harvey		Attended
Pondera	41	Joost Slammons		Attended
RMA	42	Amila Wickramasinghe		Attended
	43	Lakmali Liyanage		Attended
	44	Bhasara Sirisinghe		Attended
	45	Thirasara Gunaruwan		Attended

CEA

World Bank Technical Assistance for Sri Lanka: Offshore Wind Power Development Phase II

Detailed Q & A session in Final Regional Workshop – Puttalam

(Draft final report was disclosed to Stakeholders)

Date: 19.03.2025

Time: 9.00 a.m. – 12.30 p.m.

Stakeholder Agency/Group	Questions Raised	Responses Provided
Marine Environment Protection Authority (MEPA)	Will there be oil spilling to sea? Then there's risk. If there's a risk, this risk needs to be reduced.	No. There is very little risk for this.
Assistant Director, Fisheries Department	Is there a plan to collect fisheries data? Then, what is the method?	There is no project yet. Once there is a project, WB also can provide guidance to collect data in future in a proper way. Getting data about livelihoods is important. In Puttalam, the proposed offshore project is close to the shore than Mannar site. In mature markets, there is large scale fishing & large amounts of fish. When using small scale fishing & traditional methods, people can do fishing during operational period also. In a project context, there will be an EIA and baseline data collection is important during that phase too. Collecting data on fishing is important as it is considered as a sensitive area during pre-feasibility. When doing Norochcholai power plant also, there was lack of baseline data to investigate post project issues.

Stakeholder Agency/Group	Questions Raised	Responses Provided
Central Environment Authority (CEA)	Need to consider about sustainable development. Puttalam is a sensitive area. There is no offshore wind experience but, there are onshore projects. Therefore, its better to study environment issues of onshore projects & its better to get comments from other organisations for the ToR. SL has old techniques in wind power plants. There need to be new techniques to mitigate noise & vibration & other impacts. The air-cooling systems specially are outdated. There are environment sensitive areas. Migratory birds come to Anavillundawa & other wetlands. Need to consider this in studies.	This is an early stage. Stakeholder engagement & consultations are important. This can be included as a recommendation to MoPE. In Phase II, the study team mainly consisted international experts. In phase III, there need to be more Sri Lankan expert/organisation involvement. There will be advanced techniques in offshore wind plants. At preliminary stages, the study teams try to understand these bird migratory routes. It is important to study these prior to the project stage.
Study team	SL grid is still developing and sometimes unstable. Adding 1000 MW, will the grid system overload?	In current context, it seems too large for SL. Its good to look in the need. In 10 years' time, SL power system will also change. Therefore, need to keep this option open. The interconnector with India is also a strong opportunity for SL.
Department of Archaeology	The coast in between Mannar & Puttalam is archeologically important. There have been old ports along the coastal line. The red soil & these	The importance is understood. In addition, there will be ship wrecks as well. As per the legal regulations in SL, Archaeology Impact Assessment can be carried out parallel to EIA. It is difficult to proceed with AIA at this stage without an exact project detail.

Stakeholder Agency/Group	Questions Raised	Responses Provided
	locations are important & need to be protected.	
Study team	LCoE, offshore wind is expensive compared to onshore wind. However, SL may have to move to offshore due to the limitations in land areas in onshore wind. And, there are environment issues such as birds in onshore projects as well. As government stakeholders, do you all think its needed & worth? When compared to solar, it lasts for 8 hours and need batteries to store. Therefore, combination of wind & solar is the best.	The solar power cannot be absorbed to the grid although we have the potential for solar power generation. However, rate of return needs to be considered. The land area is limited and at one point, may have to stop onshore projects. There are issues of onshore projects for tourism due to shadow flicker & noise. The remaining capacity for onshore is 50 MW. The land area for a 500 MW project will be higher. If we can move to offshore mitigating environment and social impacts, its better. The cost needs to be studied by relevant professionals. SL has to move with the latest technology. If the lifetime of old wind turbines is over, those need to be removed. And, the coastal areas are already having many onshore projects.
Study Team	Will the cost of offshore wind reduce in future?	Three years ago, the inflation was high in Europe. The prices of offshore wind were high. The cost modelling was done for that. The offshore wind cost needs to come down for it to move forward.

Stakeholder Agency/Group	Questions Raised	Responses Provided
Secretary, Pradeshiya Sabah, Kalpitiya Tourism Development Authority	Kite surfing is popular in Kalpitiya. And also, the whale watching. Will those be affected by the offshore wind project?	The kite surfing is very popular around the world. If the two sites Mannar & Puttalam are considered, there is sufficient area for kite surfing in between two sites. And the impact from offshore wind for kite surfing is very low. However, this can be further studied in next phases. The whale watching will also not be affected.
Coast Conservation Department (CCD)	Will sea erosion increase/decrease due to the project? What is the experience in other countries?	There is no high risk. The location of project, the type of foundation needs to be studied. There will be no excavation of sea bed for installation. In other countries, this is a concerned area as well. EIA need to look in to these aspects. It's important to consider this when installing onshore cables.
Navy	In Chillaw & Arrippu, there are radar points. Will offshore wind project affect the radar points?	Yes. There are technical solutions that are developed in mature markets such as updating software & upgrading radar systems to ignore turbine locations. And, additional radar locations can be installed. EIA can look in to existing radar systems, impacts & mitigations. SL government need to attend to these with clear regulations to the developer.

Captured moments from Puttalam Regional Workshop on 19th March 2025

Appendix C8: Stakeholder Workshop Colombo (March 20th, 2025) – Invitation Letter/ Agenda, Attendance Sheet, Q&A, Photos

Ministry of Energy
Offshore Wind Power Technical Assistance Phase II: Pre-feasibility Assessment
Stakeholder Workshop - II

Date: Thursday, 20th March 2025
Venue: Ruby Hall, BMICH
Time: 8.30am to 01.00 pm

The Background: The government has received technical assistance from the World Bank to conduct preliminary studies toward developing offshore wind power. A road map of activities was prepared in 2023, and presently, pre-feasibility study has been conducted. Mannar and Puttalam are two locations where offshore wind power possibilities are good.

The workshop: Developing offshore wind power projects requires careful planning to balance environmental considerations and stakeholder interests while ensuring efficient power transmission. Engaging with government officials is crucial, as they oversee project assessments, feasibility studies, and compliance with social and environmental safeguards. Continuous stakeholder engagement and transparent communication are essential for addressing concerns, and facilitating smooth project implementation.

Building on the first workshop held in March 2024, which introduced officials to the process of designing, building, and operating an offshore wind park, this session serves as a follow-up to present the findings of the pre-feasibility study and discuss the next steps for offshore wind power development. Experts from The World Bank, along with consultants from Pondera (Netherlands) and RMA (Sri Lanka), will share key insights from the study, covering technical, economical, regulatory, environmental and social aspects and guide the next phases of implementation.

Agenda

8.30 – 9.00	Registration of participants
9.00 – 9.15	Opening remarks
9.15 – 9.30	Introduction and context by the World Bank
9.30– 10.30	Presentation by Pondera & RMA on study findings
10.30 – 10.45	Tea break
10.45– 11.45	Presentation by Pondera & RMA on study findings (Cont.)
11.45 – 12.45	Stakeholder feedback session
12.45 – 13.00	Presentation by the World Bank on key takeaways and next steps

Tea and lunch will be provided.

"This attendance list together with your contact details will be included in the pre-feasibility study report. The World Bank may contact you during subsequent studies related to offshore wind development in Sri Lanka."

Offshore Wind Power Technical Assistance Development Phase II:
Pre-feasibility Assessment Stakeholder Workshop – Colombo, 20th March 2025 at BMICH

Attendance Sheet

No.	Organisation	No. of Participants	Name & Address	Contact	email	Signature
1	Ministry of Energy	1	Secretary			Attended
2	British High Commission	1	Commissioner			Attended
3	Central Cultural Fund	2	Mr HAC Goyan	070 454 2955	ccfinform@gmail.com (DG email)	
			Rasika Muthukumarana	071 810 0690	muthurasika@gmail.com	
4	Central Environmental Authority	2	Ms Priyangani Gunathilake Acting Deputy Director General (EMA)			
			Ms. Nilmini Attanayake Director (EIA) Environment Impact Assessment Unit	071 610 6646	nilmini@cea.lk	

			Mr. W. Edussuriya (CM)	776455969		
			~~Mr N. S. Weerasinghe,~~ AGM(Tr-NOW)			
			Dr. H M Wijekoon, DGM(TGP)	071 411 5592	Wijekoon.Banda@ceb.lk	
			Mr Eranga Jayarathna, CE (GP)	071 152 9429	Eranga.Jayarathna@ceb.lk	
			Ms D P Liyanage, EE(GP)	071 830 5004	Dilini.Liyanage@ceb.lk	
			~~Mr. Sachitra Peiris,~~ CE(REP)	071 490 8906	Sachitra.Peiris@ceb.lk	
5	Ceylon Electricity Board	16	Mrs. Tharanga Wickramarathne, PM (Mannar & Pooneryn Projects)	071 832 3384	Tharanga.Wickramarathna@ceb.lk	
			Mr Ajith Alwis	071 415 0639	amaawpsm@gmail.com	
			Mr Asela Jayasinghe	071 536 0308	Asela.Jayasinghe@ceb.lk	
			Eng. Chinthaka J Dissanayake		chindissa@gmail.com	
			Ms W G Pavithra, EE(TP)	071 125 7390	Pawithra.Gamage@ceb.lk	
			Mr D R K Bowatte, EE(TP)	077 235 2784	Darshana.Bowatte@ceb.lk	
			Mr K A M N Pathiratne, EE(GP)	071 875 5949	Mevan.Pathiratne@ceb.lk	
			Ms M D V Fernando, EE(GP)	071 123 5751	Dilini.Fernando@ceb.lk	
			Mr Vidura Samandara	0712130224	vidurasamandara@gmail.com	

			Mr. Dulan Lakshitha, PM (Siyambalanduwa Project)	071 687 6177	Dulan.Lakshitha@ceb.lk
			Mr. Manuj Wijerathne, EE (REP)	071 606 1764	<Manuj.Wijayaratne@ceb.lk>
			Mr Pushparuban Panchadcharam	071 568 3384	<pushparubanp2@gmail.com>
			Ms Chathuri Rajapakse	077 265 1566	<chathurir@yahoo.com>
6	Civil Aviation Authority	2	Ms Uttara Narmada Kumari	011 235 8802	cdrao@caa.lk, dgcoffice@caa.lk, dae@caa.lk
			Civil Engineer		
7	Coast Guard Department	0	To be received	0117 199 800, 041 750 1217	dgcghqstaff@gmail.com/ dgcg@coastguard.gov.lk
8	Department of Archaeology	1	Ms. Udeni Wickramasinghe Department of Archaeology	011 269 2840	udeni.rupika@yahoo.com
9	Department of Coast Conservation and Coastal Resource Management	2	Eng. Sakuntha Pathmasiri Chief Engineer	0112 449 754, 071 641 7083	sakunthaceepal@gmail.com

			Mr. K.H.R. Sriyantha Asst. Director (Coastal Resource Management)	071 810 0339	sriyanthakhr@yahoo.com	
10	Department of Meteorology	1	Mr. A.L.K. Wijemannage Director	0112 694 846, 0710333088	ajithlkw@yahoo.com	
11	Department of Fisheries and Aquatic Resources	2	Ms KACP Chathurika, Assistant Director	112 445 183 (Ext: 200), 070 170 9024, 071 103 8044	info@fisheriesdept.gov.lk chathurika86kacp@yahoo.com	
			Mr. Buddhika Abeyarathna Director Fisheries Development Division	112 472 199 Ext: 271 0714 969 572	buddhikamgr@gmail.com	
12	Department of Wildlife Conservation	1	Ms. Heshani Sumarathne AD(NRM) Department of Wildlife Conservation	112 868 585	heshanidwc@gmail.com	
13	Geological Survey and Mines Bureau	2	Prof. H.M. Ranjith Premasiri Director General Geological Survey and Mines Bureau	011 288 6271, 0112 886 289	dg@gsmb.gov.lk	

			Ms. Deepani Weerakoon Senior Geologist Geological Survey and Mines Bureau	011 288 6289 / 886 290 077 757 7337	dpoweerakoon@gmail.com	
14	Lanka Hydraulic Institute Ltd	1	Dr. Sanjeewa Wickramaratne Senior Specialist Coastal / Water Resources Engineering Lanka Hydraulic Institute Ltd	0112 650 409, 077 777 3914	sanjeewa@lhi.lk	
15	Marine Environment Protection Authority	1	Dinithi Gunasena	0112 554 006,	[illegible]	
16	Merchant Shipping Secretariat,	1	Mr. Pradeep Chandana Director (Engineering) Merchant Shipping Secretariat	0112 441 429	pvtpchandana@yahoo.com	
17	Ministry of Defence	1	Maj Lakmali	[illegible]	[illegible]	
18	National Aquatic Resources Agency	2	Dr. B.P. Prabath Jayasinghe Head, Marine Biological Resources Division	+94-11-2521914, 0112 521 001	prabath_jayasinghe@yahoo.com	

			Dr. K.A.W.S. Weerasekara Head, Environmental Studies Division	94 719353169	shyamalikaww@nara.ac.lk	
19	National Building Research Organisation	1	Ms. Narmada Indeewari Liyanage Scientist (Geologist) National Building Research Organization	0112 588 946, 071 852 7019	narmada.ged@gmail.com	
20	National Physical Planning Department	1	Mr. Chaminda Kularatne Director Engineering			
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	KMA	10	[illegible]	[illegible]	[illegible]	[illegible]
			[illegible]	[illegible]	[illegible]	[illegible]
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World Bank Technical Assistance for Sri Lanka: Offshore Wind Power Development Phase II

Detailed Q & A session in Final Workshop – Colombo

(Draft final report was disclosed to Stakeholders)

Date: 20.03.2025

Time: 9.00 a.m. – 1.00 p.m.

Stakeholder Agency/Group	Questions Raised	Responses Provided
Sri Lanka Sustainable Energy Authority (SLSEA)	Southern area is excluded in the pre-feasibility study. Is there a good reason for this?	Southern area was included in the earlier study of road map. This study looked at Mannar & Puttalam. As found out in the road map, there are legally protected areas & thus, ecological constraints in the southern region. Therefore, priority was given to the Mannar & Puttalam sites.
Prof. Wijepala,	The levelized cost for offshore wind is higher than the onshore wind? How do you compare this with UK scenario? specially the cost of offshore in UK?	There's large range of uncertainties in our calculations. The time this study was carried out, globally the offshore wind cost is higher than 5 years ago due to high interest rate, capital cost & high commodity prices. Now the offshore wind market is normalising, offshore wind rates are coming down. There is an expectation that offshore wind market will come down. The initial project cost is higher due to capital cost, supply chain etc. Offshore wind cost cannot be comparable to onshore wind. Need to consider impact on the environment & wider economic benefits.
Mr. Prabath, National Aquatic Resources Research & Development Agency (NARA)	Two areas that you have selected are very shallow areas where the biodiversity is very rich, other than marine mammals and avifauna. Therefore, suggest to get the baseline data as already mentioned.	In future scope of works, the ecology & other aspects will be considered and it is presented in later slides also.

Stakeholder Agency/Group	Questions Raised	Responses Provided
	Fishing, especially in the Puttalam site is very extensive. As mentioned, there are various fishing techniques as well. Therefore, need to consider these in next phases.	
Sri Lanka Sustainable Energy Authority (SLSEA)	It seems that the turbine capacity is 10-15MW. If 1-2 turbines stop, the loss is very high. Without going for less capacity, why we are going for large capacity? It is going to step up in onshore. That means that the loss can be high. Without considering that, why we can't step up inside the turbine/why not consider that design?	Currently, what SL has, the largest is 3.6 MW. But, if you start a wind power project, the wind turbine supplier will offer is minimum 5MW even for onshore. Here, we are considering 2035. At that time, the 10-15MW will be lower level. Even now, 10 MW is the lowest offer for Offshore wind considering economies of scale & considering the size of the project. Even if we consider 1-2 turbines being out, although its 15 MW, it is out from 250MW large power plant. In that way, what you lose is not a high %. And, maintenance cost will be very high if there are many small wind turbines. It is the industry standard to have large turbines. In today's context, this seems large but, internationally those are not that large. If we have large turbines with high capacity, we can have less turbines. Low cost for investment, installation. And, in operation and maintenance stage, we need to look after few wind turbines, not many. And it will reduce cost. If the turbine is 690 – 800, it is done. It will be stepped up. What we have assumed here is unit transforms that turbine to be stepping up to a much larger voltage than what we do at the moment. These unit transformers will be stepping up, but, not to 220. Therefore, we have to collect at 132 KV or other somewhere. That's why we do not go for offshore wind conceptually. If its otherwise, the project may decide, but as of now, given the close proximity to the shore, these power plants, if the voltage level we are using for interconnector is 132 KV, we can manage with an onshore substation which is going to be much

Stakeholder Agency/Group	Questions Raised	Responses Provided
		easier for maintenance, cost wise much cheaper. In Mannar, we think to have it close to the existing Mannar substation. So, the connections between these existing facilities are much easier. In terms of loss, the 132 KV, we are thinking of having strings, arrays to be connected with substation. So that, it's not going to be one cable bringing 500 MW but, it's going to be several arrays connecting at the substation. In that case, the loss will be less. This is the most optimum design we have come up with at the moment. These will be further studied at feasibility & development stage.
Ms. Preeni, Petroleum Development Authority (PDA)	When it comes to marine acreage planning, it will be based on collaborative concepts or based on competing interest? These projects will come in 10-20 years' time, at that time there will be high revenue projects such as hydro carbon exploration, mineral exploration. How these projects can be handled to manage the acreage?	The marine space is coming to increasingly utilised in future. It is also there in the mature markets. How offshore wind interact with things like oil & gas exploration/exploitation? In last 5 years in mature markets have seen conflicts between these energy extractions and it have not materialised. In last 5 years, there have been entrance of oil & gas in European mature markets & offshore wind development. Have seen these two activities have aligned together. We now have projects, being developed in a later stage where power is exported to/through oil & gas. So previously competing technologies were aligned & working well together. In the event that oil & gas is found in SL, that does not mean that there cannot be close alignment with offshore wind. Pondera: Internationally, we have increasing requests from oil & gas companies to be powered by offshore wind.
Prof. Kamal Ranathunga, University of Sri Jayawardanapura	Being a marine ecologist, South of Mannar, the area you have identified as the most potential area is the same area that you can see the most of the sea grass beds as well as the habitat for the	Have looked in to presence of sea grass & coral reefs. As per the information, project areas are located outside of these main seagrass & coral reef areas. However, there's uncertainty involves around it, we have to look at what kind of habitats located in the project in future surveys.

Stakeholder Agency/Group	Questions Raised	Responses Provided
	dugongs. And there is a network of coral reefs in the same area. Wankkalai, Arripu and Silawathurai are all interconnected. Therefore, the project needs to think of lot of alternative places in the same area. Ecological surveys, the condition in SL is that its shallow waters. It's not easy to do ecological surveys, using planes unless its LiDAR surveys. Lot of sedimentation is there, you won't see anything under water even for a LiDAR survey, unless it's a proper time, it's not easy. It will be really challenging. Even the LiDAR might not work sometimes. You need to consider these in later stages.	There's local knowledge on challenges that can be faced during surveys such as sedimentation & water. There are certain methods to measure water depth. Therefore, the local partners and Sri Lankan companies/organisations will be fully involved in the next phase to do the surveys. Although international experts can bring expertise on international markets, we need the SL experience to meet the next phase a success. The level of engagement of SL experts on this in next phase will be high.
Mr. W.K.D. Wijenayake, Ports Authority	As mentioned, the ports infrastructure needs to be developed. You mentioned Wellamankaya could be developed to supply offshore vessels. Need to know the main points you considered to select that location? Ports Authority have planned to develop port of Mannar considering interconnectivity between India & Sri Lanka. Still, we have not found any financial return. This will be a good	As mentioned, the study looked at different kinds of ports. For each port, a list of requirements was made. And it's a combination of many different factors. How easy it is to enter, depth of the port, how big the area is to store the large components of offshore wind, distance to the project is also important. And we categorised ports as fabrication ports, marshalling ports...etc. And based on these factors, the ports were selected. For fabrication ports, need to have a minimum water depth of more than 12m for large vessels to bring components in & out. Trincomalee is in the East coast, it was discounted due to the distance & thus, it's not economically viable. Port of Mannar is north of Adam's bridge,

Stakeholder Agency/Group	Questions Raised	Responses Provided
	option, can provide more details. And, also the Trincomalee port is also there for supporting wind mill transportation?	thought that the vessels should not cross through Adam's bridge and port Mannar was removed for that reason. For operations & maintenance, the requirements are less. The water depth would be 4-5m. Ports in South side of Mannar or Puttalam can be considered.
Tourism Development Authority	Two areas that you have selected are very important in terms of future tourism development. With the predicted numbers of tourists for the next 5-6 years, we are looking at developing new attractions & locations. If we take Puttalam, closer to Kalpitiya, we are in the process of developing an island resort & currently 5-6 investors are in the approval process. Mannar, we are thinking of acquiring a land and developing a theme resort 3-4 years. By the time this project comes, two resorts will be in operation. We are also launching marine tourism road map within next 2-3 weeks & Mannar is a key location in this map. Considering all these factors, I think with regard to tourism, two locations will be vital & important for the future. Historically, we see that, these projects come later in 10 years' time, by that time the tourism projects are in operation. Then, tourism service providers face difficulties. We	This will be considered in future engagements. And, will have a follow up meeting with Tourism Development Authority on how we can incorporate these in the future process.

Stakeholder Agency/Group	Questions Raised	Responses Provided
	understand that you have contacted regional tourism stakeholders, it is not only the existing stakeholders, as you are looking ahead for 10 years, it will be important & good to have more detailed one to one discussion on future plans which regional stakeholders may not know. Both projects are important for the country. This is to make sure that investors are not having difficulties in future. We are open for a detailed discussion.	
Mr. Indika, Centre for Environment Justice	It is noted that consultations have been done in Mannar & Puttalam. Want to know the initial feedback. Want to know whether you have approached the fishermen as well, as they are an affected group. Based on previous experiences in Mannar, they complained about decreasing fish stocks in the area & shadow flicker impact is also there. What is the initial feedback from stakeholders such as Divisional Secretaries…etc.	Had discussions with government officials, although we identified affected people, thought its best not to reach them at pre-feasibility stage. At a later stage, we are hoping to do consultations with them. Had a good discussion with government officials such as District secretaries, Divisional Secretaries…etc. The issues of fishermen were also discussed. Officials also suggested to aware the people properly. And they also suggested to collect more baseline data as we need to have more scientific/specific data to talk to affected people.
Mr. Kularatne, National Physical Planning Department	UNDP employed a consultant, marine resource organisation. They carry out a marine spatial planning in Western and Northern waters. Have you had any collaboration with them?	We have lot of collaboration with Marine Management Organisation from UK. They are doing a pilot marine plan for North West region. We are working with them in last 6 months to explain the findings of the study, so their work can align with ours & we shared the draft report also with their organisation to make sure that work they are planning is built on the findings of this study.

Stakeholder Agency/Group	Questions Raised	Responses Provided
Mr. Thusitha, Ceylon Electricity Board (CEB)	Regarding pilot or pathfinder projects identified in feasibility report, the capacity is around 500 MW. Considering grid capacity & other aspects, is there any possibility to identify or plan a park with 500MW or higher? Implementation can be stage wise, please comment on this? Is it possible or what are the repercussions? In terms of supply chain, installation, vessel & other related equipment, will there be any restrictions for that?	The reason for 500 MW is because it's a *block size* in offshore wind terminology. Traditionally, this is the maximum amount of power that you can put through in an offshore substation & therefore, if anyone want to build an offshore substation, you need to work through most amount of power through that substation, otherwise its economically not efficient and that's the rational behind 500 MW option. There is much flexibility in terms of the capacity. We have done the assessment on 500 MW, but that's not to say that you cannot develop a 200 MW project or 400 MW project in any of those areas as the first project. You also asked about larger projects in phases, and it is something common in mature markets. Its not so relevant in Puttalam, as we see that the capacity is limited to 500 MW but, for Mannar, the total capacity over time, would be 1500 MW. That could be a single project that develop in stages. So, that option is available & it comes down to procurement options. You might find that the developed interest is more in 500 MW project, to test the environment, development opportunity you might find that the developer is interested in larger project, that they can develop over time. Something to be considered in part of regulatory framework particularly the procurement method, how you chose to procure the larger projects. For the supply chain, its an improvement. You can take longer term investment with suppliers. Suppliers think that they are going to be supplying 500 MW over 3-4 years of construction, that provide them a valuable opportunity to know that they are going to provide 500 MW of turbines of one year of installation. So larger projects have a grater appeal to supply chain. The consideration that it depends how that

Stakeholder Agency/Group	Questions Raised	Responses Provided
		supply chain is set up, if there is a lot of demand in purchasing turbines & foundations which might be the case if we see the development of offshore wind in Thamilnadu & SL at the same time. More development looking to buy turbines than supplies capable of delivering in which case trying to buy 1500 MW turbines might be more difficult than buying a smaller number of turbines & how your opportunity to fixing turbines supplier's ability to buy a consideration that you want to make much closer to having an understanding on what a supply chain looks like. At the moment, there is no supply chain for offshore wind in the region. So, we shouldn't make any early decisions until we understand what regional supply chain looks like.
Mr. Chamila Jayasekara, Sri Lanka Sustainable Energy Authority (SLSEA)	Provisions of the SLSEA act. It is mentioned it's a grey area? Why there is no concrete solution? As we are at a conclusive stage at this pre-feasibility, why final report can say act covers or not? If it does not cover, easiest way is to do necessary amendments on the existing SLSEA act to bridge the necessary gaps rather than going for a new offshore wind act & again creating another institution for necessary activities for offshore wind commission? SLSEA act itself identifies the organisation as a facilitator as well as the regulator.	Right now, what we understand in the act is that it doesn't encompass offshore areas, it only encompasses onshore areas because those are to be defined as meets and bounds. The metes & bounds of the land area as oppose to offshore. We do understand that there's lot of activities going on to amend that particular provision in SLSEA act where currently the metes & bounds are created by the recommendation of the minister of the SLSEA. When it comes to onshore, the declaration will be by the president on the recommendation of the minister. If we see that amendment, then yes. There is no grey area there & it will be law. But, until then, whether you can use this provision, because we hinging it on this metes & bounds to understand more onshore as opposed to offshore, we see it as more onshore & therefore, we would like to see that amendment making it more explicit. Why new act: SLSEA play the regulator role as they grant the energy permit. SLSEA should not be involving in developing one particular technology. SLSEA is the renewable regulator across the board for

Stakeholder Agency/Group	Questions Raised	Responses Provided
		different technologies. Therefore, it should be more technology specific act that is looked at for offshore wind. Having said that SLSEA does have wide sweeping powers & objectives but, have to relook at those, recalibrate those to really identify what does SLSEA do in terms of its powers and how it exercises it more in the regulatory realm. And have many technology specific laws or other different renewable technologies that we can look at in the future. Some of the powers that the act has, have not been used in the past. Therefore, we don't know how those powers translate in to practice. We would like to see technology specific act, as then it creates purpose related bodies & institutions to support this technology as opposed to renewable regulator playing diverse roles. Then it's difficult to put the laws in to practice. Its better SLSEA have the capacity of regulator & then work to its full potential there.
Mr. Surath Ovitigama, Former Chairman Petroleum Development Authority (PDA)	Why establish another entity rather than empowering SLSEA? Earlier there had been discussions on management of Offshore space. For long time, it was PDA doing the block maps & operating alone. Now there is so much competition for same seabed. Whether its worth elevating it even higher within government as a recommendation? There is marine spatial planning as well equivalent of seabed authority that will make all these crucial decision for every bit of seabed? Whether its offshore wind, oil & gas ecologically sensitive	We looked at an independent body for marine spatial planning because otherwise its first come priority. There are different competing interests. We see that PDA taking the lead and how it will go with offshore wind sites, and other geological & mining related activities. It's important to have an independent body to evaluate the process & to prioritise. We see that it's really important to understand who get what first, there was question on the tourism development. Etc. Right now its very decentralised and doing their own. If we can have a body, that looks at all different activities in this one space, I think we can have a coordinated approach. And, it has to be that. The idea of this workshop is to stimulate the discussion rather than making recommendations. SL can decide for itself in future. What we

Stakeholder Agency/Group	Questions Raised	Responses Provided
	areas, tourism. What would be your recommendation to SL after studying other jurisdictions to manage marine area carefully from the outset. It is important to manage it aligning with national priorities & sensitivities? How many projects do you think there will be in SL? I ask that with the background of how much governance structure have to be in place if they're going to be 2-3 big projects which can be handled as case by case basis. In UK, final call was made by Minister for Energy Security. With all the sensitivities, who will make the final call?	have seen in mature markets is that developers like clarity & certainty on how things happen and how things will be managed and handled as there are huge risks associated with developing offshore wind farms in terms of financial upfront, before projects get approvals, amount you spend in constructing before you are operating & earning revenue scheme. And, developers are managing lot of risk associated with offshore wind significantly more than other forms of generation. And what they say is they want clarity. They need to know, if there's uncertainty in regulation or decision that is made. Those are challenges for them. Therefore, clarity is important. That's why we see mature markets move towards specific provisions and specific legislation to deal with offshore wind. You don't have to go down that rule, but, there's rational. It is still the mechanism in UK. But the process leading to that final call, industry understand what the process is and even see the information that goes to the minister's decision. Its about that clarity. It's a political decision at the end of the day. In answering how many projects? And you need to wind up how much competition you won & how much of a good opportunity you want to present to developer to develop. Assuming, you have gone through a very well process of deciding a site, establishing regulations, you got a procurement process that we have seen around the work that competitive procurement process work well. And, in terms of how many projects, capacity that is available in SL, it could be anything from whole of Mannar & Puttalam to one organisation & phase the development. Could be anything from one developer doing 4 phases of project 500 MW blocks, one in Puttalam, 3 500 MW blocks in

Stakeholder Agency/Group	Questions Raised	Responses Provided
		Mannar. But we know that the grid is not ready for that level of capacity. You could also split that down in to more multiple projects, smaller projects, you could start with single project in Mannar & work through that. The central figure for project would be four. But, 2 GW and we are not ready for that and therefore, may be less than that. One thing that link to this is why we make strong recommendations in the pre-feasibility study about the link to India. These choices about how big the project is when they come through are like less critical because you are part of the regional market. There's lot of development going on port, manufacturing development, and there would be a pathfinder project that regional industry where SL is part of. SL create a part of ease for managing these questions. If SL on its own, SL has to think of how to get the projects on the right side, as it is a much more difficult challenge. You can generally have 500 MW projects, that could be billed. And, then the period of time after that where nothing gets to SL. If SL is the only market, then it's terrible for the supply chain. Producing things, and nobody buying.
Mr. Prabath, National Aquatic Resources Research & Development Agency (NARA)	My concern is on the ecology. You mentioned that only marine mammals, birds & bats are considered mostly. As we know the gulf of Mannar is a bio diversity high area. I think we need to consider doing thorough bio diversity assessments before the project. Having the baselines is important. In addition, the baselines of water quality also need to be taken. NARA also have past data & we have the capacity to assist also.	When the feasibility studies started, prior to a project, it is important to take all these ecology items in to consideration. In next phases, the priority is to focus on key items. Good to hear about the data availability at NARA & willingness to take part in survey activities.

Stakeholder Agency/Group	Questions Raised	Responses Provided
Mr. Madawa, Environment Foundation Limited.	It is mentioned that developers have to do the surveys. The past experience shows that this haven't worked in many major projects. When the developer do the surveys, if the EIA fails, the project fails as well as the project cannot move forward. I suggest to do a strategic environment assessment, not only considering environment aspects, but, also the social aspects. And to identify certain areas as if we take Mannar, it's a sensitive area both ecologically & socially. Therefore, better to do a strategic environment & social assessment to identify most suitable areas within that area. If its not suitable, can move in to another area. During the Pre-feasibility study, have you all planned some studies as such or will there be any studies done? And, if studies are going to be done, what is the period of the study. As you know ecology changes. We have a great bio diversity & studies have to be carried out for a period of time.	During pre-feasibility, we have not carried out any studies. What is presented is to identify the key risk areas that we see that need more efforts. And, those are the ones that we recommended in future scopes of works for future surveys. This phase is before we start the surveys, so that we know what surveys we need to do? How are they need to be designed. The next is phase III, starting to collect data and whether it has the terminology of Strategic Environment Assessment or not. The collecting data for scientific assessment & questions to be answered before a Project EIA comes on board. In places where the offshore wind is new, its difficult establish a robust environment baseline or ecological assessments. If you go straight to project development, EIA can't answer many questions as it should do as there's no evidence behind that. The purpose of this phased gradual approach is that we can identify areas that we really need to focus on biodiversity and strategic impacts. When it comes to the project level work, it has a stronger foundation to build from.
Ceylon Electricity Board (CEB)	You referred to wind reservoirs in terms of wind speed 8.5 feet per second in Mannar & Puttalam areas. Its good if you show the plant factor to see the attractiveness of these sites as already	The main purpose behind the work we are doing to support SL in understanding offshore wind opportunity is to do what you suggested. To create this opportunity for areas of seabed to be leased out to developers for them to find its way in to the economy and in to the power system whether that means power going in to SL or power

Stakeholder Agency/Group	Questions Raised	Responses Provided
	Mannar is having about 40% plant factor, Puttalam 36% plant factor. Compared to some places in the world, these are best locations for wind development. Financing these projects bringing finance will be impossible in next 10-15 years as there will be no financeable PPAs & no government guarantees. SL government guarantees will be taken serious in the international market in next 10 years. So, these will be almost impossible task. But, if the interconnection comes in 500MW *2, may be SL should consider leasing out these spaces on royalty to develop on timely plan may be 20 years. May be Indian developers, who has already shown interest in SL wind reservoirs to lease out these locations and develop projects and to sell energy in the market may be to Indian market or open market with the south Asian grid that will be developed. I think that will be more marketable. In finalising your reports, I would like if you think of different market models that could be practically feasible rather than going on other types of projects which will never come in next 10-15 years under these financial circumstances.	going in to India. These are questions for later times. Really what we are saying at this stage is offshore wind is an option in all of this landscape for SL. We are not saying to go for offshore wind, we think it's a good option for SL. We have tested the many key barriers that exist in mature markets and we found that nothing is red flag or show stopper. No major issue in terms of offshore wind development here that can't be sold & some of the issues we see around, the bankability of selling the power. We have recognised that there are particular challenges in SL at the moment. But, we see these in all mature markets on bankability of offshore wind. And, it's something that we have optimism, to be sold over next 10 years. Actually, when looking to commission offshore wind power plants. That's something for the future. If you want to have that opportunity in 10 years' time to have offshore wind, the world would be different. The price of coal, the price of gas would be different. If you want to have the opportunity of offshore wind at that point, you need to work now. If you think that offshore wind will be there in future & do nothing now and 5 years after you will think that the offshore wind is more attractive & can work with this. Then, its too late. Then it takes 10 years again. These things about regulatory updates & establishing mechanisms for stakeholder engagements to decide what's going on, undertaking wind resource assessments to understand economic in more detail & understanding the ground conditions. These are the foundational blocks that need to be undertaken now in order to give SL an opportunity for offshore wind in medium term in 10 years or so time.

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Ms. Prini Vitanage, Petroleum Development Authority (PDA)	This is a suggestion. Now we have already initiated a good marine special planning. Why not we think of another step? To covert it to a marine spatial management authority where multiple projects in offshore acreage could be managed by this authority as they have already initiated the planning. The regulatory aspects of managing multiple projects in specific acreage. And there can be projects, where they can dictate exclusive rights. It is very advantageous to have focal marine management authority where they could look in to all these terms & conditions. We also heard that there are tourism projects also that we are unaware. It will be good for you all to think how well you could work within this context, legislatively as well as commercially managing the acreage as well as how well we could take terms rather than hindering other projects.	In regulatory gap analysis report, we have this discussion where we recommend marine spatial planning authority. And in report we go in to more specific to who would constitute this authority drawn from different planning institutions like PDA, tourism authority...etc. The institutions who will have representation in this body will have a voice & collectively then you can prioritise, how to go about planning this marine space.
Mr. Kelum, Ceylon Electricity Board (CEB)	Looking at the potential maps, we can say that Tamilnadu, India also sharing the same potential for offshore wind. Wonder why India is yet to develop their offshore wind potential.	India has good potential in Tamilnadu. And there is ongoing tender at the moment where they have invited bids, government funds in terms of viability gap funding to those first projects that they are hoping to come through in Gujarat & Tamilnadu. Some recommendations that we making in SL is clear regulatory setup, what is expected of developer to do in order to get a permit & to construct is not clear in India as it is not clear in SL. So, developers look at that and there is a

Stakeholder Agency/Group	Questions Raised	Responses Provided
		risk & they are cautious about their willingness to invest. Part of this work in SL is to understand those risks & uncertainties. The things we already discussed in presentations today. They all need to be solved, in order to market to look attractive. That is not there in India at the moment.

Captured moments from Colombo Workshop on 20th March 2025

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