Philippine Market Movers

An analysis of three high potential areas to accelerate the offshore wind market in the Philippines

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Authors and Acknowledgments

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RMI's Catalytic Climate Capital program (C3) is leading the initial launch and management of project preparation and development facilities in the Caribbean, sub-Saharan Africa, and Southeast Asia, targeting a 10 gigawatt project pipeline in three years.

This report stands as a testament to the collective efforts of those mentioned above, and RMI is grateful for the positive impact each individual and organization has had on this endeavor.

About RMI

RMI is an independent nonprofit, founded in 1982 as Rocky Mountain Institute, that transforms global energy systems through market-driven solutions to align with a 1.5°C future and secure a clean, prosperous, zero-carbon future for all. We work in the world's most critical geographies and engage businesses, policymakers, communities, and nongovernmental organizations to identify and scale energy system interventions that will cut greenhouse gas emissions at least 50 percent by 2030. RMI has offices in Basalt and Boulder, Colorado; New York City; Oakland, California; Washington, D.C.; and Beijing.

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Abbreviations

2020 CPH	2020 Census of Population and Housing
BESS	Battery energy storage system
Capex	Capital expenditure
COD	Commercial operation date
CTS	Cable terminal station
DA-BFAR	Department of Agriculture Bureau of Fisheries and Aquatic Resources
dB	Decibel
DENR	Department of Environment and Natural Resources
DOE	Department of Energy
EPC	Engineering, procurement, and construction
EVOSS	Energy Virtual One-Stop Shop
FID	Final investment decision
GEAP	Green Energy Auction Program
GW	Gigawatt
HVDC	High-voltage direct current
IPCC AR5	Intergovernmental Panel on Climate Change's Fifth Assessment Report
kV	Kilovolt
LCOE	Levelized cost of energy
LNG	Liquefied natural gas
LGU	Local government unit
MARINA	Maritime Industry Authority
MW	Megawatt
NAMRIA	National Mapping and Resource Information Authority
NGCP	National Grid Corporation of the Philippines
NIPAS	National Integrated Protected Areas System
OEM	Original equipment manufacturer
Opex	Operating expenditures
O&M	Operations and maintenance
OSWESC	Offshore Wind Energy Service Contract
PHIVOLCS	Philippine Institute of Volcanology and Seismology
PPA	Philippine Ports Authority
PSA	Philippine Statistics Authority
PAGASA	Philippine Atmospheric Geophysical and Astronomical Services Administration
PMG	Permanent magnet generator
RESC	Renewable Energy Service Contract
TDP	Transmission development plan
WESC	Wind energy service contract
WTG	Wind turbine generation

Executive Summary

With over 36,000 kilometers of coastline and an estimated total technical potential of 178 gigawatts (GW), offshore wind is gaining attention in the Philippines as a means to enhance energy security, lower electricity costs, reduce greenhouse gas emissions, and create a backbone for economic growth. The country's goal of reaching 35% renewable energy by 2030 has signaled the government's commitment to renewable energy.

Although the Philippines has abundant solar, hydro, and geothermal resources, the land availability and ancestral domain have become growing challenges for the development of renewable energy in the past decade. In parallel, electricity demand in the Philippines continues to grow, putting increased pressure on the power system. To build momentum in the offshore wind sector, President Ferdinand Marcos Jr. signed Executive Order No. 21, Series of 2023, which directs the Department of Energy (DOE) to establish the policy framework for offshore wind development. The Philippines, with its promising wind potential, growing government support, and relatively high electricity costs, is an ideal market to catalyze the offshore wind industry across Southeast Asia.

Although offshore wind offers significant potential to help meet the Philippines' growing renewable energy demands, the country's regulatory framework, permitting requirements, infrastructure, tariff mechanism, and policies are currently not ready to implement large-scale projects. The World Bank's *Offshore Wind Roadmap for the Philippines* identified recommendations for DOE and other stakeholders for how to prepare the market.[1]

Building on the World Bank's report, the purpose of this report is to identify specific challenges potentially preventing market readiness for large-scale offshore wind projects, and to evaluate offshore wind development areas that show promise for the country's first offshore wind projects (i.e., operational by 2035) and the country's next wave of offshore wind development.

More specifically, this report provides a desktop, pre-feasibility analysis of three high-potential offshore wind development zones located near Manila Bay, Tayabas Bay, and Guimaras. This paper focuses on zones that can accommodate fixed-bottom installations to support the current administration's 2030 renewable energy target. These three zones were chosen for their high wind speeds of greater than 7 meters per second; proximity to major load centers in southern Luzon and western Visayas; areas with relatively shallow water depths (<50 meters), which allow for fixed foundation wind turbine generation (WTG) designs for the market's first project; and access to deeper areas (>50 meters) for floating offshore wind farms.

Given that 90% of the Philippines' offshore wind technical potential is in deep waters (>50 meters), which would require wind turbines with floating foundations, it is assumed that the long-term offshore wind market in the Philippines will need to focus on floating foundation turbines. By studying three zones that warrant both fixed and floating foundation development, the aim of this analysis is that infrastructure investments (e.g., transmission, ports, site access), marine spatial planning, social and environmental coordination, and learnings from the first fixed foundation projects can apply to and support the development of longer-term floating offshore wind projects in adjacent areas.

This analysis includes location-specific information such as available wind resources, bathymetry, environmental considerations, social impacts, competing uses, site access via ports, and points of interconnection. This report also includes an overview of offshore wind development and equipment costs and considerations, a summary of the legal and regulatory landscape pertaining to offshore wind, and a discussion of relevant stakeholders who are vital to a healthy offshore wind market.

This report recommends development in phases based on where ports and transmission are best able to support smaller capacity offshore wind farms (<300 megawatts [MW]), specifically near Manila Bay and Tayabas Bay, where substations are better equipped for interconnection (estimated available capacity of ~450 MW of offshore wind capacity) and nearby ports would require minimal (<US$5 million) upgrades, according to the World Bank's *Offshore Wind Roadmap for the Philippines*.[2]

Part of DOE's 4-Point Strategy for Energy Transition is to build and develop a Green and Smart Transmission System that enables the grid to accommodate the target renewable energy capacities needed to meet the country's renewable energy goals. This strategy also includes building and expanding the necessary port infrastructures to support offshore wind projects and other marine-based energy resource development project, including tidal stream projects. The Asian Development Bank is currently providing technical assistance to DOE on 10 ports, of which 6 are managed by the Philippine Ports Authority. This technical assistance is expected to be completed by October 2024.

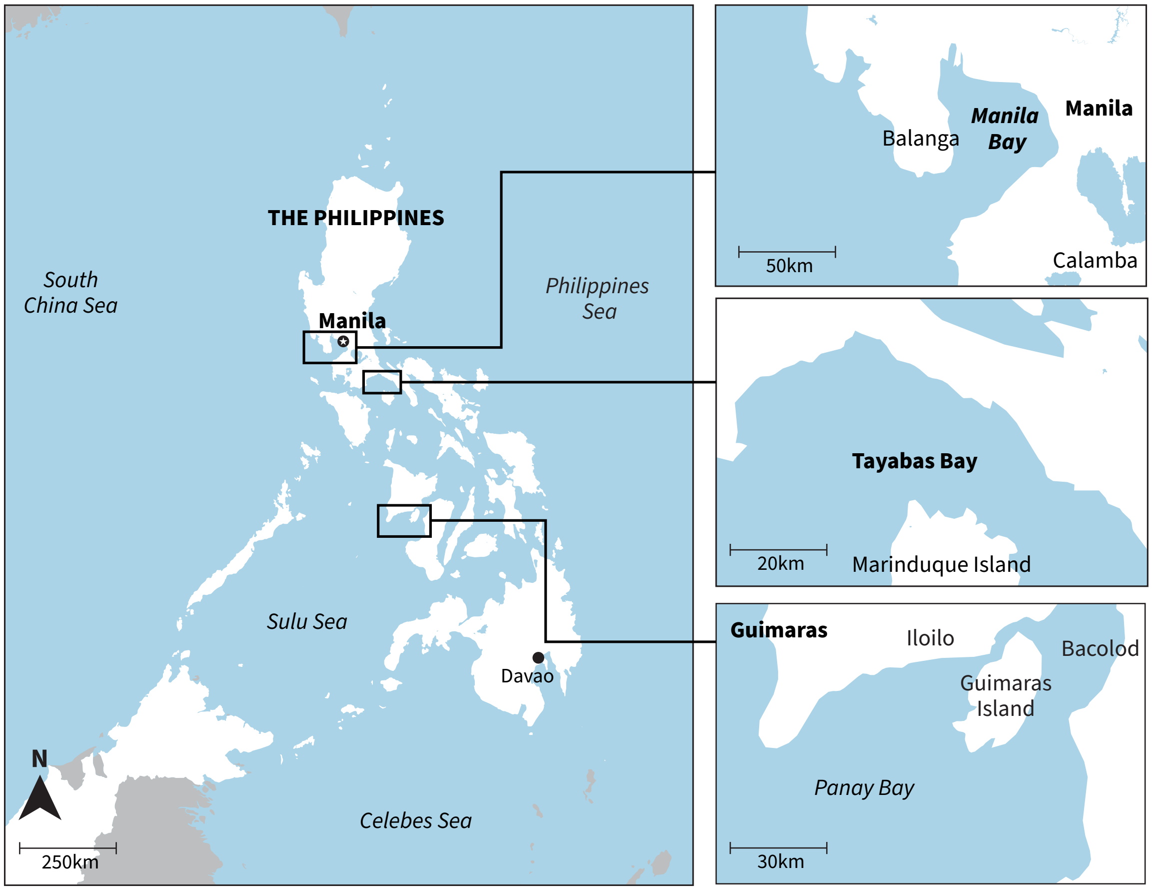
As transmission and port infrastructure are improved for the offshore wind ecosystem, the market for floating foundation wind generation is expected to grow significantly, allowing the Philippines to tap into its wealth of wind potential in deeper waters. Areas surrounding Guimaras Province (i.e., Panay Gulf, Guimaras Strait, and Iloilo Strait), with its mix of shallow (<50 meters) and deep bathymetry, provide an opportunity for a matured fixed foundation offshore wind market and an early floating foundation market to develop in parallel and share the transmission and port upgrades that would be required in this area.

Below is a summary of the key findings:

- **Manila Bay and Tayabas Bay have the potential for near-term (i.e., operational by 2035) offshore wind development, with wind farms using fixed foundation turbines and wind energy service contract (WESC) leases of less than 300 MW.** The nearby points of interconnection and ports require minimal upgrades for small offshore wind projects. Relatively small projects (<500 MW) are well positioned to be first movers in the Philippines' offshore wind market but may quickly struggle to reach sufficient economies of scale at the early stages of market maturity.

- **Manila Bay and Tayabas Bay have the potential for longer term offshore wind development, with their adjacent deep bathymetry (>50 meters) with high wind resources.** Transmission and port upgrades used for the sector's first projects in the Philippines can be used to facilitate the country's first floating offshore wind projects in these areas.

Exhibit ES1 Philippines' three high-priority offshore wind development zones



Source: OpenStreetMap

- **Like the other two zones, Guimaras is recommended for near-term (i.e., operational by 2035) development for fixed foundation turbines.** Available WESCs in this area have economies of scale with 600 MW or higher capacities. However, this area requires more infrastructure investments in transmission because there are few high-capacity transmission lines (>230 kilovolts [kV]). Additionally, this zone has a variety of environmentally protected areas. Results from the Marine Spatial Planning currently being conducted by BVG Associates, as well as site-specific geotechnical studies, must first be analyzed before further developing the area. Like the other zones, Guimaras has a mix of shallow and deep water that will allow any initial infrastructure investments made for the fixed foundation offshore wind industry to facilitate the country's first floating offshore wind projects in this area.

- **Northwest Luzon has among the highest wind resources in the Philippines (>10 meters per second) and is recommended for long-term development.** The absence of nearby ports big enough for manufacturing provides significant challenges, with Currimao Port in Ilocos Norte and Port of Irene in Cagayan being the nearest. The closest port that would require minimal upgrades (< US$ 5 million) for offshore wind installation is in Subic Bay, around 450 kilometers from the DOE-awarded WESC sites in Ilocos Norte. These areas also require significant transmission upgrades to deliver offshore wind energy to major load centers in southern Luzon.

- **Mindoro-Batangas is also recommended for long-term development because the deep bathymetry (>50 meters) makes the area more suitable for floating offshore wind technology.** The Batangas-Mindoro, Palawan-Mindoro, and Mindoro-Panay interconnections are recommended to be at least 230 kV to accommodate the power generated by offshore wind. Many ports used for Tayabas Bay may also help facilitate offshore wind development in the Mindoro-Batangas areas.

- **Offshore wind development has potential to affect both marine and terrestrial ecosystems.** All three zones are near or within protected areas, Environmentally Critical Areas, or important animal areas such as mangrove forests, protected wetlands, and marine sanctuaries. These zones also host vulnerable species such as the Chinese egret (Egretta eulophotes), which has a migration route throughout the country. Of the three zones, Guimaras has the most protected areas within its vicinity, such as the Iloilo and Guimaras Straits Important Marine Mammal Area, the Negros Occidental Coastal Wetlands Conservation Area Ramsar Site, and the Jordan and Nueva Valencia Key Biodiversity Areas. This zone also hosts a variety of endangered species, such as the Irrawaddy dolphin (Orcaella brevirostris), the Hawksbill turtle (Eretmochelys imbricata), and the Green Sea turtle (Chelonia mydas).

- **Wind farms and their export cables must be required to avoid protected and environmentally critical areas as much as possible.** In addition to avoiding the noted protected and environmentally sensitive areas, baseline surveys of offshore wind sites should identify marine, terrestrial, and avian species and their habitats, foraging routes, migration paths, and landing areas. Based on the results of baseline environmental studies and on-site surveys, turbine layout should be adjusted to provide sufficient buffer zones from protected areas and areas with higher concentrations of avian routes to minimize collision and displacement. Coordination with the relevant regulatory agencies, communities, and local governments can mitigate harmful environmental impacts. Additionally, mitigation measures for underwater noise and vibration, electromagnetic fields that interfere with marine species, and soil erosion (for land-based facilities) can reduce harmful environmental impacts during the project.

- **A comprehensive social impact assessment and socioeconomic surveys will enable all stakeholders to understand the potential impacts on communities, especially when land acquisition is unavoidable.** The socioeconomic surveys and vulnerability screenings are essential for determining appropriate entitlements for those who are physically or economically displaced due to the project.

- **Coordination with stakeholders and relevant agencies to mitigate socioeconomic risks is recommended, especially on issues related to conflicts among existing uses of marine water and plans for future development.** In addition, to ensure minimal impact on tourism, historical landmarks, and ancestral domains, project developers should work with the Department of Tourism and local tourism offices, the National Historical Commission of the Philippines, the LGUs, and the National Commission on Indigenous Peoples.

- **Fishing and aquaculture industries and maritime navigational routes must be considered during project development due to their critical role in food and income for all three zones.** Ensuring that the placement of turbines allows large vessels to access major fishing grounds and ports will mitigate the impact on artisanal and commercial fishing production. An on-site analysis of marine usage will inform turbine placement to minimize impact on fishing, aquaculture, and other maritime industries.

1. Introduction

The offshore wind industry has experienced significant growth and technological advancements in recent years, contributing to the global transition toward renewable energy. In the Philippines, the Marcos administration sees offshore wind, with its relatively higher capacity factor (~30%), as one potential solution for meeting the country's renewable energy goals. In addition to the country's target of reaching 35% renewable energy in its power generation mix by 2030, these goals include enhancing energy security, lowering greenhouse gas emissions, and creating a backbone for continued economic growth.

Blessed with consistent and high average wind speeds (greater than 7 meters per second) and over 36,000 kilometers of coastline, it is estimated that the Philippines has a total technical offshore wind potential of 178 GW.[3] As of April 2024, DOE had awarded 92 offshore WESCs, accounting for a total potential capacity of nearly 65 GW, signaling growing interest in a quickly evolving Philippine offshore wind market.[4] The Philippines, with its relatively high electricity costs and promising wind potential, is an ideal market to catalyze the offshore wind industry across Southeast Asia.

"In the Philippines, the Marcos administration sees offshore wind as one potential solution for meeting the country's renewable energy goals. In addition to the country's target of reaching 35% renewable energy in its power generation mix by 2030, these goals include enhancing energy security, lowering greenhouse gas emissions, and creating a backbone for continued economic growth."

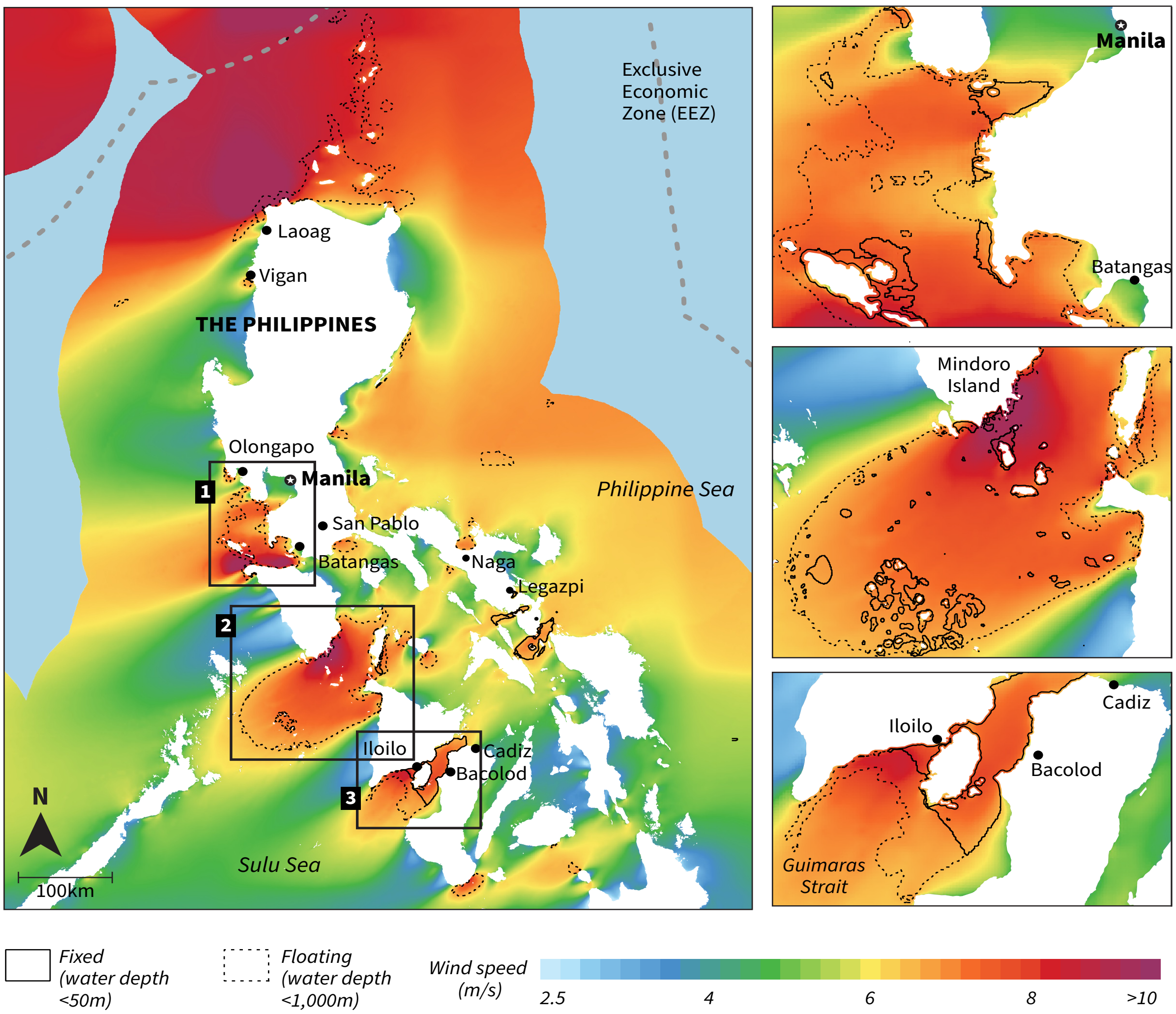
Although offshore wind offers significant potential to help meet the Philippines' growing renewable energy demands, the country's regulatory framework, permitting requirements, infrastructure, tariff mechanism, and policies are currently not ready to implement large-scale projects. The World Bank's *Offshore Wind Roadmap for the Philippines* identified recommendations for DOE and other stakeholders for how to prepare the market.[5]

Building on the World Bank's report, the purpose of this report is to identify specific challenges potentially preventing market readiness for large-scale offshore wind projects, and to evaluate offshore wind leasing sites that show promise for near-term (i.e., operational by 2035) and medium-term development. More specifically, this report provides a desktop, pre-feasibility analysis of three high-potential offshore wind development zones located near Manila Bay, Tayabas Bay, and Guimaras. This analysis includes location-specific information such as available wind resources, bathymetry, environmental considerations, social impacts, competing uses, site access via ports, and points of interconnection. This report also includes an overview of potential sources of supply for offshore wind development and equipment costs, a summary of the legal and regulatory landscape pertaining to offshore wind, and a discussion of relevant stakeholders who are vital to a healthy offshore wind market.

2. Priority Offshore Wind Development Zones

The World Bank's *Offshore Wind Roadmap for the Philippines*, published in 2022, highlights areas with high technical potential (i.e., mean wind speeds at 100-meter height exceeding 7 meters per second and water depths of up to 50 meters for fixed foundation and up to 1,000 meters for floating foundation) in Northwest Luzon, Manila Bay, Mindoro-Batangas, and areas between Panay and Negros Island (Guimaras).[6]

Exhibit 1 **Offshore wind technical potential in the Philippines**

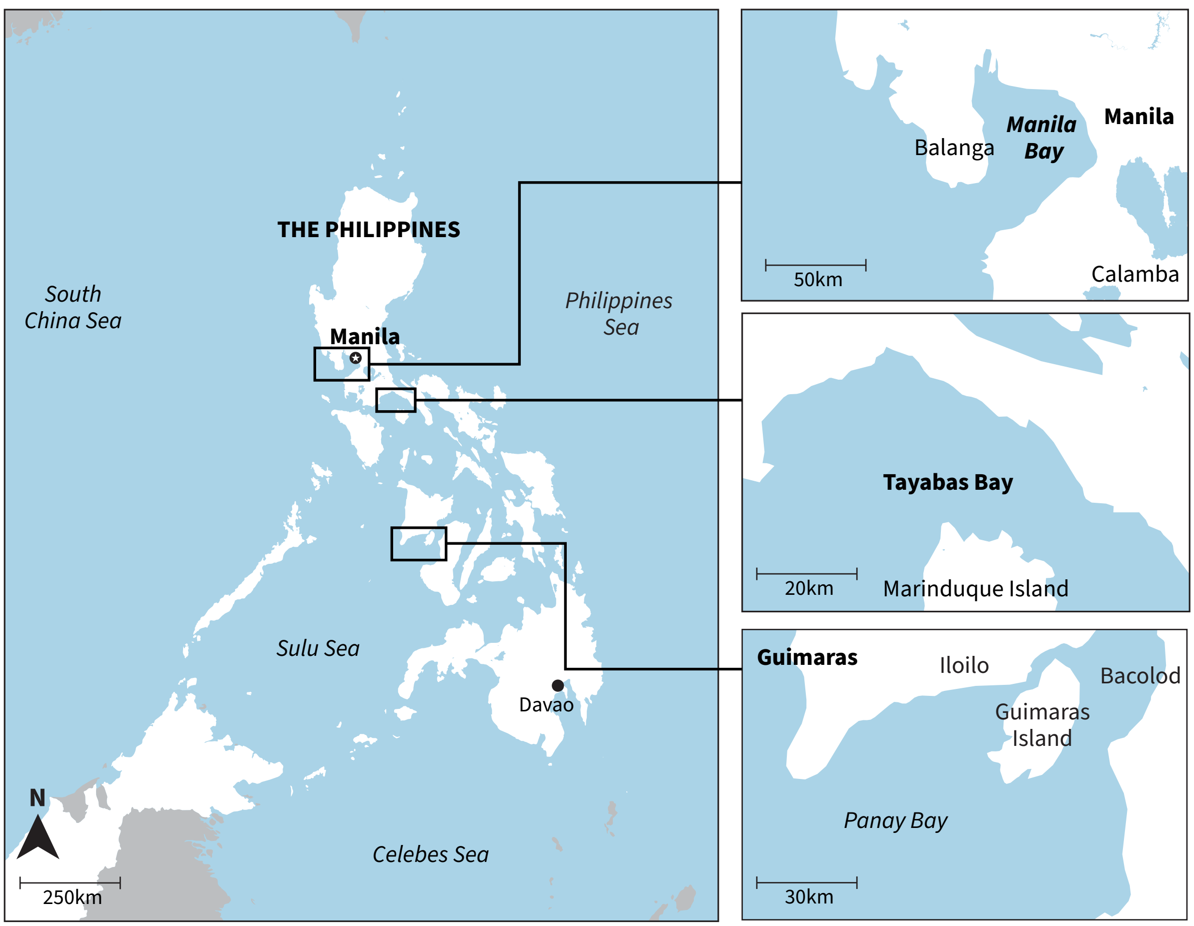


Source: The World Bank, **https://documents1.worldbank.org/curated/en/519311586986677638/pdf/Technical-Potential-for-Offshore-Wind-in-Philippines-Map.pdf**

According to the roadmap, 90% of the Philippines' offshore wind technical potential is in deep waters (depth >50 meters) that would require wind turbines with floating foundations. Therefore, the long-term offshore wind market in the Philippines will need to focus on floating foundation turbines. This poses a challenge because floating foundation technology is less commercially mature than fixed foundation technology, especially in the Philippines, where no offshore wind projects were operating when this report was published. Therefore, this study assumes that the first offshore wind projects in the Philippines will be fixed foundation to take advantage of commercially mature offshore wind practices and technologies.

To help offshore wind industry first movers build momentum in the Philippines, this report focuses on offshore wind development zones that include a mix of both shallow (<50 meters) and deep (between 50 and 1,000 meters) bathymetry. The aim is that infrastructure investments (e.g., transmission, ports, site access), marine spatial planning, social and environmental coordination, and learnings from the first fixed foundation projects can apply to and support the development of longer-term floating offshore wind projects in adjacent areas.

Exhibit 2 **Philippines' three high-priority offshore wind development zones**



Source: OpenStreetMap

This study identifies three priority offshore wind development zones: Manila Bay, Tayabas Bay, and Guimaras. These zones were selected based on the areas from the World Bank's *Offshore Wind Roadmap for the Philippines*, areas near Tayabas Bay, as well as publicly available geospatial information on wind speed, bathymetry, shipping lanes, availability of ports, proximity to load centers, and estimated WTG capacity. All three priority zones were selected for their consistent high mean wind speeds (>7 meters per second), mix of both shallow (<50 meters) and deep (>50 meters) bathymetry, and proximity to major ports (<150 kilometers), which would allow for both the near-term deployment of fixed foundation turbines and parallel development of floating offshore wind projects.

Because the focus of this study is on offshore wind zones that show potential for the Philippines' offshore wind projects in the near term, areas in Northwest Luzon and Mindoro-Batangas were not studied further as part of this work despite their favorable wind resources.

Areas in Northwest Luzon (i.e., Laoag, Burgos, Bangui) show some of the highest wind resources in the Philippines (>10 meters per second); however, these areas are relatively far from major load centers and have deep bathymetry that would exclusively require floating wind turbine foundations. Additionally, the lack of major ports in this region severely hinders site access and WTG development, which requires windows of favorable weather to safely tow turbine assemblies to the site. Ports such as Currimao Port in Ilocos Norte and Port of Irene in Cagayan could eventually serve these offshore wind zones, but the ports would require significant upgrades.

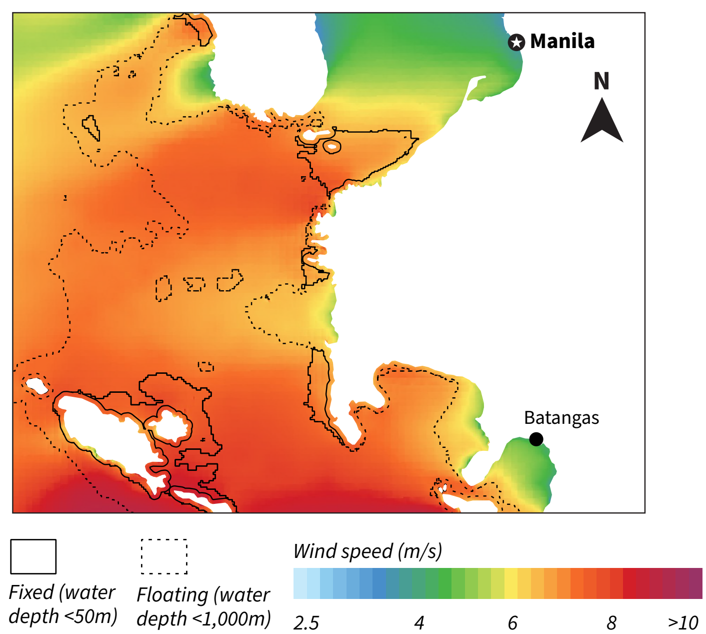
Similarly, areas near Mindoro-Batangas have large wind resources with deep bathymetry that would require primarily floating foundations. The Batangas-Mindoro, Palawan-Mindoro, and Mindoro-Panay interconnections are also recommended to be at least 230 kV to accommodate the power generated by offshore wind. Because of these conditions, these areas may be positioned for long-term offshore wind development once a floating foundation market has matured and interconnection to the Luzon grid is complete.

The following is a summary of the three priority offshore wind zones that were identified for this study.

2.1 Zone A: Manila Bay

Located at the entrance of Manila Bay, this zone includes Corregidor Island and borders Bataan Province to the north and Cavite Province to the south. This zone was chosen for its high wind speeds (>7 meters per second), mix of shallow and deep bathymetry, and proximity to Metro Manila, the highest load center in the country. This zone's access to major ports and shipbuilding facilities in Subic, Mariveles, and Batangas also supports efficient and economical offshore wind construction and operation. Of the three zones, Manila Bay has the best access to substations and high-capacity transmission lines (>230 kV) and will be able to accommodate more generation capacity.

Exhibit 3 **Zone A: Manila Bay**

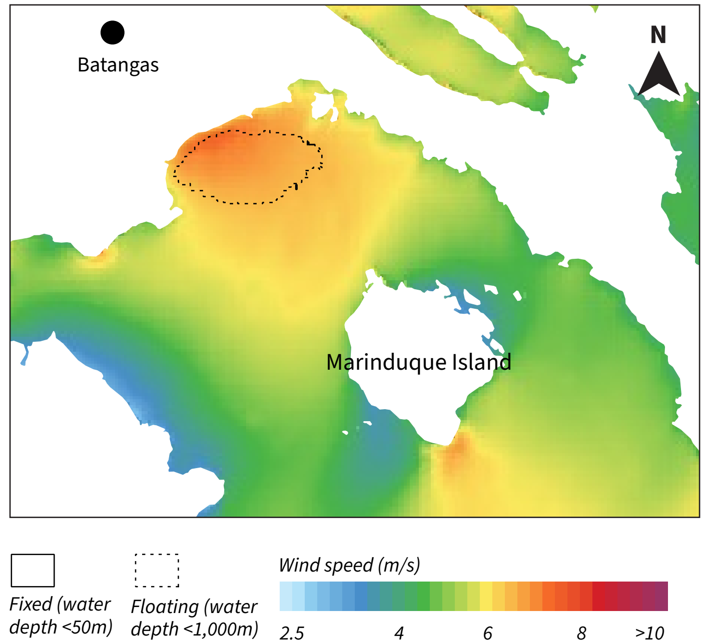


Source: The World Bank, https://documents1.worldbank.org/curated/en/519311586986677638/pdf/Technical-Potential-for-Offshore-Wind-in-Philippines-Map.pdf

2.2 Zone B: Tayabas Bay

This zone focuses on the pocket of high-wind resources (>7 meters per second) in the northern areas of Tayabas Bay, which hugs the southern shores of Quezon Province and eastern shores of Batangas Province. Like Zone A, this zone was chosen for its high mean wind speeds that are available relatively close to shore, close to Metro Manila, and adjacent to sites suitable for floating foundation turbines in Tayabas Bay and Mindoro-Batangas (thus justifying longer-term port and transmission upgrades). This zone is accessible by major shipbuilding facilities located in Batangas Bay to the west. Its access to the Luzon transmission backbone would allow the wind farm to export electricity to major load centers using high-capacity substations.

Exhibit 4 **Zone B: Tayabas Bay**

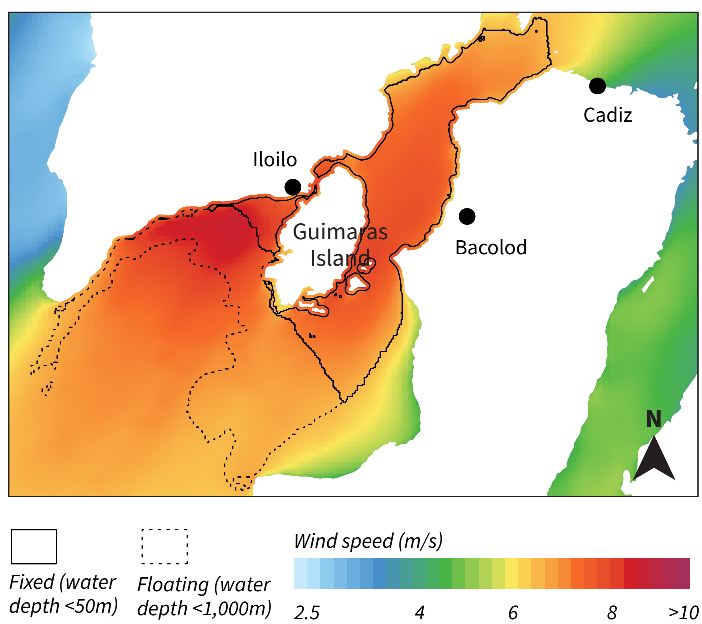


Source: The World Bank, **https://documents1.worldbank.org/curated/en/519311586986677638/pdf/Technical-Potential-for-Offshore-Wind-in-Philippines-Map.pdf**

2.3 Zone C: Guimaras

Located in the area surrounding Guimaras Island, this zone includes water along the Guimaras Strait and Panay Gulf with Panay Island to the west and Negros Island to the east. This zone was chosen primarily for its large areas of shallow bathymetry, which is conducive for offshore wind projects, and proximity to key load centers such as Cebu, Bacolod City, and Iloilo City. Significant additions of offshore wind would require transmission upgrades because there are limited high-capacity transmission lines (>230 kV) in this zone. Additionally, this area hosts a variety of protected and environmentally sensitive areas such as mangrove forests, protected wetlands, and Important Marine Mammal Areas.

Exhibit 5 **Zone C: Guimaras**



Source: The World Bank, **https://documents1.worldbank.org/curated/en/519311586986677638/pdf/Technical-Potential-for-Offshore-Wind-in-Philippines-Map.pdf**

3. Site Data Collection

An understanding of each zone's underwater landscape, oceanography, and current usage is needed to inform the optimal turbine class and selection. This chapter aims to summarize the underwater landscape of each of the three zones, including depth, tidal variation, general topography, marine usage, and notable hazards such as wrecks, submerged cables, and rocks. Because geological and geotechnical studies of the seabed and sub-seabed are limited in the three zones, it is recommended that on-site geological and geotechnical studies be conducted as part of detailed feasibility studies before final investment decisions are made.

Image courtesy of Seobyoung Jr Chil

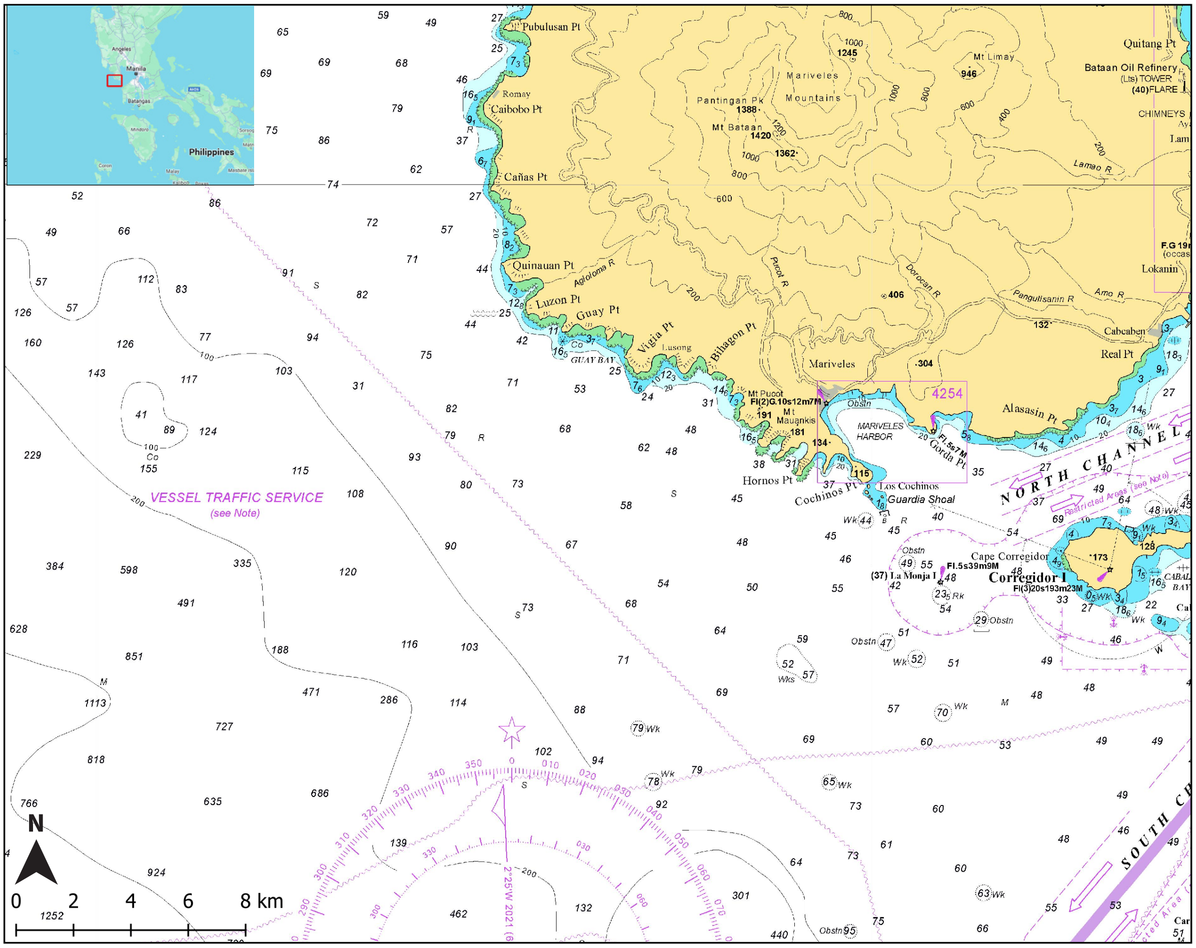
3.1 Water Depth and Tidal Variation

Nautical charts used for this study were sourced from the National Mapping and Resource Information Authority (NAMRIA). These charts depict the relief of the sea bottom, including water depth, current force and direction, aids and hazards to navigation, characteristics of the sea bottom, and other vital information. This information informs turbine foundation (e.g., fixed versus floating), turbine design, turbine spacing, and site layout. Turbines should be placed to avoid underwater hazards (e.g., submerged cables, wrecks, rocks), and the final turbine layout will affect the total energy yield and ultimate bankability of a given offshore wind project.

Bathymetry for Zone A ranges from 20 meters to 70 meters in areas that are within Manila Bay or within approximately 7 kilometers of the western coasts of Bataan and Cavite provinces. Waters begin to reach depths closer to 1,000 meters in areas approximately 20 to 30 kilometers from the coasts, as shown in Exhibit 6 (next page) and Exhibit 7 (page 18).

For Zone B, the bathymetry remains below 50 meters in areas that are approximately 2 kilometers from the northwestern shores of Tayabas Bay. These shallow waters extend out farther from the coast in the northeastern portions of the zone (closer to Pagbilao Bay) than in areas in the western part of the zone (closer to the southern end of the Municipality of San Juan in Batangas). All water depths within this zone are less than 750 meters, with most deep water closer to 500 meters.

Exhibit 6 **Nautical chart of Manila Bay and approaches showing the southwestern coast of the Bataan Peninsula**



S	Sand	M	Mud	Cy	Clay	G	Gravel	R	Rock, rocky	Bo	Boulder(s)

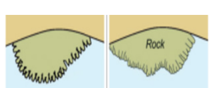
Wreck, least depth known by sounding only

Obstruction

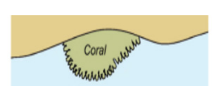
Established (mandatory) direction of traffic flow

Submarine cable

Limit of restricted routing measure



Rocky area, which covers and uncovers

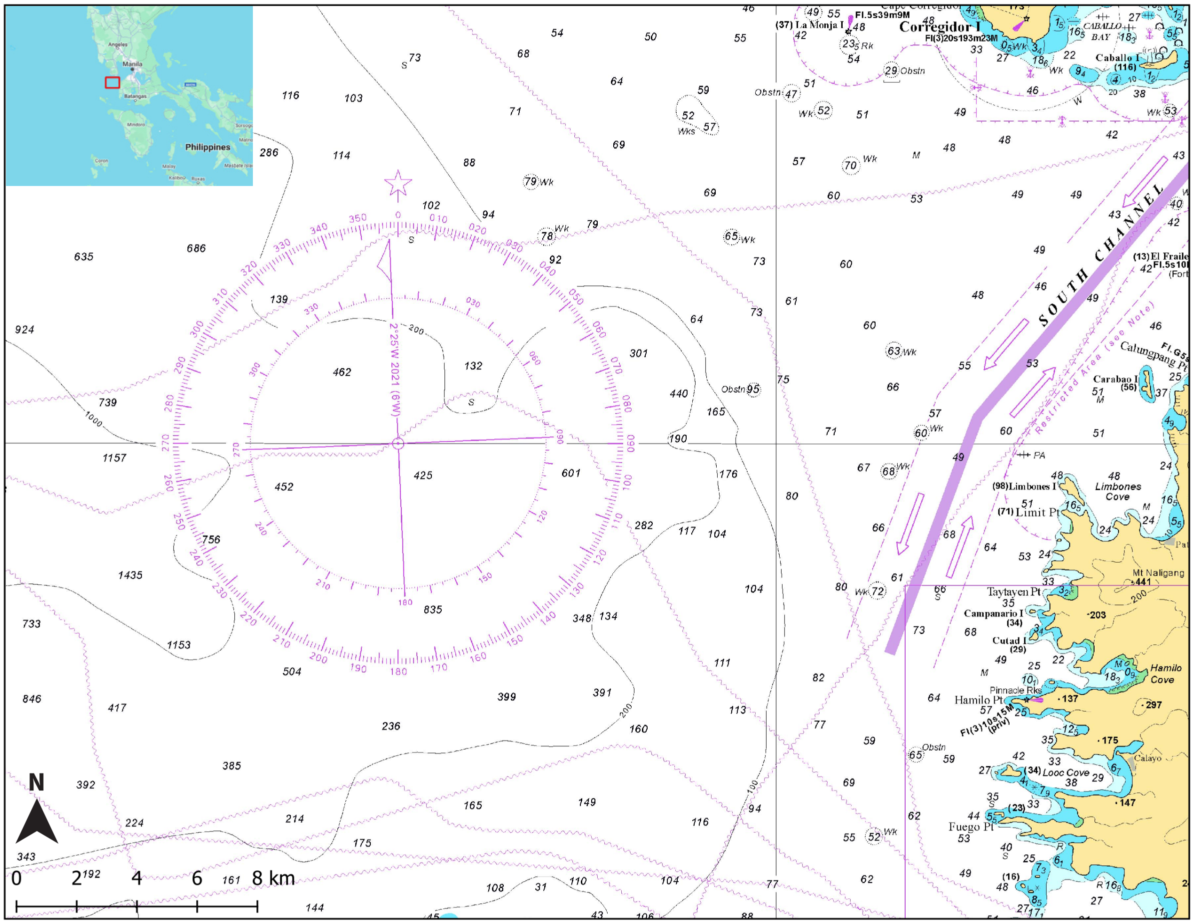


Coral reef, which covers and uncovers

Note: Depths are denoted in meters. Sources for this map range from 1960 to 2019.

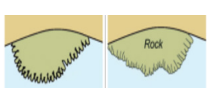
Source: National Mapping and Resource Information Authority

Exhibit 7 Nautical chart of Manila Bay and approaches showing the western coast of Batangas Province

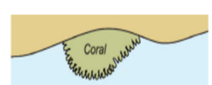


S	Sand	M	Mud	Cy	Clay	G	Gravel	R	Rock, rocky	Bo	Boulder(s)

- Wreck, least depth known by sounding only
- Obstruction
- Established (mandatory) direction of traffic flow
- Submarine cable
- Limit of restricted routing measure



Rocky area, which covers and uncovers

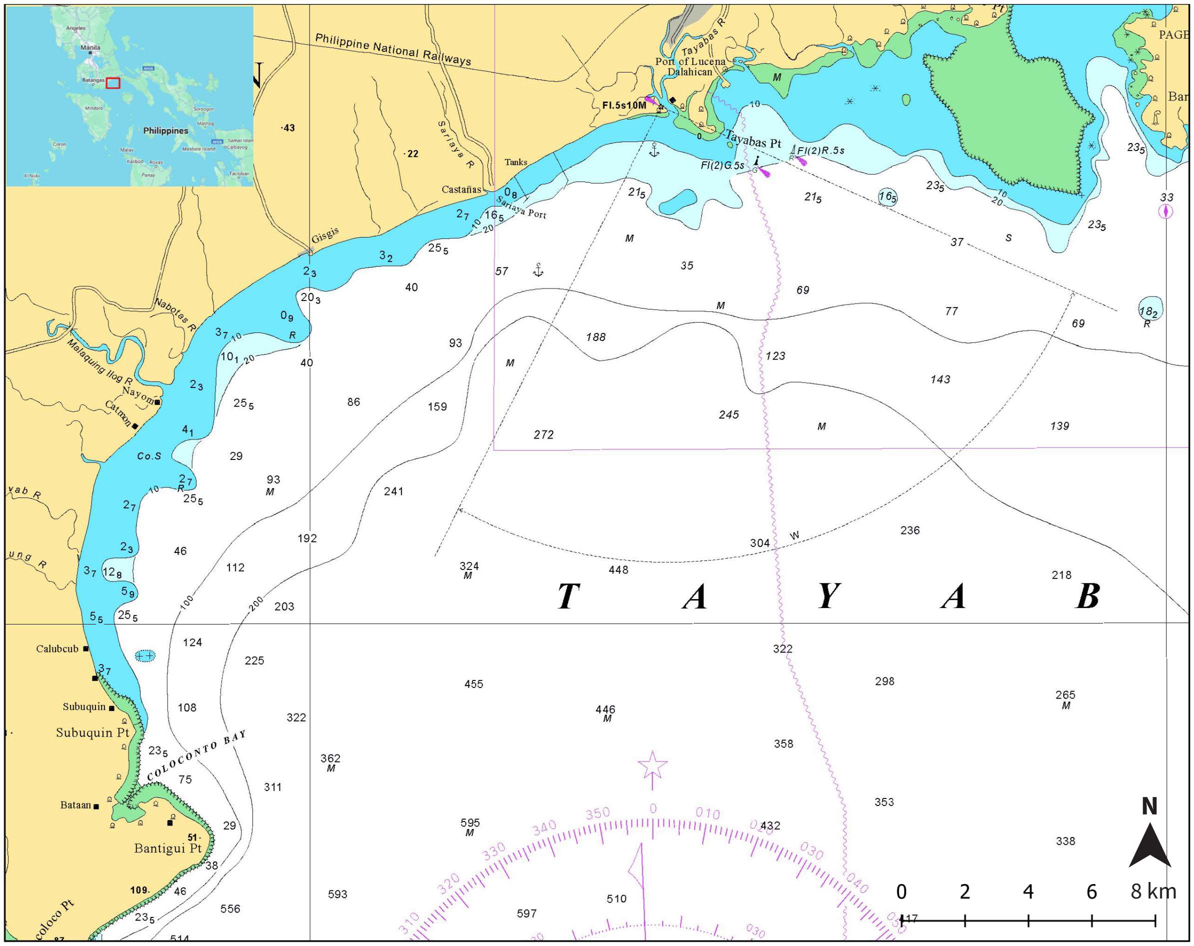


Coral reef, which covers and uncovers

Note: Depths are denoted in meters. Sources for this map range from 1960 to 2019.

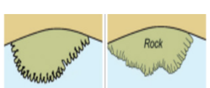
Source: National Mapping and Resource Information Authority

Exhibit 8 **Nautical chart of Tayabas Bay**

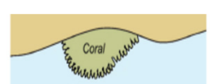


S Sand | M Mud | Cy Clay | G Gravel | R Rock, rocky | Bo Boulder(s)

Wreck, least depth known by sounding only | Obstruction | Established (mandatory) direction of traffic flow | Submarine cable | Limit of restricted routing measure



Rocky area, which covers and uncovers



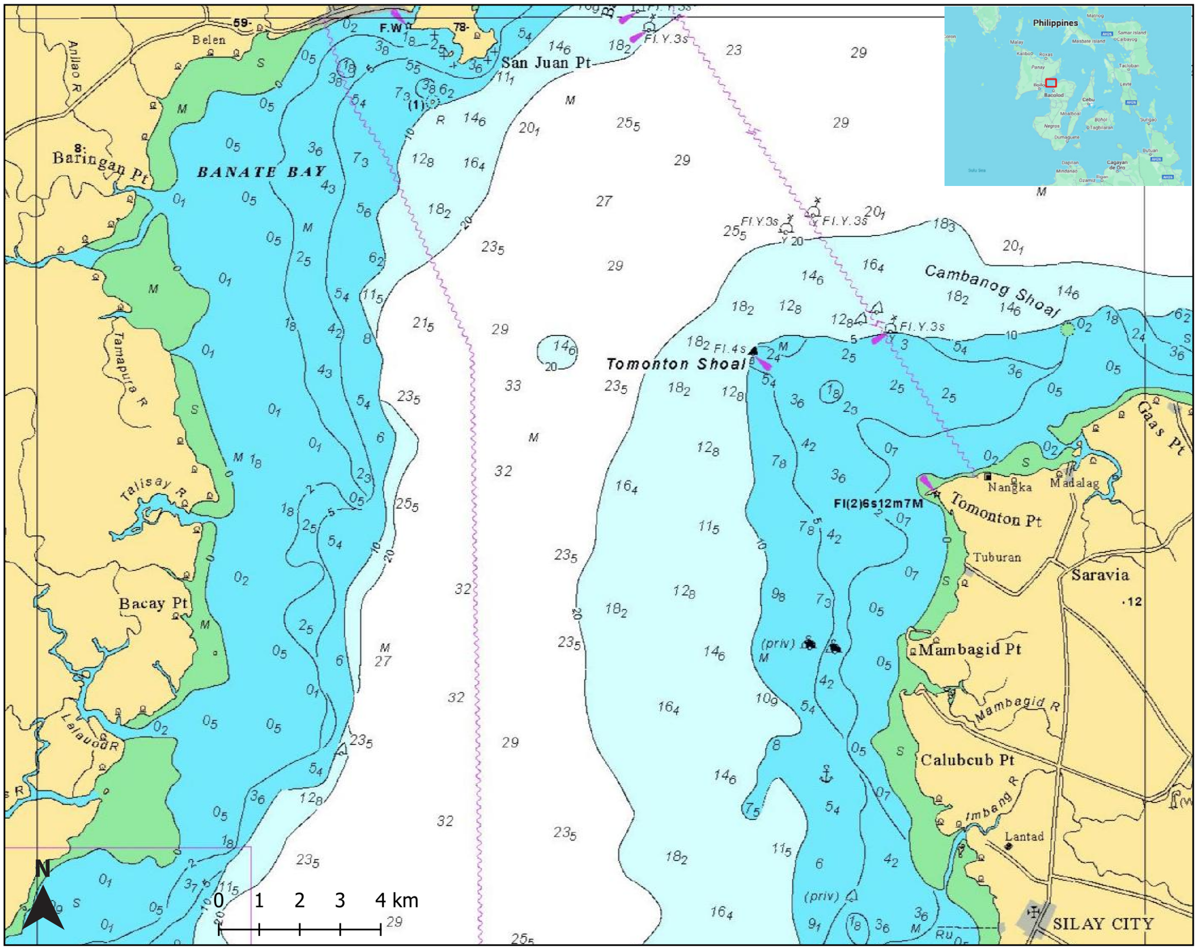
Coral reef, which covers and uncovers

Note: Depths are denoted in meters. Sources for this map range from 2003 to 2008.

Source: National Mapping and Resource Information Authority

Bathymetry for Zone C does not exceed 50 meters in the areas north of Guimaras Island, the Guimaras Strait, the Iloilo Strait, and the Oton Bank. In the Panay Gulf, water depths reach 1,000 meters quickly, within approximately 10 kilometers of the southern edges of Guimaras Island and of the coasts of the Municipality of Miagao on Panay Island. Where the Iloilo Strait meets the Panay Gulf, there is an area of approximately 300 square kilometers with water depths that are generally less than 800 meters, as shown in Exhibit 10 (page 21).

Exhibit 9 **Nautical chart of passages between Panay, Negros, and Cebu**



S	Sand	*M*	Mud	*Cy*	Clay	*G*	Gravel	*R*	Rock, rocky	*Bo*	Boulder(s)

Wreck, least depth known by sounding only

Obstruction

Established (mandatory) direction of traffic flow

Submarine cable

Limit of restricted routing measure

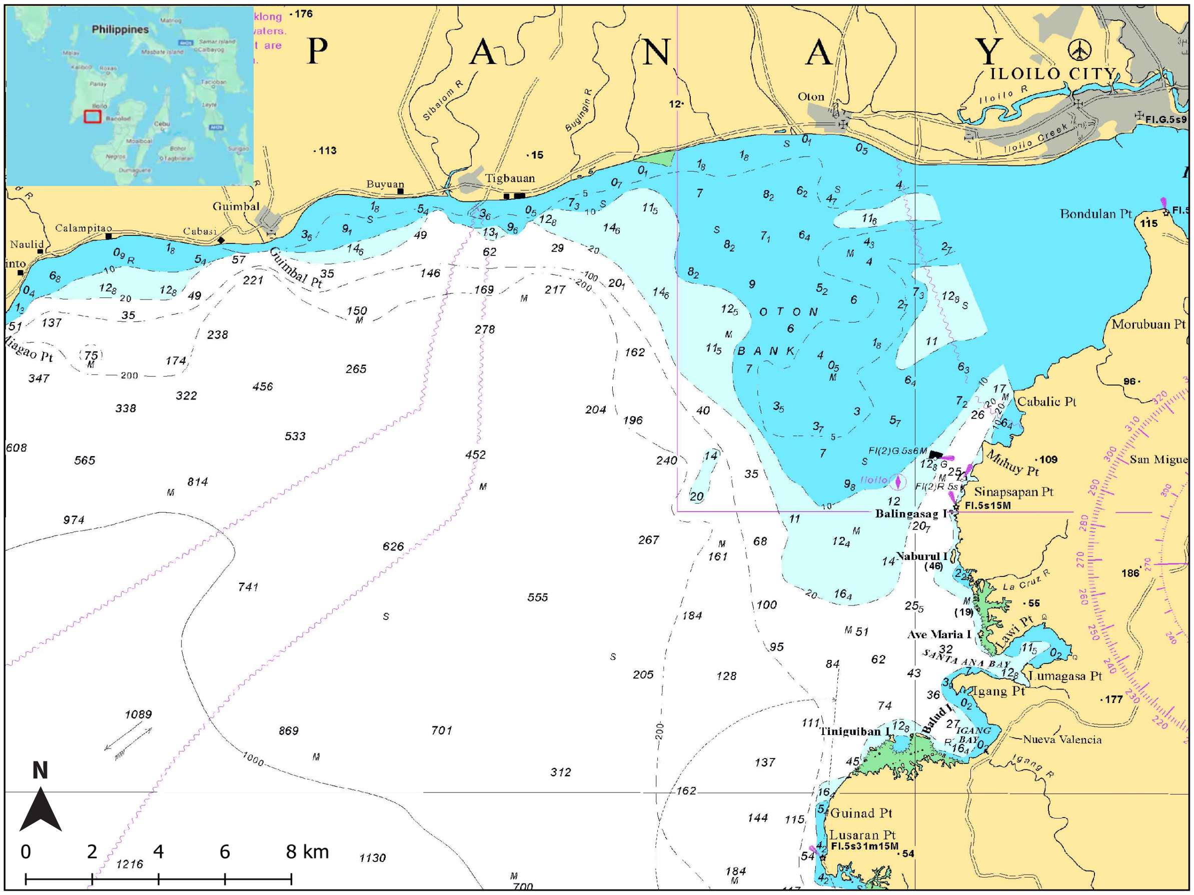
Rocky area, which covers and uncovers

Coral reef, which covers and uncovers

Note: Depths are denoted in meters. Sources for this map range from 1924 to 1992.

Source: National Mapping and Resource Information Authority

Exhibit 10 **Nautical chart of Panay Gulf and approaches**



S	Sand	*M*	Mud	*Cy*	Clay	*G*	Gravel	*R*	Rock, rocky	*Bo*	Boulder(s)

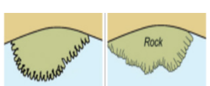
Wreck, least depth known by sounding only

Obstruction

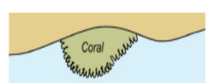
Established (mandatory) direction of traffic flow

Submarine cable

Limit of restricted routing measure



Rocky area, which covers and uncovers



Coral reef, which covers and uncovers

Note: Depths are denoted in meters. Sources for this map range from 1986 to 2020.

Source: National Mapping and Resource Information Authority

Exhibit 11 **Tidal variation of the three offshore wind zones**

Zone	Place	Year of depth data	Mean high water interval*	Mean higher high water*	Mean tide level*	Extreme low water*
A (Manila Bay)	**Hamilo Cove**	2021	10 hr., 04 min.	0.89 m	0.32 m	-1.23 m
	Port Lamao	2021	10 hr., 08 min.	1.09 m	0.52 m	-1.22 m
B (Tayabas Bay)	**Santa Cruz Harbor**	2021	11 hr., 35 min.	1.52 m	0.73 m	-0.67 m
	Tayabas River Entrance	2021	11 hr., 40 min.	1.46 m	0.70 m	-0.65 m
C (Guimaras)	**Anini-y**	2022	11 hr., 01 min.	1.35 m	0.62 m	-0.66 m
	Dumangas	2022	08 hr., 59 min.	1.87 m	0.94 m	-0.48 m
	Bacolod	2022	12 hr., 15 min.	2.06 m	1.01 m	-0.62 m
	Inampulugan Island	2022	11 hr., 25 min.	1.55 m	0.70 m	-0.68 m
	Iloilo	2022	11 hr., 20 min.	2.04 m	0.91 m	-0.63 m

*Height referred to datum of soundings (mean lower low water)

RMI graphic. Source: National Mapping and Resource Information Authority

3.2 Underwater Features and Hazards

The following is a summary of key underwater features and hazards that are common to the three zones. This is followed by details about the underwater landscape, potential hazards, and surrounding marine traffic lanes that are specific to each zone. Nautical charts from NAMRIA were the primary source of information, along with Kpler's MarineTraffic for marine traffic data.[7]

Seabed composition

All three zones include sites that have not been surveyed to modern standards. Therefore, uncharted shoals, reefs, and other hazards may exist, and on-site geophysical surveys are recommended as part of on-site feasibility studies before final investment decisions are made. Generally, according to nautical maps provided by NAMRIA, all three zones have seafloors composed of primarily mud, with isolated sand and gravel. Geologic and stratigraphic information about the ocean floor in all three zones is limited and requires further on-site investigation.

Subsea cables and underwater hazards

Subsea cables, shoals, reefs, wrecks, and other underwater hazards are present in all three zones. Below is a summary of hazards noted on NAMRIA nautical maps, though additional uncharted hazards may exist. Zone A's location near the entrance of Manila Bay is characterized by several known wrecks, obstructions, and a National Defense Zone surrounding Corregidor Island, La Monja Island, and El Fraile Island. Zone C seems to have the most varied topography of the three sites, with at least nine subsea cables crossing through the zone and several shoals and shallow reefs concentrated along the eastern edges of Guimaras Island. Mariners are advised not to anchor or trawl in the vicinity of submarine cables. Generally, a 1-kilometer buffer from submarine cables is recommended during offshore wind development. However, certain construction activities that must take place within these buffers should be done in coordination with the subsea cable owner. Proximity limits between subsea cables and the offshore wind assets should be defined by the offshore wind developer and subsea cable owner in compliance with national and local regulations.

Zone A: Manila Bay

The entrance of Manila Bay has more than 12 known wrecks and obstructions, with most of them concentrated near the approach of the National Defense Zone that encompasses Corregidor Island, La Monja Island, and El Fraile Island. To the immediate south of the National Defense Zone are at least two subsea cables that generally run east-west. Another subsea cable runs north-south along waters that range from 60 to 90 meters in depth. This subsea cable is one of approximately 14 subsea cables that make landfall in the Municipality of Nasugbu.

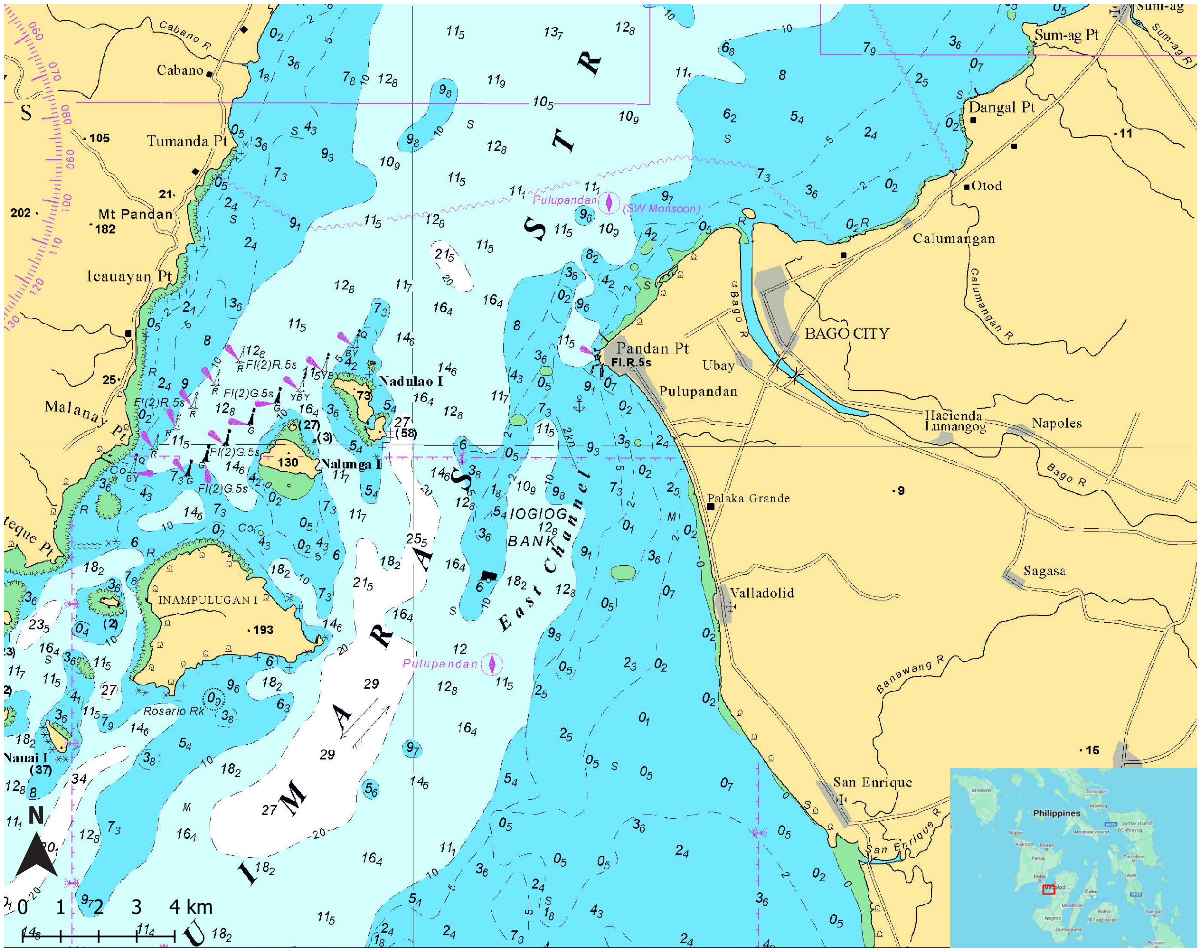
Zone B: Tayabas Bay

Of the three studied zones, Zone B has the fewest underwater hazards, according to available nautical maps. At least one subsea cable runs southward from the Port of Lucena. The majority of noted reefs are within 1 kilometer of the coast and should not pose a major risk to offshore wind development, assuming a shoreline buffer of at least 1 kilometer for offshore wind projects. There is one large reef, approximately 16 square kilometers, that extends about 6 kilometers from the entrance of the Pagbilao Bay into the larger Tayabas Bay.

Zone C: Guimaras

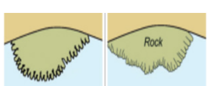
Zone C is characterized by a channel of approximately 20 to 35 meters in depth in the areas north of Bacolod City. The area where the Guimaras Strait meets the Panay Gulf is characterized by scattered shoals, reefs, and various small islands such as Inampulugan Island, as shown in Exhibit 12 (next page). Reefs are generally within 1 kilometer of the coast, except for Salong and Balaulan reefs, which are approximately 2 kilometers north of the coast of the Municipality of Manapla. In the northern shallow sections of the zone, at least two subsea cables run from the northwest corner of the Municipality of Enrique B. Magalona. From Talisay City (located 7 kilometers north of Bacolod City on Negros Island), at least one subsea cable travels west, across the Guimaras Strait. From Bacolod City, another subsea cable travels north along the deepest portions of the zone. South of Bacolod City, in Bago City, two more subsea cables make landfall after traversing the Guimaras Strait. To the west of Guimaras Island, there are at least three subsea cables: one that connects the Municipality of Oton and Guimaras Island in the shallow portions of the site, and two that move southwest from the Municipality of Tigbauan before almost immediately entering waters greater than 60 meters deep.

Exhibit 12 **Nautical chart of Guimaras Strait**

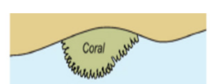


S	Sand	*M*	Mud	*Cy*	Clay	*G*	Gravel	*R*	Rock, rocky	*Bo*	Boulder(s)

- Wreck, least depth known by sounding only
- Obstruction
- Established (mandatory) direction of traffic flow
- Submarine cable
- Limit of restricted routing measure



Rocky area, which covers and uncovers



Coral reef, which covers and uncovers

Note: Depths are denoted in meters. Sources for this map range from 1986 to 2020.

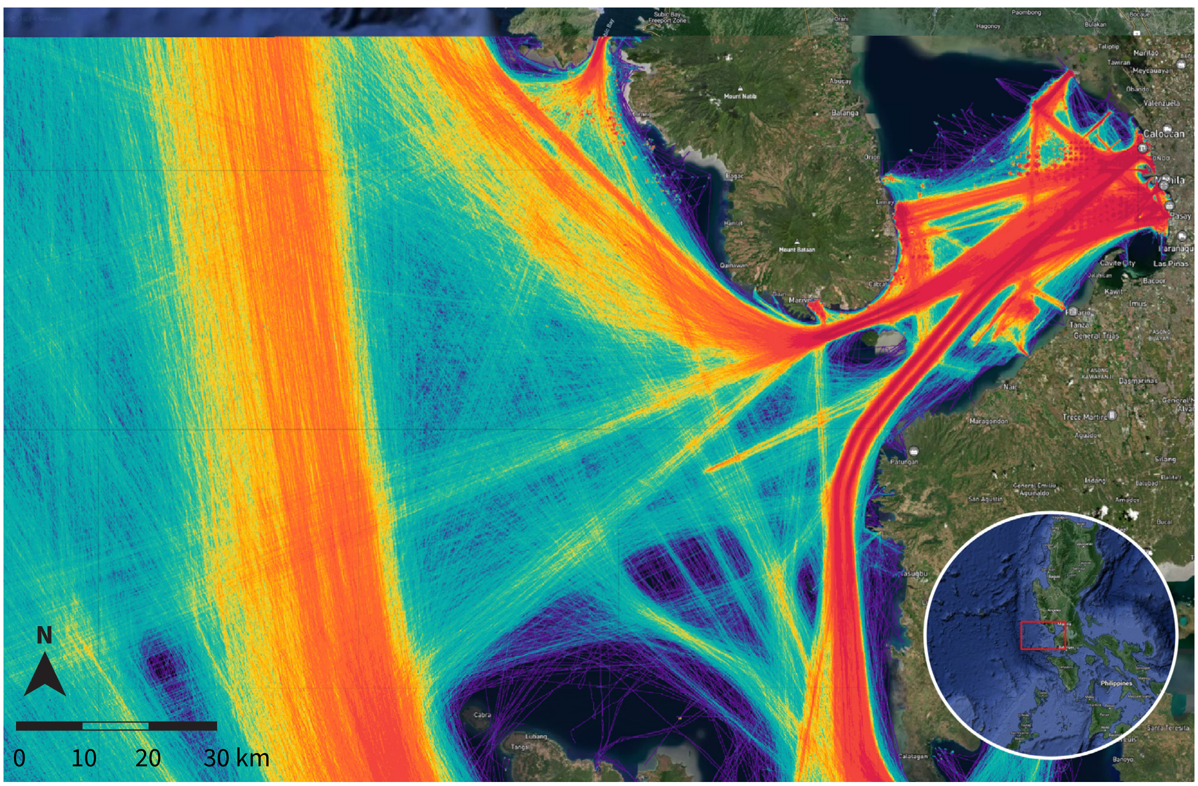
Source: National Mapping and Resource Information Authority

3.3 Shipping Lanes

With over 7,000 islands, the Philippines is rich in navigable waters. Therefore, careful consideration of existing marine traffic lanes and how offshore wind development might impact these lanes is part of the offshore wind project preparation process. Marine traffic data from Kpler's MarineTraffic was studied and is summarized below.

Zone A has the most shipping density of the three zones, with major traffic lanes limiting the development of fixed foundation turbines in the bay's shallow waters. These traffic lanes with high shipping density (greater than one passage per hour per 5 square kilometer area) correspond to marine traffic accessing Metro Manila and create a bottleneck at the entrance of Manila Bay. Most of the areas fit for floating foundation turbine development are not as constrained by these traffic lanes. Additionally, the areas surrounding Corregidor Island, La Monja Island, and El Fraile Island make up a National Defense Zone. Vessels should not approach closer than 1 mile from these three islands, unless transiting through designated marine traffic lanes. Passage between La Monja Island and Corregidor Island is also prohibited.

Exhibit 13 **Shipping routes of Manila Bay and approaches**

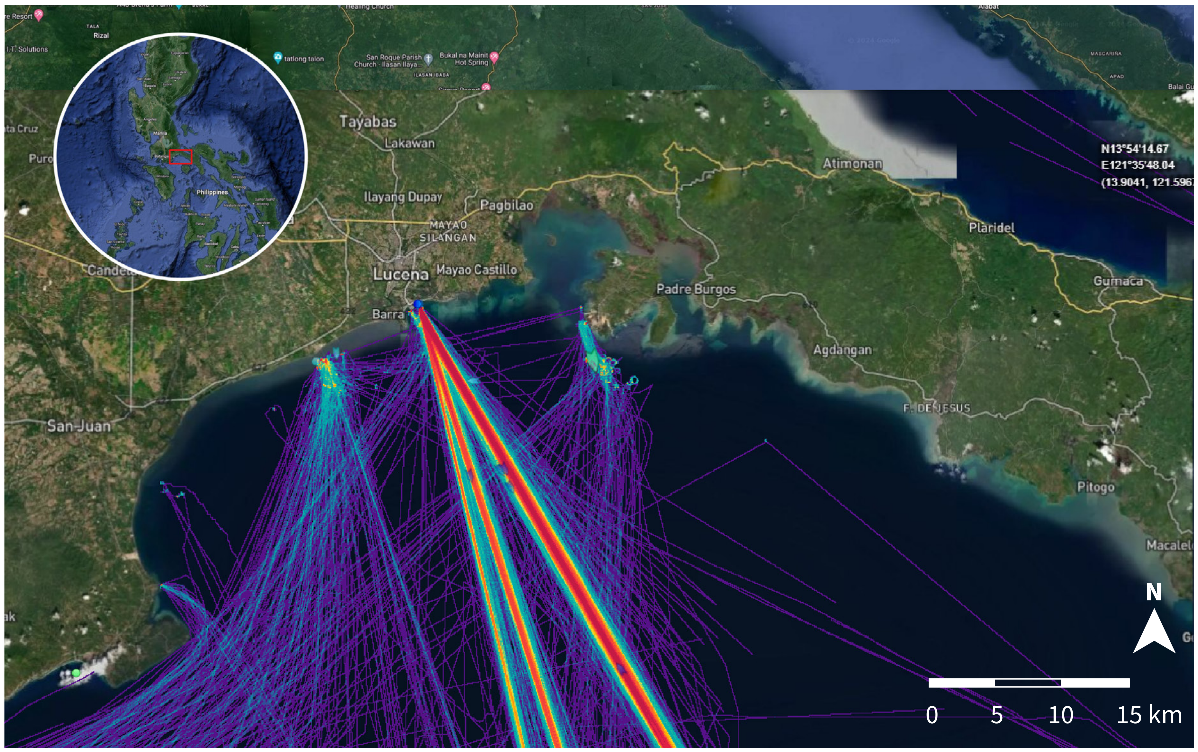


1 route per 0.08 km^2/year — 279+ routes per 0.08 km^2/year

Source: MarineTraffic, **https://www.marinetraffic.com/en/ais/home**

High shipping density is not a major concern for Zone B because the heaviest marine traffic is concentrated in two major lanes that originate at the Port of Lucena. It is also worth noting that where the Iyam River meets Tayabas Bay, there is an area used for local anchorage, as denoted by NAMRIA nautical maps.

Exhibit 14 **Shipping routes of northern Tayabas Bay and approaches**

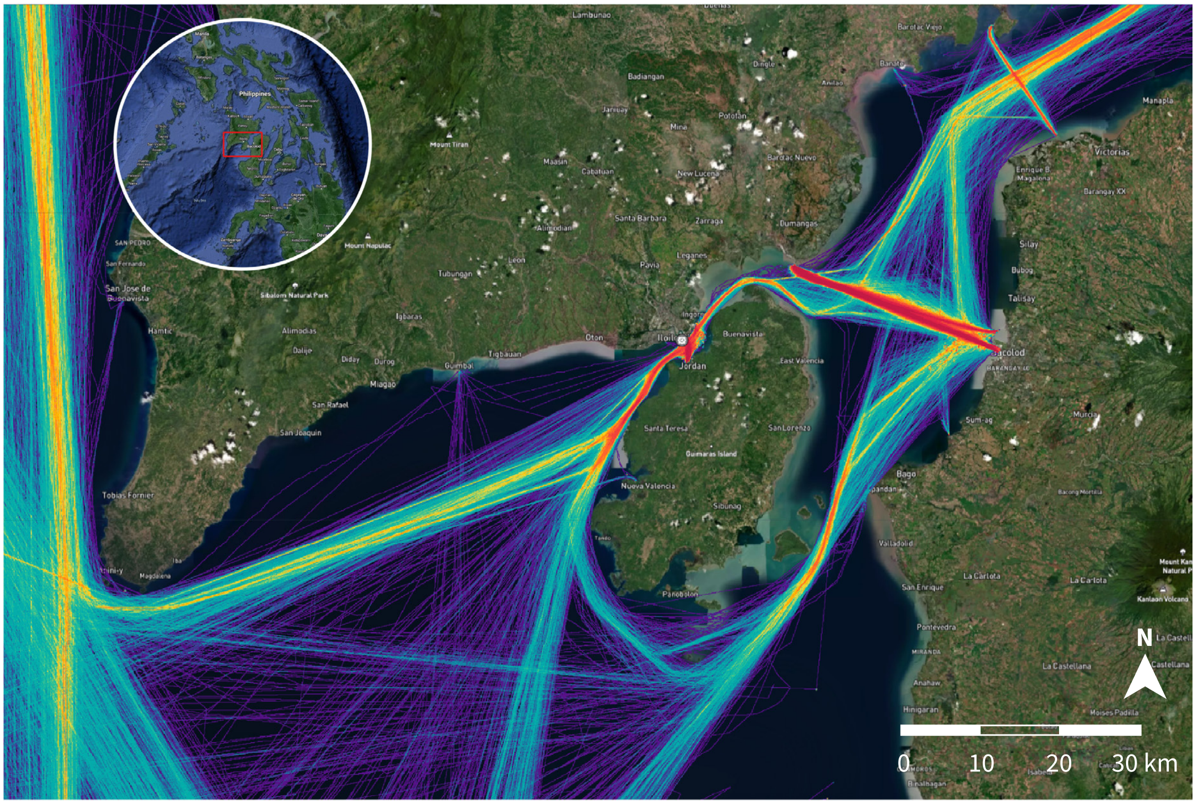


1 route per 0.08 km^2/year — 200 routes per 0.08 km^2/year

Source: MarineTraffic, **https://www.marinetraffic.com/en/ais/home**

In Zone C, high shipping density is concentrated in the shallow waters of the Guimaras and Iloilo straits. These lanes appear to accommodate traffic between ports on Panay Island, such as those in Iloilo City, the Municipality of Dumangas, and the Municipality of Ajuy, and ports on Negros Island, such as those in Bacolod City and the Municipality of Enrique B. Magalona. There are three major general anchorage areas located in this zone, with two located near Bacolod City. The third area is located where the Guimaras Strait meets the Panay Gulf, where a general anchorage area with boarding services for Pulupandan is offered, as noted on NAMRIA nautical maps.

Exhibit 15 Shipping routes of the Guimaras Strait, Iloilo Strait, and Panay Gulf



1 route per 0.08 km²/year — 279+ routes per 0.08 km²/year

Source: MarineTraffic, **https://www.marinetraffic.com/en/ais/home**

4. Site Access

The deployment of offshore wind turbines will require significant coordination between DOE, the Department of Environment and Natural Resources (DENR), the National Grid Corporation of the Philippines (NGCP), the Maritime Industry Authority (MARINA), and the Philippine Ports Authority (PPA). This section aims to summarize the ports with high potential for manufacture, staging, and assembly of offshore wind components and access to each offshore wind zone. In this section, the particular attributes of ports requiring upgrades and the projected cost for these upgrades are sourced from the World Bank's *Offshore Wind Roadmap for the Philippines*.[8] For this study, it is assumed that offshore wind components exceed the weight limit of roads and are too large for over-the-road transportation. Smaller parts may be transported by land for final assembly, but it is assumed that all components will be made and stored at the port.

4.1 Ports

This study focuses on two types of ports used for floating offshore wind project deployment:

- **Manufacturing ports:** These ports are used to transform raw materials into larger offshore wind components (e.g., blades, towers, floating platforms). For this study, it is assumed that blades and nacelles will be supplied from outside of the Philippines until local manufacturing catches up, sometime in the 2030s, as per the World Bank's *Offshore Wind Roadmap for the Philippines*.[9] Because expertise in the manufacture of ship hulls and other large marine structures is transferable to the manufacture of floating offshore wind platforms, this study focused on existing shipbuilding facilities that could serve as manufacturing sites for the offshore wind industry.

- **Staging and integration ports:** These ports are used for receiving, staging, storing, and potentially future decommissioning of offshore wind components. Floating wind turbine systems are assembled at these ports before being towed to the offshore wind site. Because towing operations require favorable weather windows and relatively low towing speeds, these ports should be as close as possible to offshore wind sites. These ports may also support major operation and maintenance activities during the lifetime of the offshore wind projects.

Generally, floating foundation turbines have more extensive port requirements than fixed foundation turbines. These requirements include port storage space of approximately 50 hectares, quay length of 250 meters, quayside and channel depth of 10 meters, quayside bearing capacity of 20 to 30 metric tons per square meter, channel width of 45 meters, and wet storage area of 13 hectares. According to the World Bank's *Offshore Wind Roadmap for the Philippines*, the Philippines has approximately 436 ports, of which about 75% are managed by the PPA. Of these sites, the study identified seven high-potential ports that meet or, with minor to moderate upgrades, could meet the requirements for floating projects.[10]

For Zone A, the Hanjin Heavy Industries Shipyard located in Subic Bay would be capable of manufacturing and assembling offshore wind systems with minor upgrades (less than US$5 million) to the quayside

bearing capacity (currently 10 to 20 metric tons per square meter). Other notable ports include the Keppel Subic Shipyard and the Herma Shipyard in Bataan. The Keppel Subic Shipyard would require moderate upgrades (less than US$50 million) to quayside bearing capacity, channel depth, and port space for marshalling. The Herma Shipyard would require moderate upgrades to quayside bearing capacity, port space, bearing capacity of storage space, and quay length.

For Zone B, the Port of Batangas Yard and the Batangas Heavy Fabrication Yard in Batangas Bay show the highest potential for offshore wind manufacture and assembly, but both would require upgrades. These upgrades would include moderate to major upgrades to quayside bearing capacity and minor upgrades to storage area bearing capacity. Other necessary investments include minor upgrades to quayside depth for the Batangas Heavy Fabrication Yard and restricted quay access at the Port of Batangas Yard. In addition to supporting Zone B, these ports could support long-term floating offshore wind development in other nearby high-potential floating offshore wind zones, such as those between Mindoro and Batangas.

For Zone C, the Tsuneishi Heavy Industries port on Cebu Island, which is capable of large steel structure and ship fabrication, could be a good fit for the zone's growing offshore wind potential. Minor upgrades needed at this port would include increasing the quayside bearing capacity, quayside depth, and quayside width.

In addition to the aforementioned ports, several smaller ports, ranging between 3 and 5 hectares, could provide storage and load-out (i.e., cargo transfer to seaborne vessels) for floating foundation projects. Transparency about and coordination of port development are essential to successfully build out manufacturing and site assembly for the growing offshore wind industry.

5. Interconnection Analysis

Each offshore wind site's energy generation capability is contingent on the adaptability of the existing grid to integrate new sources of power. This section focuses on the grid interconnection analysis conducted for the three offshore wind zones. The goals of the interconnection analysis are twofold:

1. Identify potential land-based substations that can serve as interconnection points used to export power from the offshore wind zone to the grid

2. Assess the interconnection viability for each of these points based on the grid's absorption potential

Six NGCP substations were chosen for this analysis for their proximity to an offshore wind zone and current capacity. These substations include one substation in Zone A, one substation in Zone B, and four substations in Zone C given its large potential for near-term fixed foundation offshore wind projects. These substations are listed in Exhibit 16.

Exhibit 16 **NGCP substations studied**

Site name	Substation province	Substation name
Zone A: Manila Bay	Bataan	Mariveles 500 kV
Zone B: Tayabas Bay	Quezon	Tayabas 500 kV
Zone C: Guimaras	Negros Occidental	Enrique.B. Magalona 230 kV
Zone C: Guimaras	Negros Occidental	Bacolod 230 kV
Zone C: Guimaras	Guimaras	Zaldivar (Guimaras Cable Terminal Station [CTS]) 138 kV
Zone C: Guimaras	Iloilo	Tigbauan 138 kV

RMI Graphic. Source: RMI

5.1 Methodology

To conduct the power flow analysis, a direct connection from offshore wind farms (assumed to be operational by 2030) of varying sizes to one of the NGCP substations was simulated using PSS®E version 34 software. The load profile for each zone was determined using the Transmission Development Plan (TDP) 2022–2040 provided by NGCP. According to this plan, the projected peak demand for the Luzon Grid in 2030 is estimated to be 20,069 MW and for the Visayas Grid it is estimated to be 4,423 MW.

The TDP 2022–2040 also outlines a variety of future dispatch scenarios for load and generation development planning. For the interconnection analysis, for the simulation of Zone A, a decision was

made to employ the TDP's Maximum North Luzon Scenario, during the wet season. Although this dispatch scenario, where all generation facility outputs in the northern part of the grid are set to their maximum capacities, has a relatively low probability of occurring, its selection allows the simulation to identify and highlight potential constraints within the transmission system.

Similarly, for the simulation of Zone B, the Maximum South Luzon Scenario, which assumes that all generation facilities in the southern part of the grid are outputting their maximum capacity, was used.

For Zone C, located within the Visayas Grid's service area, the Maximum Panay Scenario was utilized. This scenario assumes that all generation facilities in Panay, Cebu, Negros, and Bohol are maximized, while geothermal generation facilities in Leyte serve as regulating reserve.

A power flow analysis was conducted using two key operating conditions: effective dispatch of the full power plant capacity under normal conditions and under single-outage conditions (referred to as N-1 conditions). As part of the analysis of these two operating conditions, a meticulous examination of the power system's thermal capacity and voltage performance was conducted.

Analyzing the system's thermal capacity allows planners to identify if the system will be overloaded by the installation of new generation assets. Analysis of the voltage levels within the power system is of paramount importance because of the significant role voltage stability plays in preventing damage to both the system and the connected equipment.

The Philippine Grid Code defines the permissible variations in transmission system voltage as follows:

- During normal conditions, the voltage should remain within the range of 95% (0.95 per unit) to 105% (1.05 per unit) at any connection point.
- In N-1 conditions (where a single element outage is considered), the allowable voltage variations extend from 90% (0.90 per unit) to 110% (1.10 per unit).

5.2 Load Flow Assumptions

For this simulation, the major transmission reinforcement projects listed in the TDP 2022–2040 that have significant impact on the three zones are assumed to be in place and operational. These transmission projects are:

For Zone A: Manila Bay: (1) Castillejos 230 kV Substation Project; (2) San Simon 230 kV Substation Project; (3) Western Luzon 500 kV Backbone Stage 1; (4) Western Luzon 500 kV Backbone Stage 2; (5) Mariveles-Hermosa 500 kV Line; (6) Hermosa-San Jose 500 kV Line; and (7) Marilao 500kV Substation Project.

For Zone B: Tayabas Bay: (1) New Pagbilao 500/230 kV Substation Project; (2) Pagbilao-Tayabas 500 kV Line Project; (3) Tagkawayan 500/230 kV Substation Project; and (4) Silang-Taguig 500 kV Transmission Line and Substation Project.

For Zone C: Guimaras: (1) Cebu-Negros-Panay 230 kV Backbone Stage 1; (2) Cebu-Negros-Panay 230 kV Backbone Stage 2; (3) Cebu-Negros-Panay 230 kV Backbone Stage 3; (4) Mindanao-Visayas Interconnection Project; (5) Tigbauan 138 kV Substation Project; and (6) Panay-Guimaras 138 kV Interconnection Project.

Additionally, Exhibits 17, 18 (next page), and 19 (page 34) outline the dispatch assumptions for various power plants situated in and around the three zones.

Exhibit 17 **Dispatch assumption for power plants near the Bataan Peninsula**

Plant	Capacity (MW)	2030 Power output (MW)
Bataan Combined Cycle (Petron)	4x35	140
GN Power Dinginin	2x660	1,200
GN Power Mariveles	2x300	600
Limay-A Combined Cycle	3x70, 1x100	270
Limay-B Combined Cycle	3x70, 1x100	270
Masinloc Coal Fired	3x300	900
SMC Power	2x600	1,200
SMC Power	4x150	600
TOTAL		**5,180**

RMI Graphic. Source: Aboitiz Renewables

Exhibit 18 **Dispatch assumption for power plants near the Calabarzon Region**

Plant	Capacity (MW)	2030 Power output (MW)
Alaminos BESS	43	40
Alaminos Solar	120	89
Atimonan LNG	1,294	1,000
Avion LNG	121	97
Botocan Hydro	11	10
Calaca Coal	600	400
Caliraya Hydro	41	24
Energy World LNG	780	600
Ilijan LNG	1,440	1,200
Kalayaan Pumped Storage	720	720
Maibarara Geothermal	60	60
Makban-A Geothermal	110	60
Makban-B Geothermal	110	60
Makban-C Geothermal	110	60
Makban-D Geothermal	40	10
Makban-E Geothermal	40	10
NKS Caliraya Solar	100	100
NKS Lumot Solar	90	90
Pagbilao Coal	1,184	1,155
QPPL Coal	1,018	920
San Gabriel LNG	900	600
San Lorenzo LNG	600	400
Sem-Calaca Coal	850	550
SLPGC Coal	55	46
SLTEC Coal	135	135
SMC Pagbilao LNG	600	400
Sta. Rita LNG	1,200	800
Tagkawayan Coal	1,294	800
TOTAL		**10,436**

RMI Graphic. Source: Aboitiz Renewables

Exhibit 19 Dispatch assumption for power plants near Cebu, Negros, and Panay

Island	Plant	Capacity (MW)	2030 Power output (MW)
Cebu	BOGO	31.7	25.36
	CEDC	246	135
	CPPC	61.7	61.7
	EAUC	45	45
	KEPCO	200	76
	Medellin Hybrid	300	300
	PB103	32	24
	Toledo Solar	60	48
	TPC	145	50
	TVI	340	134
	VCEMEX	21	21
	SUBTOTAL		920.06
Panay	CASA Bagasse	12	12
	Nabas Wind	50	35
	Palm Concepcion	270	110
	Panay Diesel	112	112
	PEDC	164	130
	SPDC Hydro	300	240
	SOLEXAR Tigbauan	28.26	23
	TAREC San Lorenzo	54	52
	Tigbauan Solar	34.3	27
	Tri-Conti Wind	75.6	53
	SUBTOTAL		794
Negros	Biscom Biopower	48	10
	CABI Biopower	25	25
	Cadiz Solar (HELIOS)	108	86.4
	Calumangan Diesel (Energreen)	31	23
	Hawaiian Phils. Biopower	36.6	34.6
	Ilog Hydroelectric	21.6	10
	IslaSol Solar	67.2	53.8
	MCEI Biopower	12	12
	MonteSol Solar	15.3	12.2
	Nasulo Geothermal	50	27
	North Negros Biopower	25	20
	Palinpinon Geothermal	192.5	115
	SACASOL Solar	40.5	15.8
	SACASUN Solar	48.6	19.4
	San Carlos Biomass	8.3	8.3
	San Carlos Biopower	20	20
	Silay Solar	35	20
	South Negros Biopower	25	25
	URC Biopower	46	20
	Victoria Milling Biopower	80	23
	SUBTOTAL		580.5

RMI Graphic. Source: Aboitiz Renewables

5.3 Results

Exhibit 20 NGCP substations studied

Site name	Substation name	Estimated available capacity	Known limitation	Interconnection alternatives/ proposed enhancements
Zone A: Manila Bay	Mariveles 500 kV	450 MW	Overloading the Hermosa-Mexico 230 kV line during N-1 conditions	
Zone B: Tayabas Bay	Tayabas 500 kV	>475 MW	None	Pagbilao 500 kV
Zone C: Guimaras	Enrique.B. Magalona 230 kV	420 MW	Overloading the Calatrava-Toledo 230 kV submarine cable during N-1 conditions	Granada 230 kV (would likely have same Calatrava-Toledo constraint) **Enhancement:** Cebu-Negros 230 kV Interconnection Lines 3 and 4 Project
Zone C: Guimaras	Bacolod 230 kV	420 MW	Overloading the Calatrava-Toledo 230 kV submarine cable during N-1 conditions	Granada 230 kV (would likely have same Calatrava-Toledo constraint) **Enhancement:** Cebu-Negros 230 kV Interconnection Lines 3 and 4 Project
Zone C: Guimaras	Zaldivar (Guimaras Cable Terminal Station [CTS]) 138 kV	67 MW	Overloading the Zaldivar CTS (Guimaras CTS)-Ingore CTS (Panay CTS) 138 kV submarine cable during N-1 conditions	**Enhancement:** Panay-Guimaras 138 kV Interconnection Project
Zone C: Guimaras	Tigbauan 138 kV	150 MW	Overloading the Sta. Barbara-Jaro 138 kV Line during N-1 conditions	

RMI Graphic. Source: Aboitiz Renewables

Based on the simulations, it is ascertained that at least 450 MW of offshore wind capacity could connect directly to the Mariveles 500 kV substation without triggering any instances of overload. However, because of the critical loading of the Hermosa-Mexico 230 kV line during N-1 conditions, the system operator may impose limits on the generating output of the offshore wind assets.

For the Tayabas 500 kV substation near Zone B, it is expected that at least 475 MW of offshore wind capacity could be accommodated without overloading during normal or N-1 conditions. In this connection scheme, power generated by connected offshore wind projects would be transmitted to the load center in Metro Manila through the Tayabas-San Jose and Tayabas-Ilijan-Dasmariñas 500 kV corridors.

When analyzed individually, it was found that the Enrique B. Magalona 230 kV and Bacolod 230 kV substations in Negros Occidental could accommodate only approximately 420 MW of installed wind capacity because of a potential for overloading the Calatrava-Toledo 230 kV submarine cable during N-1 conditions.

Transmission constraints are most pronounced for the Zaldivar (Guimaras CTS) 138 kV and Tigbauan 138 kV substations. For the former, it is estimated that up to 67 MW of installed offshore wind capacity can be accommodated before there is an increased risk of overloading the Zaldivar CTS (Guimaras CTS)-Ingore CTS (Panay CTS) 138 kV submarine cable during N-1 conditions. For the Tigbauan 138 kV substation, up to 150 MW of installed offshore wind capacity can be accommodated before there is an increased risk of overloading the Sta. Barbara-Jaro 138 kV Line during N-1 conditions.

Simulations for all six substations indicate that risk of overloading is the limiting factor for offshore wind installed capacity. When the installed offshore wind capacity is kept below the limits discussed above, it is expected that the bus voltages within each simulation's study area will consistently adhere to the operational limits defined by the Philippine Grid Code.

5.4 Alternate Interconnection Points

Given the site-specific nature of offshore wind power project development, limited connection options are available.

For Zone B, a feasible alternative connection point would be the new Pagbilao 500 kV substation, completed in 2022, located approximately 20 kilometers northeast of the zone.

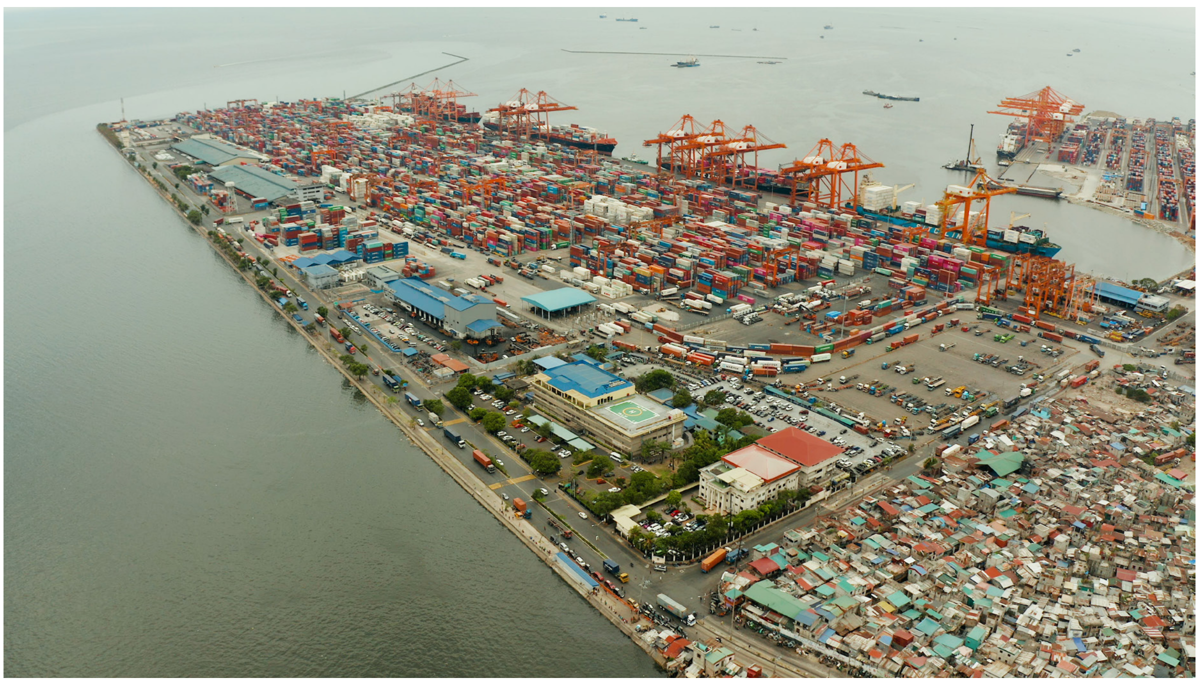
For Zone C, connection options are especially limited. A potential alternative connection point for Zone C could be the Granada 230 kV substation; however, it is highly probable that the transmission constraint with the Calatrava-Toledo 230 kV submarine cable would persist. An upcoming initiative included in the TDP known as the Cebu-Negros 230 kV Interconnection Lines 3 and 4 Project may address this known issue. By facilitating the transfer of surplus power from Panay and Negros to Cebu, this project aims to address the overloading of the Calatrava-Toledo 230 kV submarine cable during N-1 conditions. These upgrades could potentially increase the installed offshore wind capacity that could be accommodated by the Enrique B. Magalona 230 kV and Bacolod 230 kV substations in Negros Occidental, given that both sites are limited by overloading of the Calatrava-Toledo 230 kV submarine cable.

For the Zaldivar (Guimaras CTS) 138 kV substation in Zone C, the current submarine cable linking Panay and Guimaras operates at only 69 kV and has limited room to handle surplus power transmission. Therefore, NGCP is proposing to upgrade this cable to 138 kV through the Panay-Guimaras 138 kV Interconnection Project (expected to be completed by July 2026). This will necessitate the construction of an overhead transmission line from the cable terminal station in Ingore to the Iloilo substation, along with expansion and enhancement efforts at the Zaldivar substation.

6. Overview of Affected Areas

This section provides a preliminary environmental analysis and community impact assessment for each of these zones. This includes a preliminary analysis of baseline environmental and social conditions, identification of potential environmental and social impacts caused by offshore wind development in the zones, and recommendations for appropriate mitigating measures to manage identified risks and impacts.

To conduct the environmental and social impact assessment, national and local regulations and international standards set by financial institutions such as the Asian Development Bank, International Finance Corporation, and the World Bank were considered.



6.1 Content and Limitations

This section contains secondary data gathered through desk review of various published resources, including local governments' Comprehensive Land Use Plans, Forest Land Use Plans, and ecological and socioeconomic profiles. The review also included sectoral data and statistics from various agencies, including the Department of Agriculture, Department of Health, Department of Public Works and Highways, Department of Trade and Industry, MARINA, National Economic and Development Authority, Philippine Institute of Volcanology and Seismology (PHIVOLCS), and Philippine Statistics Authority (PSA).

6.2 Overview of Affected Areas

Of the three zones, Zone A and Zone B are in Region IV-A, the Calabarzon Region, whereas Zone C is in Region VI, or Western Visayas. As part of this preliminary analysis, impacts are discussed below by region and province.

Cavite

Cavite is one of the provinces belonging to Region IV-A (the Calabarzon Region). It is situated in the southern part of Luzon and bounded by Batangas Province, Laguna Province, Metro Manila and Manila Bay, and the West Philippine Sea. It has a land area of 1,427 square kilometers, which constitutes 0.42% of the country's total land area. According to the PSA's *2020 Census of Population and Housing* (2020 CPH), Cavite is the most populous province in Region IV-A, with a population of 4,344,829.[11]

Quezon

Quezon Province is in Region IV-A (the Calabarzon Region), bounded by the provinces of Aurora, Laguna, Rizal, Batangas, Camarines Norte, and Camarines Sur. According to the 2020 CPH, Quezon has a total population of 2,229,383.

Negros Occidental

Negros Occidental, one of the provinces in Region VI (Western Visayas), is situated on the northwestern portion of Negros Island, bounded by the Visayan Sea, Sulu Sea, Tañon Strait, and Negros Oriental. It also lies to the southeast of Panay Island from which it is separated by the Guimaras Strait. Among the provinces in Region VI, Negros Occidental has the highest population, with a total of 3,223,955, according to the 2020 CPH.

Iloilo

Iloilo Province, which is also in Region VI (Western Visayas), has a total land area of 4,663 square kilometers. Stretching from the southern to the northeastern portion of Panay Island, the province is bounded by Capiz and the Jintotolo Channel, Panay Gulf and Iloilo Strait, Visayan Sea and Guimaras Strait, and Antique. The province has a total population of 2,509,525.

Guimaras

Guimaras is a province in Region VI (Western Visayas) located in the southeast of Panay Island and northwest of Negros Island. Its land area is approximately 600 square kilometers. As of 2020, Guimaras had the lowest population in Region VI, with 187,842 total inhabitants based on the 2020 CPH.

7. Environmental, Social, and Climate Impacts

7.1 Baseline Environmental Analysis

Offshore wind development will have significant effects on water and land use through the utilization of the coastal and onshore areas and creation of interconnection infrastructure, power lines, and other associated facilities. As such, it is recommended that planning and coordination with the respective affected local governments and consultations with stakeholders be conducted before the start of project activities.

Land Use

All three zones have nearby built-up areas, Environmentally Critical Areas (mostly mangrove forests), marine protected areas, key biodiversity areas, and resorts for recreation. All three zones are also heavily used for aquaculture. Additionally, the Mount Palay-Palay Mataas na Gulod Protected landscape is located southeast of Zone A.

Geology and Pedology

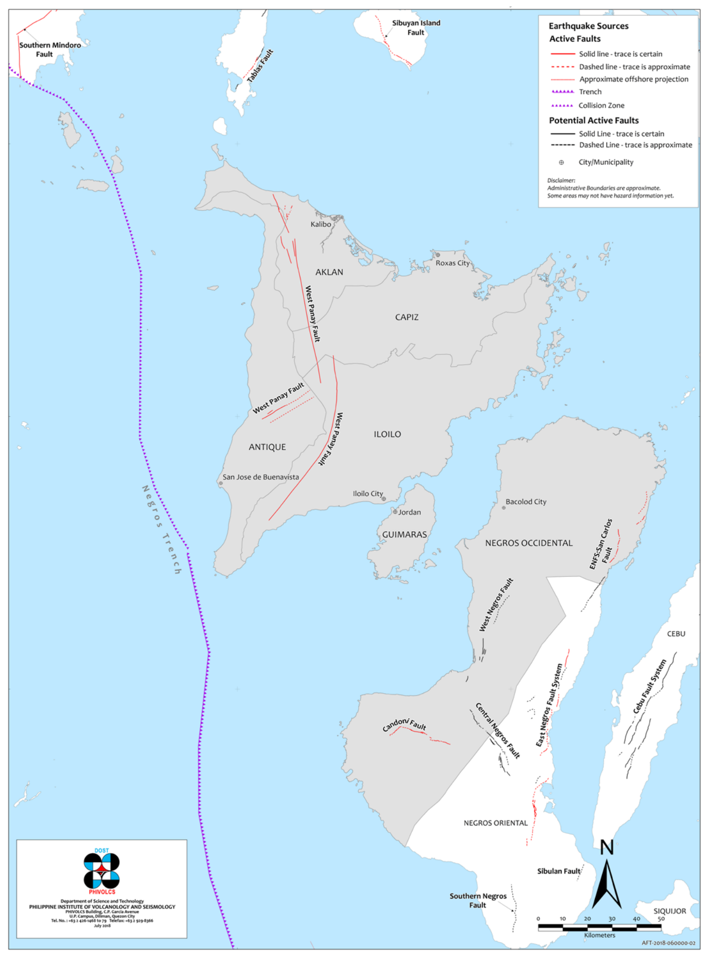
The slope of the land areas that immediately surround the three zones is relatively flat, which could entail fewer requirements for acquiring soil materials used for filling or embankment. The soil of the coastal areas surrounding all three zones is loam, composed of mostly clay and silt. Since loam soils do not suspend in the air easily, soil conditions are not expected to contribute significantly to air quality degradation.

Geological Hazards

All three zones are generally considered safe from ground rupture, although notable fault systems include the West Valley Fault, which passes through the eastern portions of Cavite; the East Negros

Exhibit 21

Distribution of active faults and trenches in Region VI



Source: Philippine Institute of Volcanology and Seismology

Fault System, which runs along the eastern edges of Negros Island; the West Negros Fault, which is approximately 15 kilometers from the central-western coasts of Negros Island; and the West Panay Fault on Panay Island.

All three zones are susceptible to ground shaking, ranging between a PHIVOLCS Earthquake Intensity Scale rating of VII (destructive) and VIII (very destructive). All sites are at risk of ashfall from nearby active volcanoes, including Taal Volcano, Mt. Banahaw, and Mt. Kanlaon.

Earthquake-induced landslide hazards exist in Zone A and portions of Zone C. With the exception of Zone A, several coastal areas of the sites are susceptible to liquefaction. Zone A and Zone C are susceptible to tsunamis, with wave heights reaching 6 to 7 meters (near Manila Bay), 1 to 3 meters (near the Municipality of Dumangas), 1 to 6 meters (near Bacolod City), 11.5 meters (near the Municipality of San Enrique), and 13 meters (near the Municipality of Oton). Submarine landslide hazards should be investigated in future phases given their potential threat to offshore wind turbines.

Hydrological Hazards

All three zones are susceptible to a storm surge wave height ranging from 1 to 4 meters, except for coastal areas in Iloilo Province, which may experience wave heights greater than 2 meters because of the constricted waterway along the Iloilo Strait.

Ambient Air Quality

All three zones have an Air Quality Index rating of good. For all of the zones, the anticipated impact on ambient air is short term and localized during the construction phase of the project.

Ambient Water Quality

The marine water classification of the three zones defines the parameters and standard values for assessing each site's water quality. The DENR published the Water Quality Guidelines and General Effluent Standards of 2016 (DAO 2016-08) to serve as a guide to maintain the water quality according to its intended use.[12] Exhibit 22 (next page) shows the classification of bodies of marine water and their intended use.

Zone A has water quality that does not conform with the standards for Class SB, whereas Zone B marine water has a high concentration of total dissolved solids. Heavy metals such as cadmium and lead have been detected in the waters of both zones.

For Zone C, data from 14 water-quality monitoring stations in the Guimaras and Iloilo Straits was collected. Of the 14 stations, only one station, located in the Iloilo Strait, was within the standard limit for fecal coliform. As for oil and grease, one station in the Iloilo Strait and four stations in the Guimaras Strait exceeded the standard limit.

Exhibit 22 **Water body classification and usage for marine water**

Classification	Usage
Class SA	**Protected Waters** – Waters designated as national or local marine parks, reserves, sanctuaries, and other areas established by law (Presidential Proclamation 1801 and other existing laws) or declared as such by an appropriate government agency, such as local government units (LGUs) etc. **Fishery Water Class I** – Suitable for shellfish harvesting for direct human consumption
Class SB	**Fishery Water Class II** – Waters suitable for commercial propagation of shellfish and intended as spawning areas for milkfish (*Chanos chanos*) and similar species **Tourist Zones** – For ecotourism and recreational activities **Recreational Waters Class I** – Intended for primary contact recreation (bathing, swimming, etc.)
Class SC	**Fishery Water Class III** – For the propagation and growth of fish and other aquatic resources and intended for commercial and sustenance fishing **Recreational Water Class II** – For boating, fishing, or similar activities

RMI Graphic. Source: Department of Environment and Natural Resources

Ambient Noise and Vibration

During construction, activities such as pile driving can generate noise up to 250 decibels (dB) at the source, and marine vessels transporting construction materials can generate noise up to 130 to 160 dB. During the operational phase, offshore wind farms can produce noise ranging from 90 to 120 dB. This may cause temporary or permanent hearing loss for sensitive marine life and may alter migration paths of marine life such as the endangered Irrawaddy dolphin, which inhabits Zone C waters.

Ecology and Biodiversity

It was found that all three zones are near or within protected areas, Environmentally Critical Areas, or important animal areas. Exhibit 23 summarizes the major protected areas near or within each site.

Exhibit 23 **Notable protected areas**

Site name	Relative location	Name of protected area
Zone A	Southeast of Zone A	Mt. Palay-Palay and Mataas na Gulod Protected Landscape
Zone B	East of Zone B	Important Bird Area in Pagbilao Bay
Zone C	Within zone	Iloilo and Guimaras Straits Important Marine Mammal Area
	Within zone	Negros Occidental Coastal Wetlands Conservation Area Ramsar Site
	Within zone	Jordan and Nueva Valencia Key Biodiversity Areas

RMI Graphic. Source: RMI

All three zones host the vulnerable Chinese egret (*Egretta eulophotes*), which has a migration route throughout the country. Zone C hosts the endangered Irrawaddy dolphin (*Orcaella brevirostris*) as well as three globally threatened marine turtles: the critically endangered Hawksbill turtle (*Eretmochelys imbricata*), the endangered Green Sea turtle (*Chelonia mydas*), and the vulnerable Olive Ridley turtle (*Lepidochelys olivacea*).

7.2 Climate Impact Risk

In 2011, the Philippine Atmospheric Geophysical and Astronomical Services Administration (PAGASA) released a study titled "Climate Change in the Philippines," which presented projected future climates in 2020 and 2050 using three emissions scenarios.[13] This study was updated in 2018 to project climatological parameters such as rainfall and temperature for two time frames: 2036–65 (mid-21st century) and 2070–99 (late-21st century).

According to the study, the level of the Philippine Sea has risen by as much as 5.7 to 7.0 millimeters per year, nearly double the highest global average sea level rise rate of 2.8 to 3.6 millimeters per year (observed from 1993 to 2010). The difference in these two values can be attributed to the occurrence of natural climate-related phenomena such as the El Niño Southern Oscillation. The study also notes a seal level rise of 4.5 to 5.0 millimeters per year to the east of the islands of Leyte and Samar, and along the southwestern coasts of Central and Western Visayas, east of Mindanao and south Zamboanga.

In terms of storms, the number of tropical cyclones entering the Philippines shows a minimal decrease from 1951 to 2015. However, the number of strong tropical cyclones with wind speeds exceeding 170 kilometers per hour have slightly increased from 1980 to 2015. This observed trend is consistent with expected future trends, based on findings from PAGASA's 2018 study. The study used five regional climate model simulations and a greenhouse gas emissions scenario in line with the Intergovernmental Panel on Climate Change's Fifth Assessment Report's (IPCC AR5) business-as-usual scenario (also known as Representative Concentration Pathway 8.5).[14] According to PAGASA's study, the average annual number of tropical cyclones is expected to decrease while the intensity of these storms is likely to increase. These findings are also consistent with the findings of the IPCC AR5.

The design of the WTG and its associated facilities must consider the level of susceptibility of the offshore wind sites to sea level rise and the increasing severity of tropical cyclones. Foundations should be designed to withstand not only typhoon force winds but also powerful waves. As floating foundations become more commercially available, further analysis is required to understand their performance during storms.

In addition to robust foundation and blade design, the turbine's control systems play an integral role in ensuring safe operation during storms. These systems are used to adjust blade pitch and yaw angles to mitigate the forces experienced by the turbine while maintaining stable operation. It is essential that these control systems have forms of backup power during storms and other emergencies to ensure their continued operation.

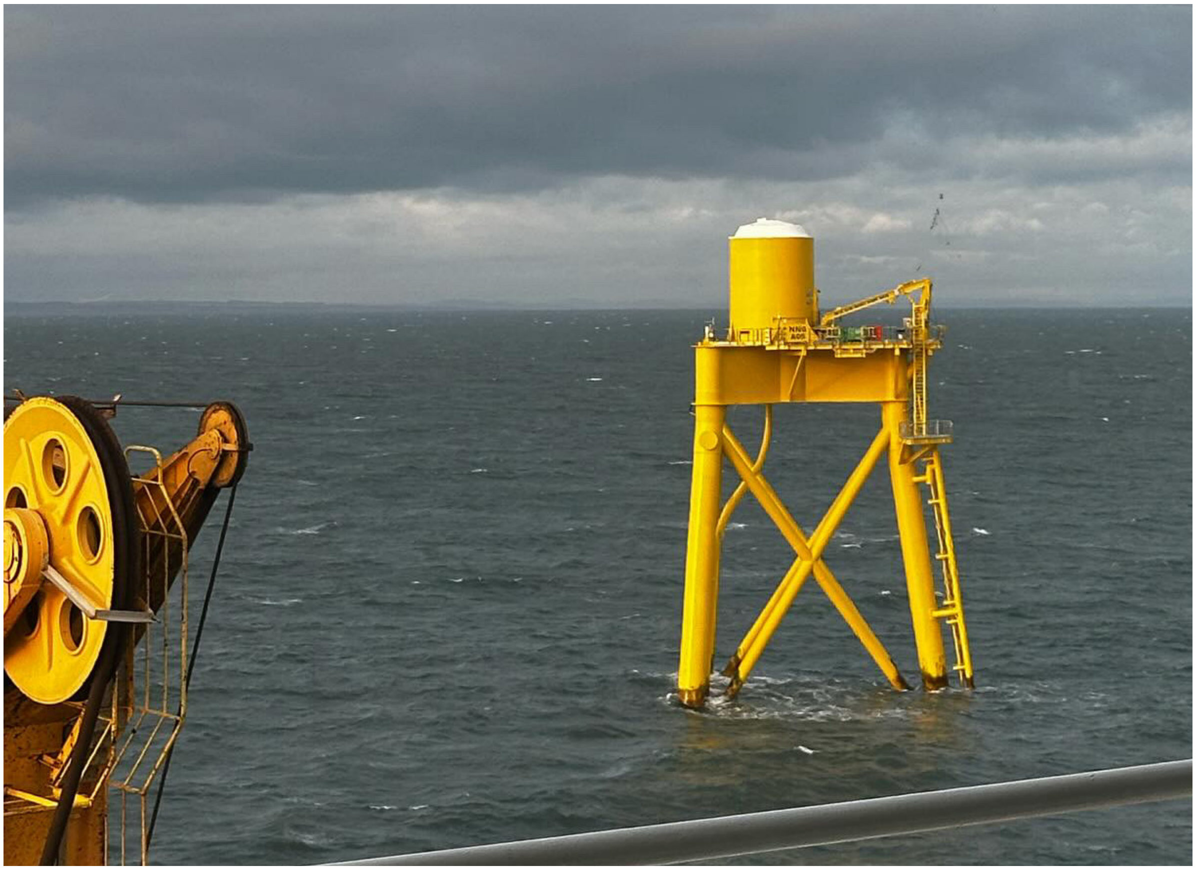


Image courtesy of Seobyoung Jr Chil

7.3 Baseline Social Analysis

This section provides baseline social conditions for the areas surrounding the three zones, including ongoing economic activity and existing infrastructure.

Local Economy

Agriculture, fisheries, and aquaculture are the major industries for the areas surrounding the three zones. Fishing, including commercial and artisanal fishing, is among the main sources of food and income in the areas. Tourism, including water recreation, also serves as an income generator.

Infrastructure, Utilities, and Public Health

All provinces surrounding the three zones have developed road infrastructure, including national, provincial, and municipal roads, as well as water supply, power supply, and telecommunication services. The presence of several airports means air traffic patterns might cross through some sites. All three zones have access to nearby government hospitals and, except for Guimaras Province, have at least one private hospital. Several ports, wharfs, and naval stations are located almost adjacent to all zones, which may affect the overall operations and access for marine navigation. Shipping vessels may experience limited or restricted access to certain portions or areas near the offshore wind sites.

7.4 Impacts, Mitigation, and Benefits

This section identifies potential environmental and social impacts of offshore wind projects and recommends measures to mitigate and manage these impacts.

Environmental Impacts and Mitigation

Environmental impacts are of paramount concern during project construction because of large disturbances of land, seabed, water, and natural habitat during installation. Proper planning and coordination can help mitigate this.

Environmental impacts were evaluated for the planning, construction, operation, and decommissioning phases, including effects on areas of importance to biodiversity, marine life, water and air quality, coastal area usage, electromagnetic fields, and underwater noise and vibration.

Regarding biodiversity, turbine placement can affect both marine and terrestrial ecosystems. The location of WTG assets impacts the seafloor's ecosystem by displacing key species and can cause collisions with or displacement of migrating bird and bat populations. Therefore, wind farms and their export cables must be required to avoid protected and environmentally critical areas as much as possible. In addition to avoiding the noted protected and environmentally sensitive areas, baseline surveys of offshore wind sites should identify marine, terrestrial, and avian species and their habitats, foraging routes, migration paths, and landing areas. Based on the results of baseline environmental studies and on-site surveys, turbine layout should be adjusted to provide sufficient buffer zones from protected areas and areas with higher concentrations of avian routes to minimize collision and displacement.

Understanding migration patterns is also important for marine species that use electromagnetic fields for navigation and hunting because turbines and export cables generate electromagnetic fields that may interfere with these species' migration patterns and behaviors. Mitigation measures include burying submarine cables at greater depths and covering them with concrete mats.

During construction, an inventory and on-site survey of trees and wildlife around the project area should be conducted. Vegetation clearing should be limited to reduce soil erosion and conducted with proper clearance from the DENR and Philippine Coconut Authority.

It is not expected that wind farm construction will have any adverse effect on water or air quality if the work adheres to adequate pollution prevention practices. These practices include employing sediment and erosion control measures and establishing water quality monitoring stations at project sites. To protect air quality, mitigation strategies include using low-emissions fuels in construction and operation vessels, limiting the speed of construction trucks, covering sediment during transport, and regularly maintaining equipment and machinery.

In terms of competing uses, commercial and artisanal fishing traffic and the presence of fishing grounds near each of the sites are large concerns. Proper coordination with the affected LGUs and key stakeholders can mitigate potential conflicts among existing users of marine water and plans for future development. Coordination with the relevant regulatory agencies to secure the necessary permits can also mitigate potential conflict with competing uses.

Underwater noise and vibration during construction is a concern, especially during the installation of foundations on the seafloor, which may require driving large piles into the bottom if using a monopile system or driving or drilling piles if installing a jacket system. This may cause temporary or permanent hearing loss for sensitive marine life and may alter migration paths of marine life. In each case, it is necessary to evaluate noise impacts on marine life and adopt mitigation measures to lessen noise impacts. These measures include proper coordination and notification of affected stakeholders (e.g., nearby communities, marine authorities, fishermen), scheduling and limiting loud activities during the daytime, and using good noise-abatement practices such as the installation of noise barriers or screens and bubble curtains in strategic locations. Regular ambient noise and vibration monitoring should also be conducted to determine the intensity trends of the on-site activities.

Community Impacts and Mitigation

Multiple perceived social impacts, both positive and negative, were determined based on the characteristics of LGUs covered in the study areas and the proximity of the three zones to key community facilities. Social impacts related to employment, livelihood, marine and air navigational activities, and tourism were among the most commonly identified issues.
Occupational health and safety issues are of paramount importance. Potential risks include working at height, over water, and in remote locations, and undertaking lifting operations. Therefore, projects must be managed with the highest standards for safe practices and attention to workers' health. Regular safety and health reports should be submitted to the Department of Labor and Employment.

> **"Impacts on community health and safety are affected by aviation and marine navigation, electromagnetic interference, and abnormal load transportation. To mitigate these impacts, proper coordination with stakeholders representing local fishermen, commercial shipping, local boating groups, and the LGUs is needed."**

Impacts on community health and safety are affected by aviation and marine navigation, electromagnetic interference, and abnormal load transportation. To mitigate these impacts, proper coordination with stakeholders representing local fishermen, commercial shipping, local boating groups, and the LGUs is needed. To minimize impacts on shipping routes and ports, projects should also coordinate with the Philippine Coast Guard, Ports Authority, MARINA, and Philippine Navy to ensure that the specified standards set by these agencies are met.

Air traffic is expected to pass through all three zones. Offshore wind farms may impact radar, navigation, and communication systems and create increased risk of collision. To mitigate these impacts, projects should conduct additional studies on the flight paths over each site and obtain the necessary permits and clearances from the Civil Aviation Authority of the Philippines and the Philippine Air Force.

Regarding land acquisition, offshore wind projects are expected to require manageable amounts of land for ancillary structures, such as substations and off-site construction areas. In cases where land acquisition cannot be avoided, a complete social impact assessment should be conducted that includes the potential impacts on the people and the communities residing on or occupying the land in question. Socioeconomic surveys and vulnerability screenings should also be conducted to understand baseline living conditions and to determine appropriate entitlements for those who are physically or economically displaced due to the project.

Because each site is close to fishing grounds and ports, it is expected that each of the three zones will directly affect the fishing and aquaculture industries, major sources of food and livelihood in the affected provinces. Potential impacts include economic displacement and issues related to accessibility to major fishing grounds and ports. It is recommended that after conducting an on-site analysis of maritime navigational routes, the placement of WTG structures be determined in a way that allows large vessels to access major fishing grounds and ports to mitigate the impact on artisanal and commercial fishing production.

Although offshore wind projects may temporarily disrupt existing tourism activities near high-priority sites, a long-term benefit to local tourism is also anticipated. Owing to its relatively new technology, wind farms can attract tourists and in turn, create tourism opportunities. Projects should coordinate with the Department of Tourism and local tourism offices to further assess the implication of projects on local tourism and mitigate their impacts during construction and operation.

To reduce impacts on indigenous peoples and ancestral domains, it is recommended that projects coordinate with the National Commission on Indigenous Peoples and the representing bodies of impacted communities.

Key historical and cultural landmarks are present within the three zones, particularly in the provinces of Cavite, Negros Occidental, and Iloilo. Areas of cultural and historical importance, including those located onshore close to project sites, are anticipated to be affected by physical and visual obstruction, considering the height of the turbines. Depending on the final turbine design and its aesthetic appeal, project design can blend with and enhance the quality of the visual experience in the area, therefore contributing to the tourism sector. Further coordination and consultations with the National Historical Commission of the Philippines and LGUs may be necessary to ascertain that there will be no significant impacts or damages to heritage sites. High-priority sites that are situated within or near historical marine waters where naval warfare took place (e.g., Manila Bay, Guimaras Strait, Panay Gulf, and Iloilo Strait) should be further investigated for the presence of underwater war artifacts and explosive remnants through underwater surveys, seafloor mapping, and hydrographic surveys.

8. Wind Turbine Technology and Generators

The offshore wind industry has experienced significant growth and technological advancements in recent years, contributing to the global transition toward renewable energy. This section provides an overview of modern offshore wind turbine technology and generator systems between 2023 and 2030. It highlights key developments, innovations, and trends that have emerged during this period.

8.1 Increasing Turbine Size and Capacity

One of the notable trends in offshore wind turbine technology is the continuous increase in turbine size and capacity. Turbines with larger rotors and higher power ratings have become more prevalent, enabling greater energy capture and cost reduction. The shift toward larger turbines has been driven by advancements in aerodynamics, materials, and manufacturing processes. By 2030, it is projected that offshore wind turbines will reach capacities of 15 to 20 MW or even higher, allowing for increased energy production and improved efficiency.[15]

8.2 Innovative Blade Designs

Blade design has undergone significant improvements to enhance turbine performance. Longer blades with optimized shapes and improved aerodynamics enable turbines to generate more electricity at lower wind speeds. Moreover, advanced materials, such as carbon fiber composites, are being utilized to reduce the weight of blades while maintaining structural integrity. These developments contribute to increased energy capture and reduced turbine loads, improving overall reliability and performance and making blades fully recyclable.

8.3 Floating Wind Turbines

Floating wind turbines have gained significant attention and investment in recent years. Unlike fixed-bottom turbines, floating turbines can be deployed in deeper waters, where wind resources are abundant. Advances in floating foundation designs, including tension leg platforms, semi-submersibles, and spar buoys, have enabled the commercialization of floating wind farms. Although as of September 2023, only four commercial-sized floating wind farms were operating globally: one in Portugal, one in Norway, and two in Scotland. China recently completed and connected its first offshore floating wind turbine, but to date it is not a multiple turbine commercial project.[16] Ongoing research and development efforts aim to optimize floating turbine technology, reduce costs, and overcome technical challenges associated with installation and maintenance in harsh offshore environments and deeper waters.

8.4 Hybrid Foundation Systems

To address the varying seabed conditions found in offshore locations, hybrid foundation systems have emerged as a viable solution. These systems combine different types of foundations, such as monopiles, jackets, and gravity-based structures, to optimize load-bearing capacity and stability. By tailoring the foundation design to specific site conditions, hybrid systems offer greater flexibility and cost efficiency while ensuring reliable and safe turbine operation.

8.5 Grid Integration and Power Transmission

Efficient grid integration and power transmission are critical for maximizing the potential of offshore wind energy. High-voltage direct current (HVDC) technology has gained prominence as an effective means of transmitting electricity from offshore wind farms to onshore grids over long distances. HVDC systems offer lower transmission losses, improved grid stability, and increased interconnectivity between offshore wind farms and onshore networks. Additionally, advanced grid management techniques, including smart grid technologies and energy storage solutions, are being explored to enhance the stability and reliability of offshore wind power systems.

8.6 Generator Technologies

Offshore wind turbine generators have also undergone significant advancements. Permanent magnet generators (PMGs) and direct drive systems have become increasingly popular due to their higher energy conversion efficiency and reduced maintenance requirements compared to traditional gear-driven generators. PMGs offer improved power density, compact designs, and enhanced control capabilities, making them well suited for offshore applications. The development of superconducting generators, although still in the experimental phase, shows promise in further improving generator efficiency and reducing weight.

The period from today to 2030 will witness remarkable advancements in offshore wind turbine technology and generator systems. The industry has seen a shift toward larger turbines with improved aerodynamics, innovative blade designs, and increased capacity. Floating wind turbines have gained market traction, enabling the exploitation of wind resources in deeper waters. Hybrid foundation systems, grid integration solutions, and advanced generator technologies will also play pivotal roles.

Below are a few potential scenarios for the size of offshore wind turbine generators that may be available for installation and operation in the Pacific region by 2030.

8.7 Larger Capacity Turbines

It is likely that turbines with capacities exceeding 15 to 20 MW will be available by 2030. Manufacturers are working on developing and commercializing higher-capacity turbines to improve energy production efficiency and reduce the levelized cost of energy (LCOE).[17]

8.8 Technological Advances

Continued advancements in turbine design, aerodynamics, materials, and control systems may result in more efficient and higher-capacity turbines. Innovations could include larger rotor diameters, optimized blade designs, and enhanced power conversion technologies, leading to improved performance and higher power ratings.

Image courtesy of Seobyoung Jr Chil

8.9 Floating Offshore Wind

The Pacific region, with its deep waters, may see increased deployment of floating offshore wind farms. Floating turbines enable the utilization of wind resources in deeper waters where fixed-bottom foundations are not feasible. By 2030, floating turbines with larger capacities and more advanced floating foundation designs may become commercially viable.

8.10 Market Competition and Demand

The growth of the offshore wind industry, increasing demand for renewable energy, and market competition among manufacturers may drive the development of larger turbines. Manufacturers will likely strive to offer turbines with higher capacities to meet the demand for more efficient and cost-effective offshore wind projects.

It is important to note that these are speculative projections, and actual developments in offshore wind turbine technology and availability by 2030 will depend on various factors, including research and development efforts, market demand, policy support, supply chains, and industry trends.

9. Implementation Timeline

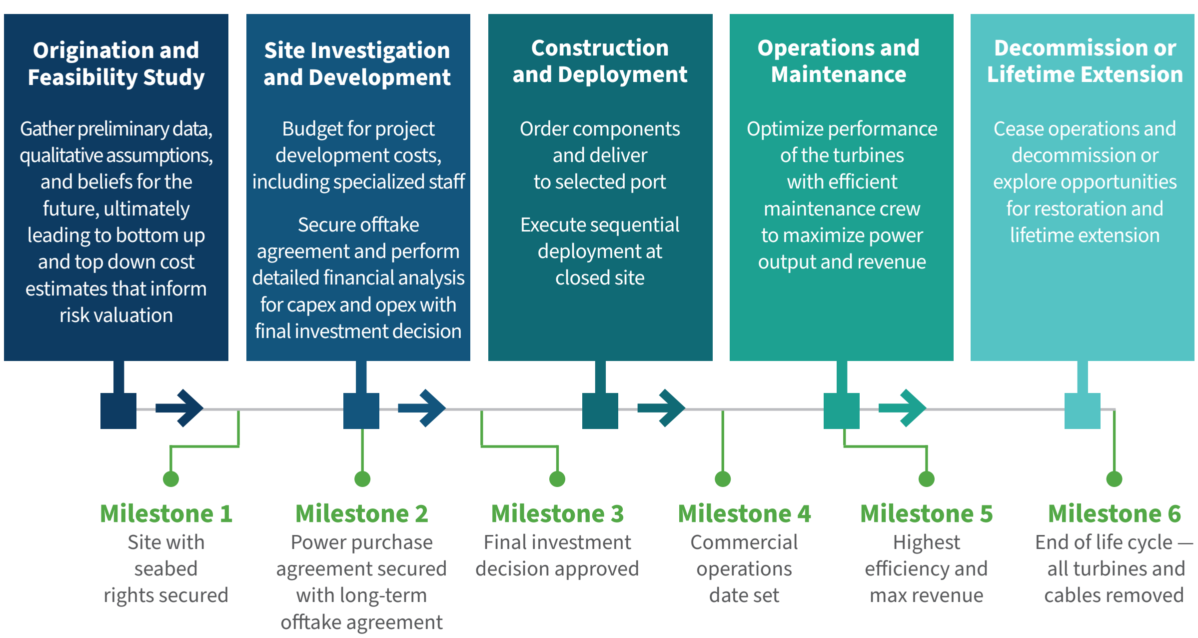
This section details the implementation timeline of a typical offshore wind development, from origination and feasibility study through site acquisition to decommissioning.

9.1 Introduction

The implementation of an offshore wind farm can be considered in five discrete phases:

1. Origination and feasibility study, leading to site acquisition (one to two years)
2. Site investigation and development, leading to a final investment decision (FID) (six to eight years)
3. Construction and deployment, leading to commercial operation date (COD) (approximately two to three years)
4. Operations and maintenance (25 to 30 years)
5. Decommissioning or lifetime extension (approximately one to two years)

Exhibit 24 **Key offshore wind implementation functions that lead to major milestones**



RMI Graphic. Source: RMI

9.2 Origination and Feasibility Study

The site characteristics evaluated in this early development phase include:

- Wind speed (secondary data) with daily, monthly, and seasonal diurnal trends
- Water depth (determining if the site is suitable for fixed bottom or floating units)
- Proximity to ports (for construction and deployment as well as for subsequent operations and maintenance)
- Proximity to airports and possible obstruction to civil and military aircraft operations
- Potential conflict with existing subsea cables (power or communication) and other submerged artifacts
- Potential conflict with shipping lanes and other ocean users, including commercial and recreational fishing, marine sanctuaries, and areas with endangered species
- Proximity to an existing or future substation to link with a suitable transmission cable on the grid to take the power to load centers

These characteristics are normally weighed against the challenges of advancing on any related regulatory issues (e.g., environmental, permitting, or procurement with offtake), along with an assessment of concerns from other stakeholders (e.g., local citizens who may object to obstructed views, environmental groups, and environmental justice groups).

The origination and feasibility study provides a high-level determination of the current fact base, qualitative understanding, and reasoned beliefs to assess the value of the site being considered. Normal practice is to perform both a bottom-up cost estimate with a detailed budget for the components and services needed to cover the capital expenditure (capex) and development expenditure along with anticipated revenue, and a top-down cost estimate using internal rates for capital, inflation, and strategic positioning. Rarely do the results of the two approaches reach the same conclusion. The difference is used to stimulate internal discussions to reach a conclusive ceiling for site acquisition. When multiple sites are being considered, then a merit order is performed to identify the preferred site in terms of investment versus risk exposure.

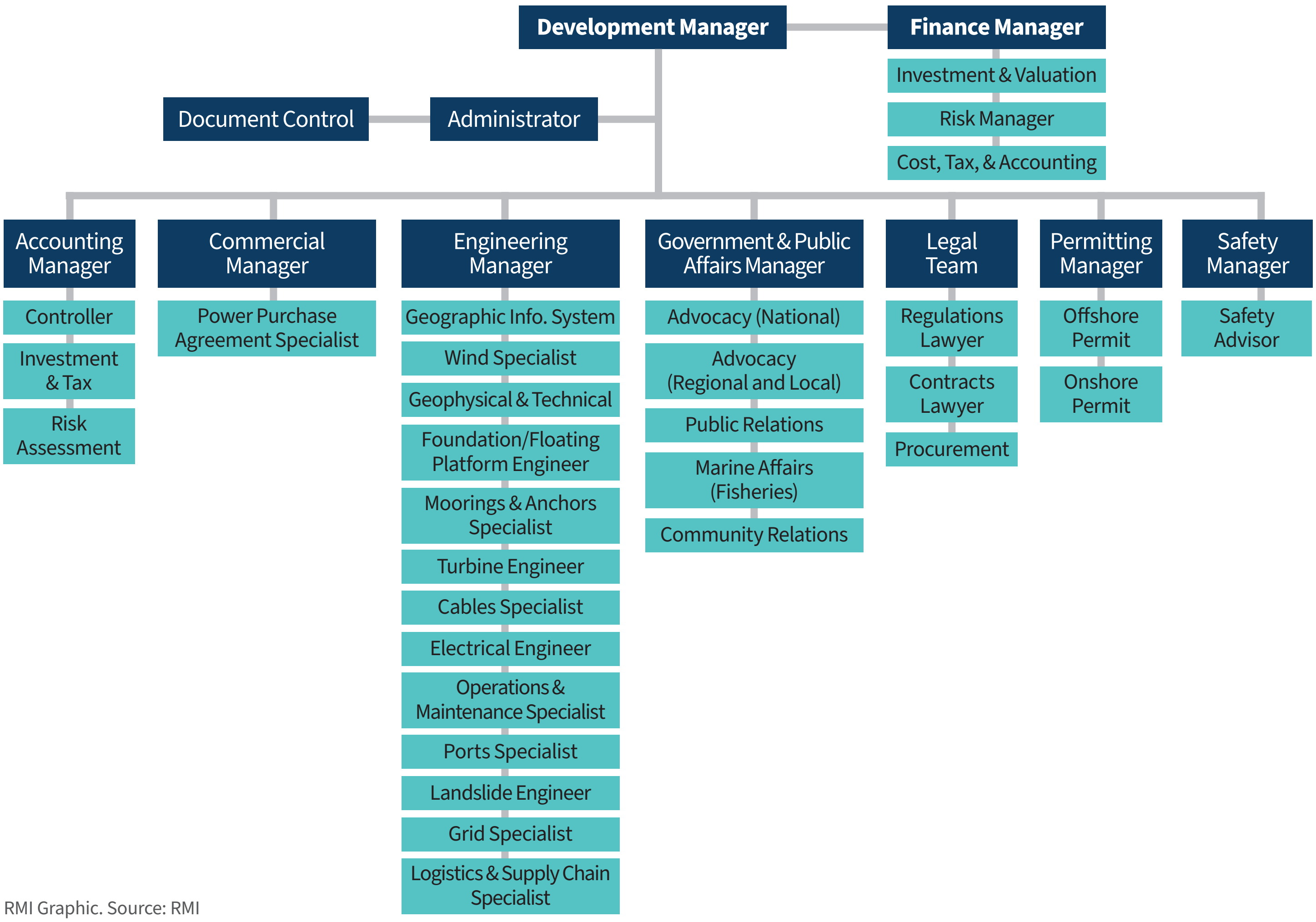
When the decision to acquire a site is made, it is necessary to secure the needed funds. Site acquisition is often a competitive process done through a public auction, hence the term bid expenditure or bidex. Securing a site or a portfolio of sites is necessary before advancing the offshore wind project to the next phase, site investigation and development.

9.3 Site Investigation and Development

It is normal practice for an offshore wind developer to assign certain work streams to a larger team with specialized skills and experience to complete the site investigation and development phase, which leads to an FID. It is important to have a clear understanding of all the tasks required for this phase and to ensure from the outset that there is a sufficient development expenditure budget to support all the activities and any unexpected delays to reach FID.

Companies seeking early entry into the offshore wind space may find that they lack certain expertise or skill sets, so they should be prepared to hire or contract outside resources to complete the requirements. Alternately, they can form a partnership with an experienced international developer. In the Philippines, there may also be an opportunity to tap into expertise in maritime sectors such as offshore oil and gas site development.

Exhibit 25 **Example organizational structure for site assessment and development**



RMI Graphic. Source: RMI

The site assessment and development team's responsibility is to take the information gained from the feasibility study and research the topics further to verify that a solid commercial decision can be made before significant capital expenditures are spent during the construction and deployment phase.

Because the global deployment of offshore wind energy is evolving at a rapid pace, it is particularly important in today's environment to be able to make a solid commercial decision. In Asia, Europe, and North America, the offshore wind industry is quickly growing, with demand that is outpacing supply chain availability. This is putting upward pressure on the costs for offshore wind developers and the broader offshore wind industry. Additional factors affecting cost include high oil prices, which motivate offshore wind suppliers to service the oil and gas sector; the Russian invasion of Ukraine; high inflation; and the increased cost of capital.

Historically, until 2020–21, offshore wind developers would detail their development expenditures, which would ultimately provide a very precise boundary for costs. These cost estimates determine the lowest floor for pricing to forecast total revenue and profit. With that information, the penultimate step in the development phase would be to execute a power purchase agreement to secure revenue, thereby significantly de-risking the project's financing structure. The final step would be to secure an FID. Once an FID had been reached, the development team would hand over the project to the construction team, which would start ordering and procuring all the components. However, with the present pressure on the supply chain, this approach is likely to lead to a significant delay in the supply of the components and could extend the construction timeline by several years.

To counter the challenges of the present market conditions and possible construction delays, offshore wind developers are being forced to consider committing to the supply chain much earlier in the process. Original equipment manufacturers (OEMs) are not willing to take unsecured risks in case developers cancel projects. So, they are imposing nonrefundable deposits to reserve manufacturing space for key components such as the substation, array and export cables, foundations, transition pieces, towers, turbines, and blades. Further, some service suppliers, including specialized survey providers with their vessels and installation vessels, are requiring deposits to reserve their availability. A consequence of these market conditions is that a percentage of traditional capital expenditures, normally raised and expended after FID, is being brought forward and spent before FID. This increases development expenditures and increases the money at risk for the site but preserves the planned COD.

To mitigate or at least reduce the risk exposure, some developers pursue a new practice where they work to quickly gain an accurate assessment of the site's wind resources and verify its power output. These results then inform the expected income from either a power purchase agreement or existing known revenues from vertically integrated markets. Only if the long-term expected revenues exceed the estimated remaining development, capital, and operating expenditures will a favorable FID be reached, and the project advance to construction.

This new development phase requires the development expenditure budget to include a partial amount of the traditional capital expenditure budget. It also requires a mini-FID that reviews risk related to the capital expenditure deposit before the end of the development phase. To mitigate financial exposure, early efforts are made to secure frameworks for offtake agreements and to best foresee revenue levels before making the deposits.

9.4 Construction and Development

Upon securing an FID and its associated budget, the construction team will:

- Secure port terminal space for the marshaling of the components (foundations, transition pieces, towers, turbines, blades, array cables, and export cable). It is important to store the fixed-bottom foundation in a sequence for easy access to match the preferred order of deployment and an alternative order of deployment. Foundations are made individually in different lengths for specific locations and their particular water depths. If the weather conditions are not suitable for installation at one location in the wind farm, the vessel may be able to go to another location where the weather conditions may be more favorable, thus the need for an alternative order of deployment.

- Complete contracts for the purchase of components, cranes, and special purpose transportation vehicles to move heavy components around the port staging area.
- Schedule and contract the appropriate vessels.
- Ensure all permits have been secured.
- Engage a workforce for any component finishing work, such as installing electronics and cables inside the transition pieces and towers, placing secondary steel landing pads around the transition pieces of the fixed foundation units, or placing the ladder and safety harnesses in the towers.

Once all the components have been marshaled for final construction, deployment can commence. For fixed-bottom turbines the sequence is:

- Installation of all the fixed-bottom foundations.
- Installation of the transition pieces with the electronic systems already in place.
- Installation of the at-sea substation and connection with an export cable (or two depending on redundancy) to the onshore point of interconnection.
- Connection of the array cables from the at-sea substation to transition pieces; this is important because shore power is initially used to keep each turbine rotating during installation of the remaining turbines so that they do not seize given the weight on their bearings.
- Completion of the mounting of the tower, turbine nacelle, and blades.
- "Black start" of the turbines. This is done by shore-based power once all the turbines have been installed. When the turbines are fully commissioned, power will flow in the opposite direction. This will mark the COD and the beginning of the operations and maintenance stage.
- Return of the port terminals to their original condition. This is done before the construction team hands over the project to the operations and maintenance (O&M) team and marks the end of construction and deployment and the start of the O&M phase.

9.5 Operations and Maintenance

Following the complete commissioning of the offshore wind farm, the normal procedure, depending on the contract, is for the OEM technicians to service and maintain the turbines for a defined warranty period (usually 2 to 10 years). Recently, the industry has learned that the most effective approach is to have a mixed team of both OEM technicians and the developer's technicians servicing and maintaining the turbines throughout the warranty period, with the OEM technicians being replaced by technicians on the developer's payroll at the end of the warranty period.

With this approach, the developer's technicians (both mechanical and electrical) require internationally recognized Global Wind Organization's "safety at sea" training prior to working alongside the OEM's technicians. The safety-at-sea certification often requires annual or biannual renewal. Provision should be made for regular safety-at-sea training as well as turbine training for new technicians throughout the up-to 30-year lifetime of the wind farm.

The O&M port should be as close as possible to the offshore wind farm so that the technicians can travel to the turbines efficiently, without becoming tired or seasick. The servicing technicians should become part of the control center and work as a team to learn how to optimally keep the turbines running with the greatest output. Experience and good record-keeping will reveal best practices for minimizing downtime while performing necessary maintenance.

The O&M port should also house essential replacement and spare parts, as well as specialized tools that might be required in the event of an emergency. All work should be documented in detailed records that can be reviewed so that adjustments in practices can be made to gain optimal efficiency throughout the project's lifetime.

Most importantly, all near accidents and actual accidents must be recorded, and all safety procedures need to be regularly reviewed and closely followed. Every developer's employee and contractors' employee must feel safe and everything must be done to keep them safe throughout every moment of work, both at sea and on land.

9.6 Decommissioning or Lifetime Extension

Once the project has reached the end of its useful life, the substation and cables must be removed. This requires specialized vessels with cranes and the means to transport the components to a port for dismantling and, where available, recycling. It is worth noting that the industry is under growing pressure to demonstrate the cradle-to-grave responsible use of all the materials in the components and to contribute to increased sustainability.

Following the removal of the cables and substation, the blades, nacelles, towers, and transition pieces are disassembled and taken to port for metal and parts recycling. Finally, the fixed-bottom foundations are normally cut 1 to 2 meters below the surface of the seabed. The United Nations has approved this practice because it is less disruptive to the seabed and its ecosystems than pulling the entire structure out of the depths of the seabed soils or clay. As part of the practice, it is essential to cover the cut edges with the seabed substrate not only to allow the ecosystems to recover but also to reduce the chance of having any future bottom trawling fishing nets snag on them.

Alternatively, turbine restoration, and even upgrade, at the end of the wind farm's useful life is becoming increasingly prevalent in some mature markets. Refurbishment involves inspecting key components such as the foundation, tower, nacelle, and blades for damage and corrosion. Offshore wind turbine foundations can be preserved through corrosion control and foundation repair and strengthening services, which are commonly used in the oil and gas industry. If the foundations can continue to be used, it is expected that the nacelle and blades will need replacement. This presents an opportunity to incorporate new technologies such as more efficient blades and upgraded control and monitoring systems that can enhance turbine performance, reliability, and efficiency. Developers should consider whether refurbishment is viable given the condition of the wind farm at the end of its design life and whether refurbishment can offer cost savings compared to decommissioning.

10. Legal References and Related Regulations

This section summarizes laws relevant to offshore wind development in the Philippines, including recent policies.

10.1 Republic Act No. 9136 – Electric Power Industry Reform Act of 2001

The Electric Power Industry Reform Act,[18] or the act ordaining reforms in the electric power industry, was passed in 2001 to ensure the accelerated electrification of the country with quality, reliable, secure, and affordable power. The law privatized the assets and liabilities of the National Power Corporation, established the Wholesale Electricity Spot Market, and implemented the Retail Competition and Open Access Act, among many others.

The Electric Power Industry Reform Act also mandated that DOE promote the exploration and development of renewable energy resources, while encouraging private-sector investment.

10.2 Republic Act No. 9513 – Renewable Energy Act of 2008

The Renewable Energy Act,[19] or the act promoting the development, utilization, and commercialization of renewable energy resources for other purposes, is the primary law that provides the overall framework for the use of renewable energy resources, including biomass, geothermal, solar (rooftop, ground mounted, and floating), hydro (run-of-river, dam, and pump-storage), ocean, and wind (onshore and offshore), for power and non-power applications in the Philippines. The law recognizes the need to reduce the country's dependence on imported, non-renewable sources of energy and to mitigate the environmental impacts of energy production.

The Renewable Energy Act requires all renewable energy developers that will explore, develop, and utilize resources in the Philippines to apply for a Renewable Energy Service Contract (RESC), a service agreement between the Republic of the Philippines, through DOE, over a period of 25 years in which the renewable energy developer is given the exclusive right over a particular area for exploration and development of renewable energy resources. The RESC serves as the foundation for the construction by the developer of a renewable energy power plant in the Philippines.

DOE Department Circular No. DC2021-11-0036, Providing the Revised Guidelines for the Green Energy Auction Program in the Philippines

The Green Energy Auction Program (GEAP) was created to accelerate the development of renewable energy in the Philippines, and to promote more active participation and investment by the private sector. GEAP ensures transparent and competitive selection of renewable energy facilities to provide end users with affordable power, and addresses price volatility related to procurement and pricing of Renewable Energy Certificates.

In April 2023, DOE released the Notice of Auction for Green Energy Auction 2, for a total of 11.6 GW installation targets from 2024 to 2026. However, offshore wind was not included in the list of technologies with the prices provided by the Energy Regulatory Commission.

DOE Department Circular No. DC2022-11-0034 – Prescribing Amendments to Section 19 of Department Circular No. DC2009-05-0008 Titled, Rules and Regulations Implementing Republic Act no. 9513, Otherwise Known as "Renewable Energy Act of 2008"

In November 2022, DOE Secretary Raphael Lotilla signed the circular amending the implementing rules and regulations of the Renewable Energy Act 2008 to allow 100% foreign ownership of renewable energy projects to help the country achieve its 35% renewable energy goal by 2030.

In the past, foreign entities were allowed only up to 40% ownership of renewable energy projects, but the Department of Justice stated that "exploration, development, and utilization of inexhaustible renewable energy sources are not subject to the 60:40 foreign equity limitation, as mandated by Section 2, Article 12 of the 1987 Constitution." DOE has initially opened 100% foreign ownership to large-scale geothermal projects.

10.3 Executive Order No. 21, Series of 2023 – Framework for the Offshore Wind Development

On April 19, 2023, Executive Order No. 21 (EO 21),[20] entitled "Directing the Establishment of the Policy and Administrative Framework for Offshore Wind Development," was issued by President Ferdinand Marcos, Jr. It directs DOE to formulate and issue a policy and administrative framework for the efficient and optimal development of the country's offshore wind potential. The goal of EO 21 is the Energy Virtual One-Stop Shop (EVOSS) integration of all the permit requirements for offshore wind development activities.

As a response to EO 21, on May 18, 2023, DOE issued Department Circular No. DC2023-05-0013, which promulgates the Implementing Guidelines of Executive Order No. 21 ("Implementing Guidelines").

According to the Implementing Guidelines, offshore wind development activities shall be divided into three stages:

1. Predevelopment Stage

Under the Predevelopment Stage, the offshore wind developer must acquire an Offshore Wind Energy Service Contract (OSWESC), after which it shall be obliged to conduct and deliver its work commitments under the approved Work Program, which includes the following:

- Acquisition of relevant permits and clearances from concerned Permitting Agencies, such as but not limited to environmental and social impact assessments and clearances, and endorsements from agencies that regulate fisheries, shipping, navigation, and security in the Contract Area; and

- Permits and clearances needed to avail themselves of the incentives under the Renewable Energy Act, such as the Duty-Free Importation Certificate, among others.

The offshore wind developer, under the resource assessment, must also conduct on-site technical surveys including, but not limited to, wind resource, bathymetry, metocean, geological, and hydrographical data collection. The offshore wind developer may also install structures hosting equipment such as meteorological masts, light detection and ranging and sound detection, and ranging devices for the measurement of wind and other atmospheric data. These structures can be floating anchored structures, installed on the seabed, or deployed onshore near the coastline, depending on what is feasible for the site.

Upon the availability of the preliminary resource assessment, the offshore wind developer is also required to conduct an in-depth assessment on the capacity of roads and capability of ports and the grid in its vicinities. The offshore wind developer is also required to apply for a grid assessment to be undertaken by the Network Service Providers to determine the impact of the offshore wind project on the grid. The port capacity assessment shall be undertaken by the offshore wind developer, in coordination with the PPA.

Upon determining the viability of the resource in its contract area through the assessments conducted, the offshore wind developer shall conduct a feasibility study, which shall include the following:

- Market study to determine the availability of offtake for the offshore wind project

- Technical study providing the micro-siting, annual energy yield assessment, and preliminary engineering design

- Financial and economic study providing the financial parameters to determine the commercial viability of the offshore wind project

- Social and environmental impact study, which summarizes the result of the offshore wind developer's compliance with all the requirements of the permitting agencies

If the result of the feasibility study suggests that the offshore wind project is commercially viable, the offshore wind developer will secure financing for the offshore wind project.

2. Construction Stage

The offshore wind developer has the option to tender an agreement with engineering, procurement, and construction (EPC) contractor/s. The EPC contractor/s shall secure all construction permits with the permitting agencies. The offshore wind developer shall comply with all the permits and clearances required.

The offshore wind project shall include the construction/installation of wind turbine generators, substation, submarine cable, transmission line, and interconnection facilities, and, if applicable, special-purpose port/jetty, among others. The offshore wind project will then be tested and commissioned for the commercial operations stage.

3. Commercial Operation Stage

Under the Commercial Operation Stage, the offshore wind developer will operate and maintain the project as a power generation facility. It shall ensure reliable and safe operations, consistent with the Philippine Grid Code, and all other applicable laws, regulations, and issuances.

At the end of the operational life of the offshore wind project, the developer shall, at its own expense, cause the decommissioning and abandonment of the offshore wind project in accordance with the approved Abandonment and Termination Plan.

10.4 DENR Department Administrative Order No. 2024-02

DENR released the “Interim Guidelines for Environmental Compliance Certificate (ECC) Under the Philippine Environmental Impact Statement System (PEISS) for Offshore Wind (OSW) Energy Projects” on January 18, 2024.

The administrative order (AO) aims to “achieve balance between the environmental benefits of using the oceans for renewable energy exploration, development, and utilization, and the need for protection, restoration, and regeneration of the environment.”[21]

11. Key Stakeholders

Exhibit 27 (next page) presents a non-exhaustive list of the requirements that must be considered, under the governing rules and regulations of the different local government agencies associated with the development of an offshore wind project.

EO 21 s. 2023 was signed "Directing The Establishment Of The Policy And Administrative Framework For Offshore Wind Development," which will eventually streamline permitting requirements for the development of offshore wind projects.[22]

This initial list of required permits is categorized by the respective local government agency to allow for easier identification of the requirements.

Exhibit 26 **List of permits**

Agency	Certificates, permits, and registrations	Brief description
Civil Aviation Authority of the Philippines	Height Clearance Permit	A permit containing the regulating standards for determining obstructions around airports in navigable airspace that apply to existing and proposed structures such as telecommunications towers
Department of Agriculture Bureau of Fisheries and Aquatic Resources (DA-BFAR)	Project Clearance	Coordinate with DA-BFAR on the location of fisheries and aquatic resources that will be affected by the project
Department of Energy (DOE)	Wind Energy Service Contract	A contract that provides the rights and responsibilities to use wind energy and develop and operate the corresponding renewable energy facility. The developer must also register as a renewable energy developer as a requirement to secure the WESC.
Department of Environment and Natural Resources (DENR)	Environmental Compliance Certificate/Certificate of Noncoverage	A document issued certifying that based on the representation of the proponent, the proposed project or undertaking will not cause significant negative environmental impact
	Foreshore Lease	Application covering foreshore lands, marshy lands, and other lands bordering bodies of water for commercial, industrial, or other productive purposes other than agriculture
	Miscellaneous Lease	An application covering either a combination of dry land (part of the shore), foreshore land, or permanently underwater land, depending on the limitations set by the Philippine Ports Authority (PPA), Philippine Reclamation Authority, Department of Tourism, and the Department of Public Works and Highways
	Special Use Agreement in Protected Area or Protected Area Management Board Clearance	A permit that confirms if a project within protected areas will proceed or be canceled
Local Government Unit (LGU)	Barangay and LGU endorsement	A document issued by the Barangay and LGU needed for processing of different permits
	Business Permit	A compliance document that identifies a business can legally operate and do business in their respective city or municipality
	Construction Permit	A document issued to legally begin construction
	Certificate of No Objection	A legal document issued by the LGU stating that due process has been followed in the conduct of a procurement proceeding
National Grid Corporation of the Philippines (NGCP)	Connection Agreement	An agreement between a user and a transmission network provider (distribution utility) that specifies the terms and conditions pertaining to the connection of the user system or equipment to a new connection point in the grid
	Transmission Service Application	An agreement between the transmission network provider and the user of the transmission network that specifies the terms and conditions of the provider's service and the use of such service. This also serves as the "Connection Agreement"
National Water Resources Board	Water Permit/Water Rights	A document granted by the government to appropriate and use water
Philippine Coast Guard	Coast Guard/Navigational Clearance	Coordinate with the Philippine Coast Guard in securing necessary clearances for the development of offshore projects

RMI Graphic. Source: RMI

12. Recommendations

The next decade is crucial for offshore wind development in the Philippines, and the challenges and opportunities require cross-sectoral interventions for sustainable growth and success.

Based on preliminary information on the country's wind resource, bathymetric profile, and existing interconnection infrastructure, three high-priority offshore wind zones were chosen for their potential to provide the Philippines' first offshore wind projects and future opportunities for longer term development as a floating offshore wind market matures. These zones were chosen for their high wind speeds of greater than 7 meters per second, proximity to major load centers in southern Luzon and western Visayas, areas with relatively shallow water depths (<50 meters) that allow for fixed foundation WTG designs for the market's first projects, and access to deeper areas for floating offshore wind farms.

This report recommends development in phases based on where ports and transmission are best able to support smaller capacity offshore wind farms (<300 MW), specifically in Zone A (near Manila Bay) and Zone B (near Tayabas Bay), where substations are better equipped for interconnection and nearby ports would require minimal upgrades.

Part of DOE's 4-Point Strategy for Energy Transition is to build and develop a Green and Smart Transmission System that enables the grid to accommodate the target renewable energy capacities needed to meet the country's renewable energy goals. This strategy also includes building and expanding the necessary port infrastructures to support offshore wind projects and other marine-based energy resource development project, including tidal stream projects. The Asian Development Bank is currently providing technical assistance to DOE on 10 ports, of which 6 are managed by the Philippine Ports Authority. This technical assistance is expected to be completed by October 2024.

As transmission and port infrastructure are improved for the offshore wind ecosystem, the market for floating foundation WTG is expected to grow significantly, allowing the Philippines to tap into its wealth of wind potential in deeper waters. Zone C (surrounding Guimaras Province), with its mix of shallow (<50 meters) and deep waters, provides an opportunity for a mature fixed foundation offshore wind market and an early floating foundation market to develop in parallel and share the transmission and port upgrades that would be required in this area.

Other offshore wind zones that were not included in this study will also benefit from port and transmission upgrades in a mature offshore wind market, namely those northwest of Luzon and Mindoro-Batangas.

Below is a summary of the key findings:

- **Zone A (Manila Bay) and Zone B (Tayabas Bay) have the potential for near-term (i.e., operational by 2035) offshore wind development, with wind farms using fixed foundation turbines and WESC leases of less than 300 MW.** The nearby points of interconnection and ports require minimal upgrades for small offshore wind projects. Relatively small projects (<500 MW) are well positioned to be first movers in the Philippines' offshore wind market but may quickly struggle to reach sufficient economies of scale as the market matures.

- **Zone A and Zone B have the potential for longer term offshore wind development, with the location of adjacent deep bathymetry (>50 meters) with high wind resources.** Transmission and port upgrades used for the sector's first projects in the Philippines can be used to facilitate the country's first floating offshore wind projects in these areas.

- **Like Zone A and Zone B, Zone C (waters surrounding Guimaras Province) is recommended for near-term (i.e., operational by 2035) development for fixed foundation turbines. Available WESCs in this area have economies of scale with 600 MW or higher capacities.** However, this area requires more infrastructure investments in transmission because there are few high-capacity transmission lines (>230 kV). Additionally, this zone has a variety of environmentally protected areas. Also, like Zone A and Zone B, Zone C has a mix of shallow and deep water that will allow any initial infrastructure investments made for the fixed foundation offshore wind industry to facilitate the country's first floating offshore wind projects in this area.

- **Northwest Luzon has among the highest wind resources in the Philippines (>10 meters per second) and is recommended for long-term development.** The absence of nearby ports big enough for manufacturing provides significant challenges, with Currimao Port in Ilocos Norte and Port of Irene in Cagayan being the nearest ports. The closest port that would require minimal upgrades (< US$ 5 million) for offshore wind installation is in Subic Bay, around 450 kilometers from the DOE-awarded WESC sites in Ilocos Norte. These areas also require significant transmission upgrades to deliver offshore wind energy to major load centers in southern Luzon.

- **Mindoro-Batangas is also recommended for long-term development because the deep bathymetry (>50 meters) makes the area more suitable for floating offshore wind technology.** The Batangas-Mindoro, Palawan-Mindoro, and Mindoro-Panay interconnections are recommended to be at least 230 kV to accommodate the power generated by offshore wind. Many ports used for Zone B may also help facilitate offshore wind development in the Mindoro-Batangas areas.

- **Offshore wind development has potential to affect both marine and terrestrial ecosystems.** All three zones are near or within protected areas, Environmentally Critical Areas, or important animal areas such as mangrove forests, protected wetlands, and marine sanctuaries. These zones also host vulnerable species such as the Chinese egret (Egretta eulophotes), which has a migration route throughout the country. Of the three zones, Zone C has the most protected areas within its vicinity, such as the Iloilo and Guimaras Straits Important Marine Mammal Area, the Negros Occidental Coastal Wetlands Conservation Area Ramsar Site, and the Jordan and Nueva Valencia Key Biodiversity Areas. Zone C also hosts a variety of endangered species, such as the Irrawaddy dolphin (Orcaella brevirostris), the Hawksbill turtle (Eretmochelys imbricata), and the Green Sea turtle (Chelonia mydas).

- **Wind farms and their export cables must be required to avoid protected and environmentally critical areas as much as possible.** In addition to avoiding the noted protected and environmentally sensitive areas, baseline surveys of offshore wind sites should identify marine, terrestrial, and avian species and their habitats, foraging routes, migration paths, and landing areas. Based on the results of baseline environmental studies and on-site surveys, turbine layout should be adjusted to provide sufficient buffer zones from protected areas and areas with higher concentrations of avian routes to minimize collision and displacement. Coordination with the relevant regulatory agencies, communities, and local governments can mitigate harmful environmental impacts. Additionally, mitigation measures for underwater noise and vibration, electromagnetic fields that interfere with marine species, and soil erosion (for land-based facilities) can reduce harmful environmental impacts during the project.

- **A comprehensive social impact assessment and socioeconomic surveys will enable all stakeholders to understand the potential impacts on communities, especially when land acquisition is unavoidable.** The socioeconomic surveys and vulnerability screenings are essential for determining appropriate entitlements for those who are physically or economically displaced due to the project.

- **Coordination with stakeholders and relevant agencies to mitigate socioeconomic risks is recommended, especially on issues related to conflicts among existing uses of marine water and plans for future development.** In addition, to ensure minimal impact on tourism, historical landmarks, and ancestral domains, project developers should work with the Department of Tourism and local tourism offices, the National Historical Commission of the Philippines, the LGUs, and the National Commission on Indigenous Peoples.

- **Fishing and aquaculture industries and maritime navigational routes must be considered during project development due to their critical role in food and income for all three zones.** Ensuring that the placement of turbines allows large vessels to access major fishing grounds and ports will mitigate the impact on artisanal and commercial fishing production. An on-site analysis of marine usage will inform turbine placement to minimize impact on fishing, aquaculture, and other maritime industries.

Appendix

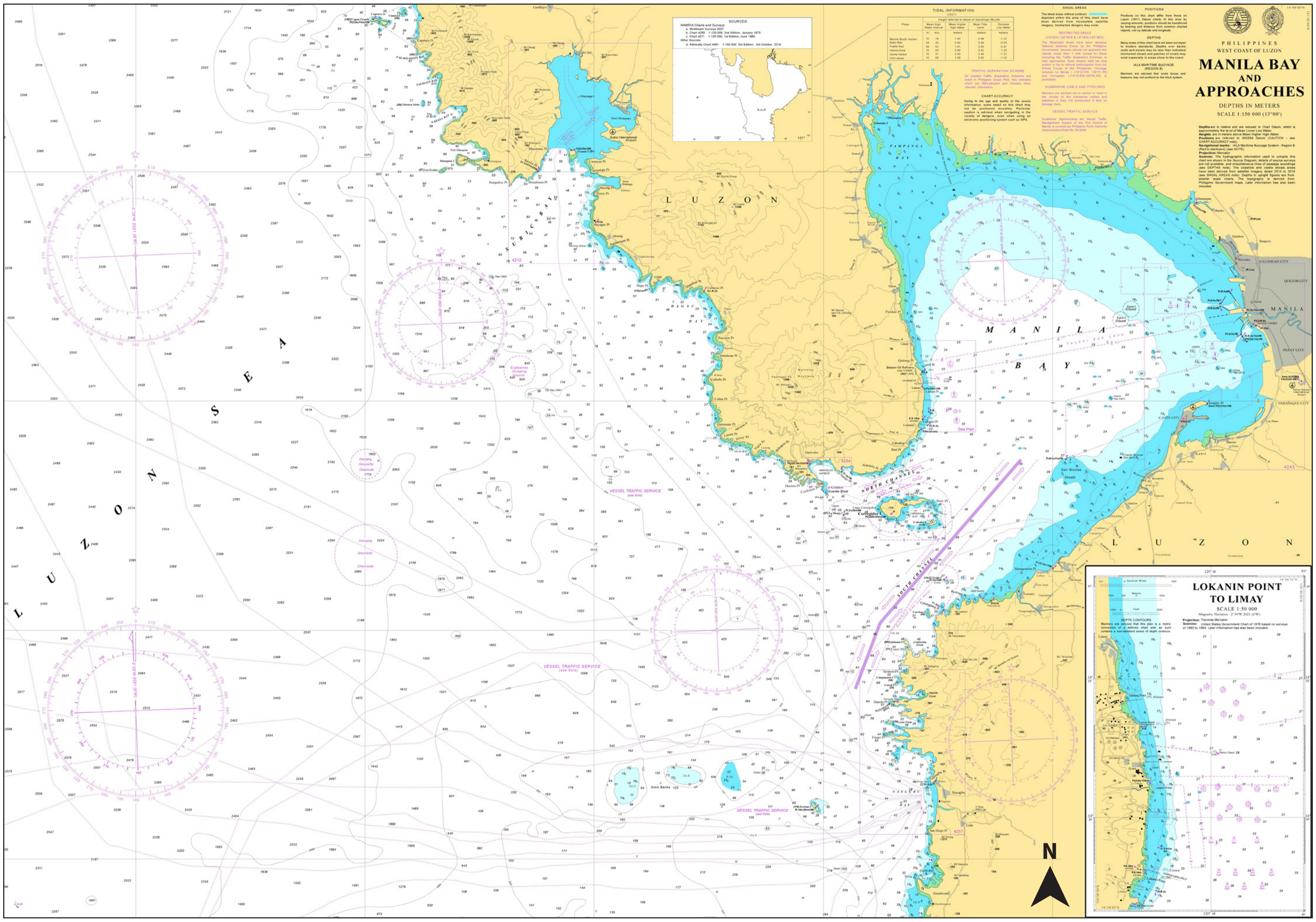
Exhibit A1 Distance to the nearest ports

Zone	Nearby ports	Recommendation
Manila Bay	~30 kilometers (km) Manila** ~100 km to Subic ~190 km to Batangas	**Hanjin Heavy Industries Shipyard**, Subic Bay **Keppel Shipyard**, Subic Bay **Herma Shipyard**, Bataan
Tayabas Bay	~90 km to Batangas ~260 km to Manila ~500 km to Legazpi	**Port of Batangas Yard**, Batangas Bay **Batangas Heavy Fabrication Yard**, Batangas Bay
Guimaras	~30 km Iloilo** ~20–50 km Bacolod* ~280 km to Cebu ~250 km to Ormoc ~250 km to Dumaguete ~250 km to Siquijor	**Tsuneishi Heavy Industries**, Cebu
Northwest Luzon	~70 km from Pagudpud to Currimao* ~450 km from Laoag to Subic ~600 km from Laoag to Manila	Major investment in port upgrades is recommended for **Currimao Port** and/or **Port of Irene** to serve as staging and integration ports
Batangas-Mindoro	~20 km Batangas ~190 km to Manila ~190 km to Subic ~470 km to Iloilo and Legazpi	**Port of Batangas Yard**, Batangas Bay **Batangas Heavy Fabrication Yard**, Batangas Bay

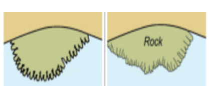
*Too small and will require major upgrades.
**Some major ports are congested, and the available land space is used for cargo, container traffic, and roll-on roll-off, among other uses.

RMI Graphic. Source: RMI

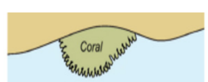
Exhibit A2 **Nautical chart of Manila Bay and approaches**



S	Sand	*M*	Mud	*Cy*	Clay	*G*	Gravel	*R*	Rock, rocky	*Bo*	Boulder(s)
4₆ Wk / 25 Wk	Wreck, least depth known by sounding only		Obstruction		Established (mandatory) direction of traffic flow		Submarine cable		Limit of restricted routing measure		



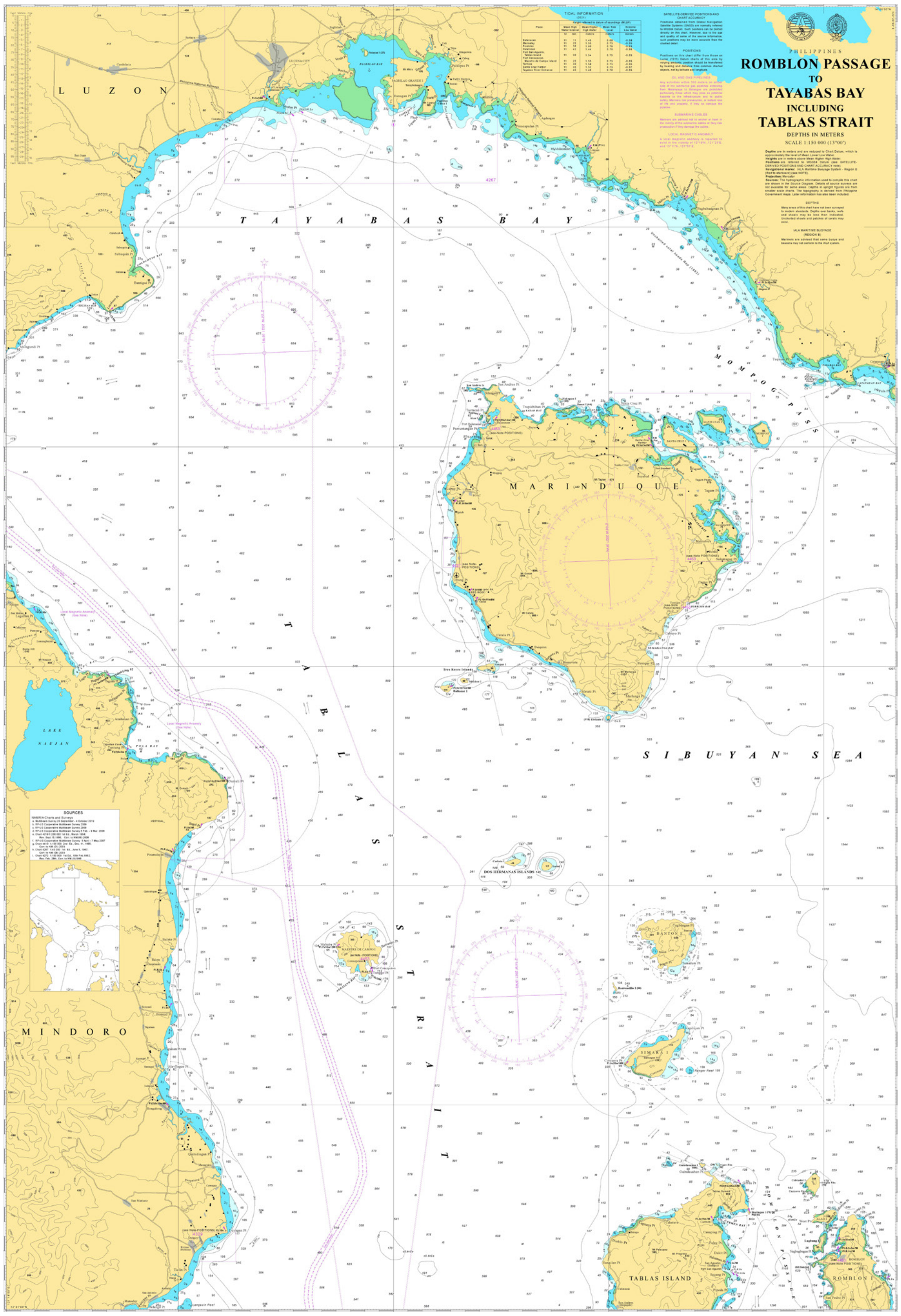
Rocky area, which covers and uncovers



Coral reef, which covers and uncovers

Source: National Mapping and Resource Information Authority

Exhibit A3 **Nautical chart of Romblon Passage to Tayabas Bay including Tablas Strait**



S	Sand	*M*	Mud	*Cy*	Clay	*G*	Gravel	*R*	Rock, rocky	*Bo*	Boulder(s)

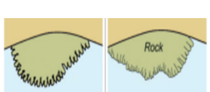
4₆ Wk / *25 Wk* Wreck, least depth known by sounding only

Obstruction

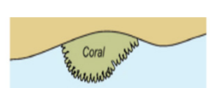
Established (mandatory) direction of traffic flow

Submarine cable

Limit of restricted routing measure



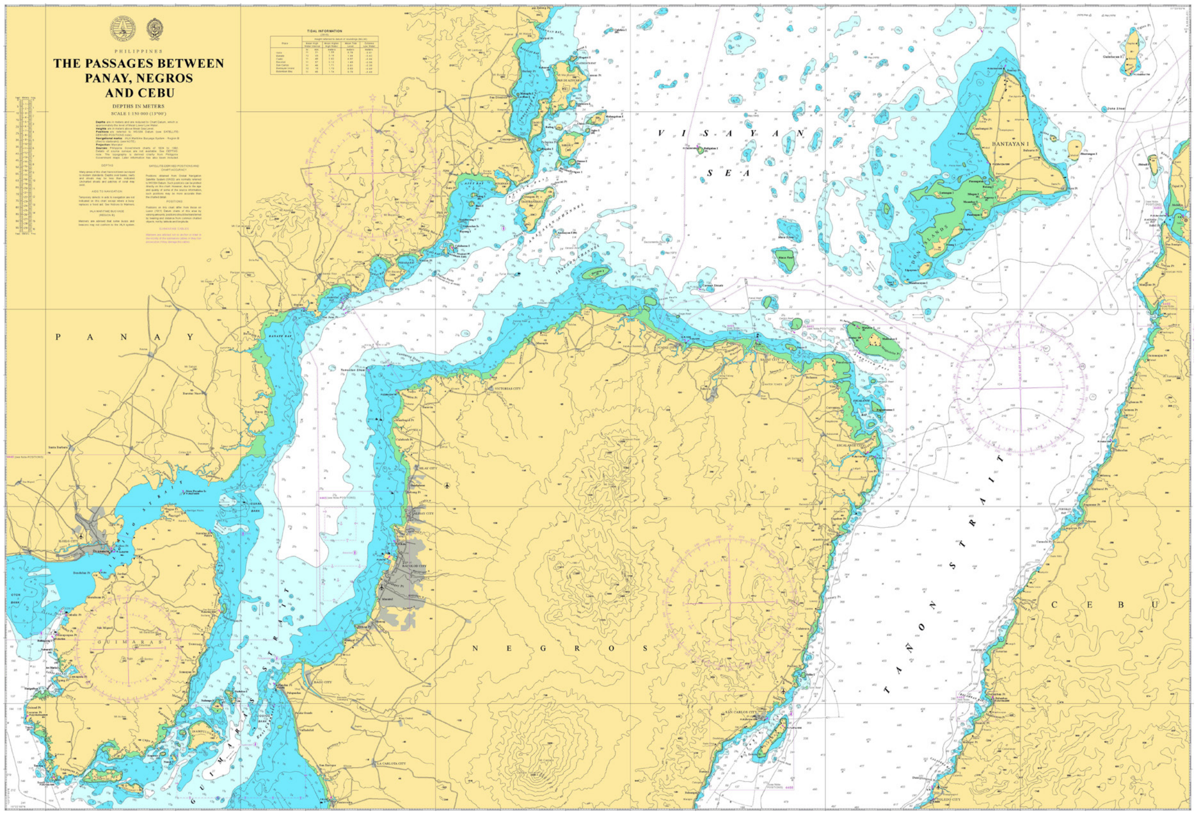
Rocky area, which covers and uncovers



Coral reef, which covers and uncovers

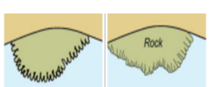
Source: National Mapping and Resource Information Authority

Exhibit A4 **Nautical chart of the passages between Panay, Negros, and Cebu**

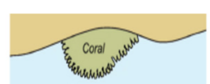


S	Sand	*M*	Mud	*Cy*	Clay	*G*	Gravel	*R*	Rock, rocky	*Bo*	Boulder(s)

- Wreck, least depth known by sounding only
- Obstruction
- Established (mandatory) direction of traffic flow
- Submarine cable
- Limit of restricted routing measure



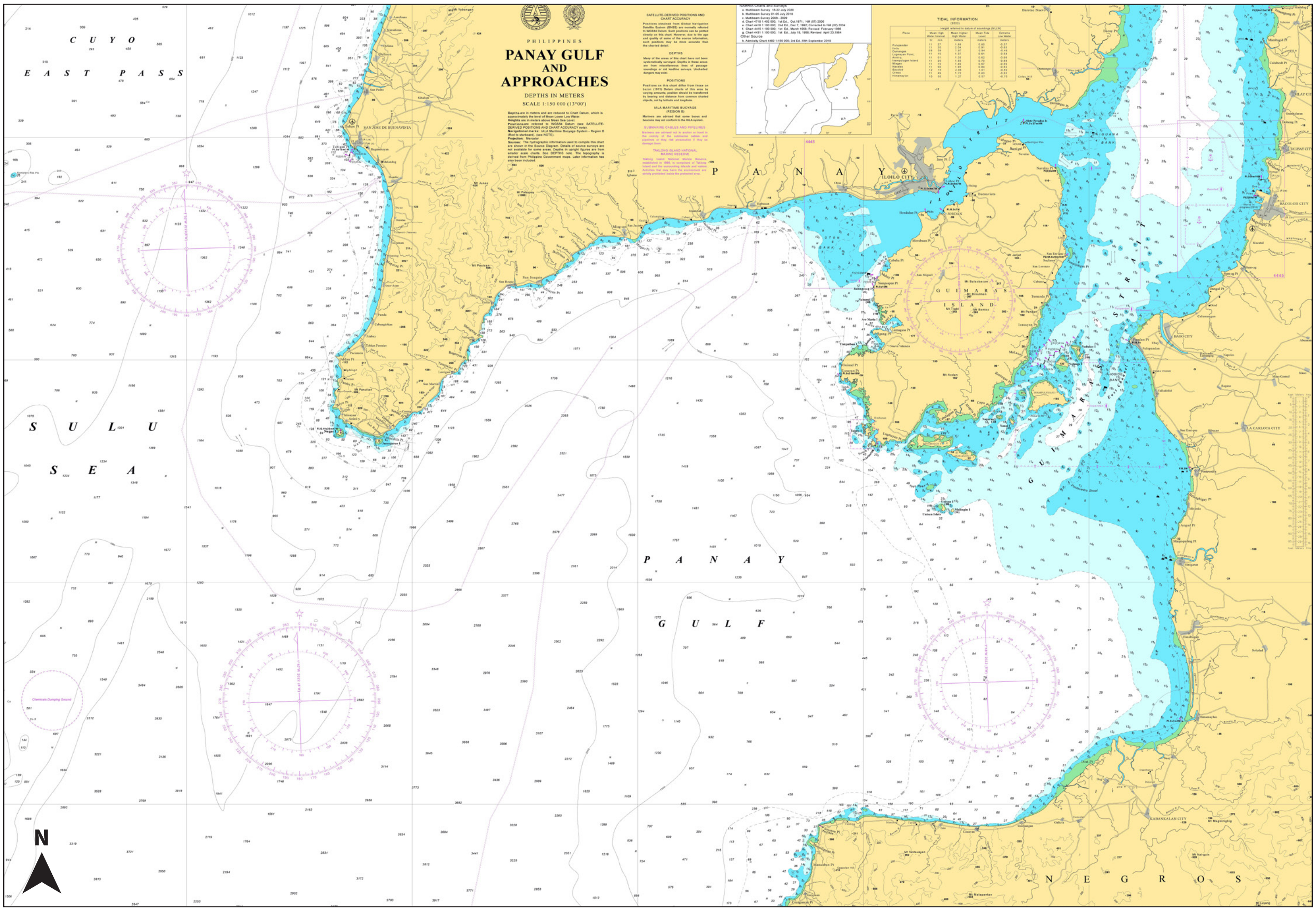
Rocky area, which covers and uncovers



Coral reef, which covers and uncovers

Source: National Mapping and Resource Information Authority

Exhibit A5 **Nautical chart of Panay Gulf and approaches**



S	Sand	*M*	Mud	*Cy*	Clay	*G*	Gravel	*R*	Rock, rocky	*Bo*	Boulder(s)

- 46 Wk / 25 Wk — Wreck, least depth known by sounding only
- Obstruction
- Established (mandatory) direction of traffic flow
- Submarine cable
- Limit of restricted routing measure
- Rock — Rocky area, which covers and uncovers
- Coral — Coral reef, which covers and uncovers

Note: Depths are denoted in meters. Sources for this map range from 1986 to 2020.

Source: National Mapping and Resource Information Authority

Endnotes

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