Advanced Energy Partnership for Asia

Annual Technology Baseline (ATB) and Cost Outlook for Offshore Wind in the Philippines

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December 2024

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Image: Prateek Joshi, NREL 85270

Agenda

- Introduction to the Annual Technology Baseline (ATB)
- Cost Outlook for Offshore Wind Globally
- Cost Assumptions for Offshore Wind in the Philippines
- Q&A and Discussion

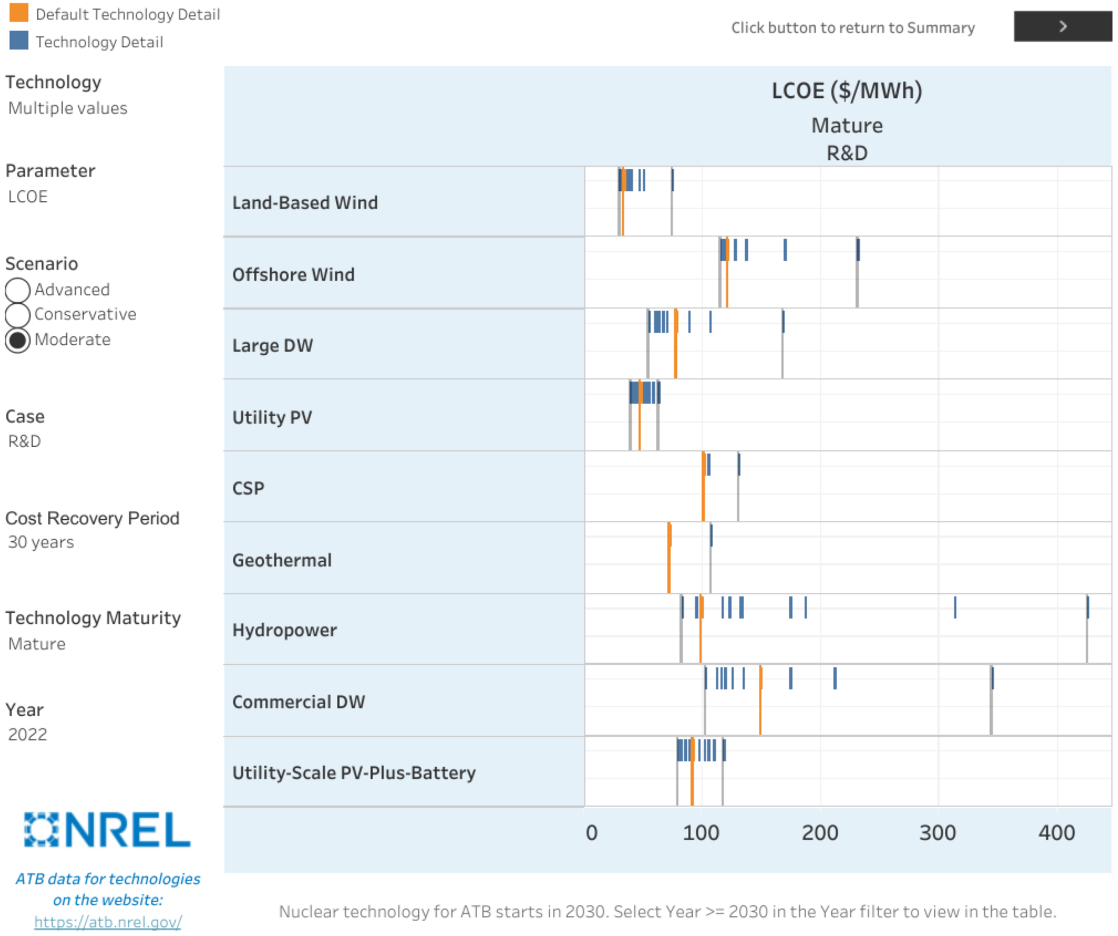
Introduction to the Annual Technology Baseline (ATB)

Annual Technology Baseline (ATB) Overview

Annual Technology Baseline (ATB): https://atb.nrel.gov/
Electricity and Transportation

Provides consistent, freely available, technology-specific cost and performance parameters across a range of R&D advancement scenarios, resource characteristics, and sites for electricity-generating technologies (both at present and with projections through 2050, updated annually).

Figure. LCOE ($/MWh) Values for Different Technologies in 2022



Why the ATB?

- Ever-changing technologies result in conflicting reports of technology progress based on inconsistent assumptions.
- A single dataset is needed to credibly and transparently assess the evolving state of energy technologies

Source: NREL (2024)

Electricity ATB Suite of Products

Spreadsheet

- Provides details on calculations
- Can be viewed as Excel or Tableau workbooks

Web Portal

- Provides interactive charts and user guidance (including presentation slides)
- Details methodology and provides comparisons to previous versions and other studies

Raw Data

- Data published in Open Energy Data Initiative
- Data can be accessed programmatically through Amazon Web Service (AWS) S3 (Simple Storage Service)
- Data also available as a Jupyter Notebook and through a GitHub ATB-calc repository

Source: Mirletz et al. (2024)

ATB Technologies

Renewable Energy Technologies

New in 2024

Wind
- Land-based
- Fixed-bottom Offshore
- Floating Offshore
- Distributed

Solar
- Utility photovoltaics (PV)
- Commercial and industrial PV
- Residential PV
- Utility PV-plus-battery
- Concentrating solar power (CSP)

Hydropower
- Nonpowered dams (NPD)
- New stream-reach development (NSD)
- Pumped storage hydropower
- **NEW: Pumped storage hydropower using existing reservoirs**

Geothermal (Flash and Binary)
- Hydrothermal
- Near-field enhanced geothermal systems (EGS)
- Deep EGS

Storage
- Utility-scale
- Commercial-scale
- Residential

Fossil Energy Technologies

Natural Gas
- Natural gas combined cycle (NGCC)
- NGCC-carbon capture and storage (95%, 97% CCS)
- **NEW: NGCC with one steam turbine and one heat recovery generator**
- Combustion turbine (CT)
- Natural gas fuel cell (no CCS, 98% CCS)
- Retrofits (90%, 95% CCS)

Coal
- Integrated gasification combined cycle (IGCC)
- Pulverized coal
- Pulverized coal with 95%, 99% CCS
- IGCC with 99% CCS
- Retrofits (90%, 95% CCS)

Nuclear
- **NEW: Large (1,000 kilowatt [kW])**
- **NEW: Small modular reactor (300 kW)**

Other Technologies
(Energy Information Administration, Annual Energy Outlook [AEO] 2023)

Biopower
- Dedicated (woody biomass)

Source: Mirletz et al. (2024)

ATB Cost and Performance Metrics

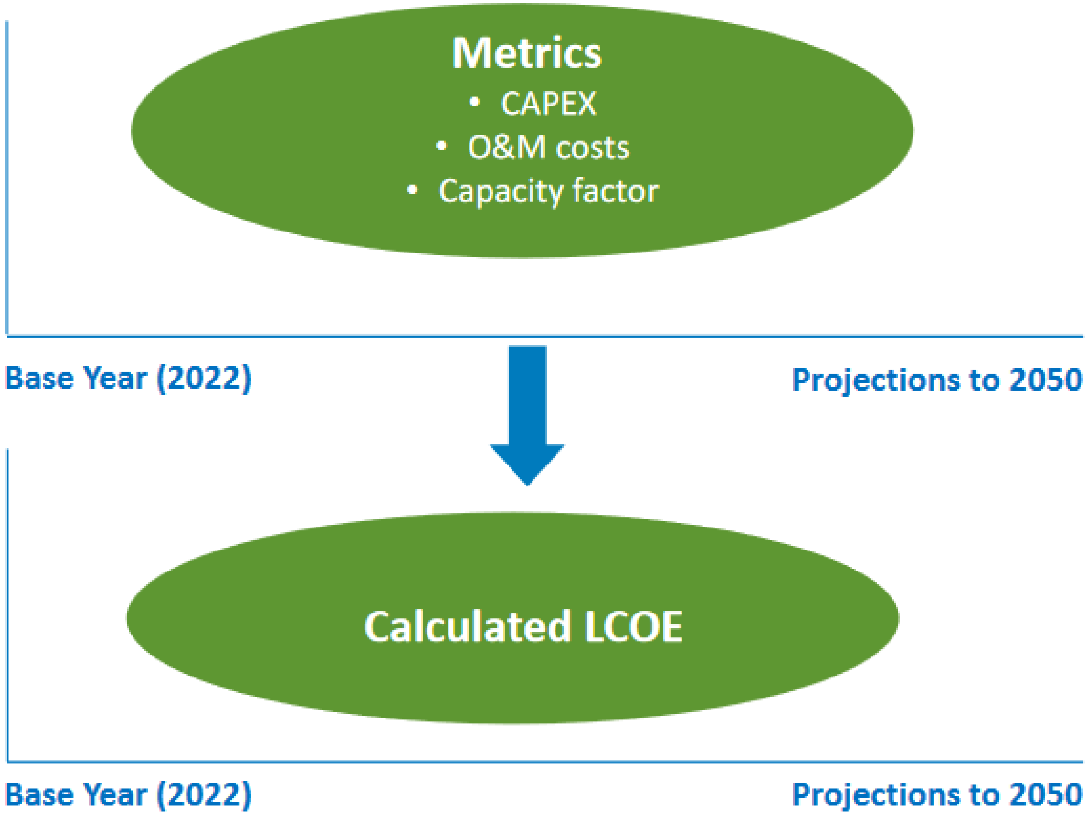


Figure. High-Level Schematic of ATB Methodology and Outputs

Source: Mirletz et al. (2024)

Cost and performance data are provided for each:

- Year
- Resource Class
- Technology
- Technology Cost Scenario

ATB Scenarios

Base Year (2022): Informed by market reports, market data, and bottom-up modeling

Projections: Generally rely on bottom-up modeling and published studies, qualitatively harmonized to three scenarios of future technology innovation:

Conservative Technology Innovation	Moderate Technology Innovation	Advanced Technology Innovation
• Today's technology with little innovation • Continued industrial learning • Decreased public and private research and development (R&D)	• Widespread adoption of today's cutting-edge technology • Expected level of innovation • Current levels of public and private R&D	• Market success of currently unproven innovation • New technology architectures • Increased public and private R&D

Figure. Technology Innovation Scenarios in the ATB

Source: Mirletz et al. (2024)

Cost Outlook for Offshore Wind Globally

Offshore Wind Resource Classes

Fixed-Bottom Turbines

Wind Resource Class	Min. Site Mean Wind Speed (m/s)	Max. Site Mean Wind Speed (m/s)	Average Site Mean Wind Speed (m/s)
1	8.77	10.43	9.74
2	8.74	10.42	9.33
3	8.79	10.45	9.47
4	8.79	10.78	9.59
5	8.03	10.87	9.51
6	6.73	10.77	7.92
7	3.35	10.50	6.78

Figure. Offshore Wind Resource Classes for Fixed-Bottom Turbines

Floating Turbines

Wind Resource Class	Min. Site Mean Wind Speed (m/s)	Max. Site Mean Wind Speed (m/s)	Average Site Mean Wind Speed (m/s)
8	8.84	10.16	9.41
9	8.69	10.87	9.64
10	8.51	10.90	9.93
11	8.59	10.96	9.91
12	7.92	11.29	9.85
13	6.67	12.21	8.15
14	2.28	11.05	6.97

Figure. Offshore Wind Resource Classes for Floating Turbines

Source: NREL (2024)

Capital Cost Components

Fixed-Bottom and Floating Turbine Assumptions:

- Hub height: 137m
- Rotor diameter: 216m
- Specific power: 327 W/m^2
- Turbine rating: 12 MW

Source: NREL (2024)

Figure. Capital Cost Components for Offshore Wind in the ATB

Balance of System Category	Balance of System
Electrical Infrastructure (electronic, onsite electrical infrastructure, electrical)	Internal and control connections
	Onsite electrical equipment
	Power electronics
	Switchgear
Generation Equipment & Infrastructure (civil works, generation equipment, other equipment, support struc..	Plant construction
	Power plant equipment
	Wind turbine supply
Grid Connection Costs	Distance-based spur line cost
	Transmission substation upgrades
	Network upgrades
	Cable landfall connection
	Offshore spur line connecting system to transmission network
	Turbine interconnection
Installation & Indirect	Distributable labor and materials
	Engineering
	Start up and commissioning
	Project management
Owner's Costs	Development costs
	Environmental studies and permitting
	Insurance costs
	Legal fees
	Preliminary feasibility and engineering studies
	Property taxes during construction
Site	Access roads
	Buildings for operations and maintenance
	Fencing
	Land acquisition
	Site preparation
	Transformers
	Underground utilities
	Port and staging area support for delivery, storage, and handling

All Technologies
OffshoreWind

Inclusions in CAPEX

Technology-specific items are shown in orange, and items included for all technologies projected in the ATB are shown in blue.

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ATB data for technologies on the website: https://atb.nrel.gov/

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Capital Cost Projections

Fixed-Bottom:

Resource Class 3

Floating:

Resource Class 12

Values in 2020 USD.

Source: NREL (2024)

Figure. Capital Cost Projections for Offshore Wind in the ATB

Parameter
CAPEX

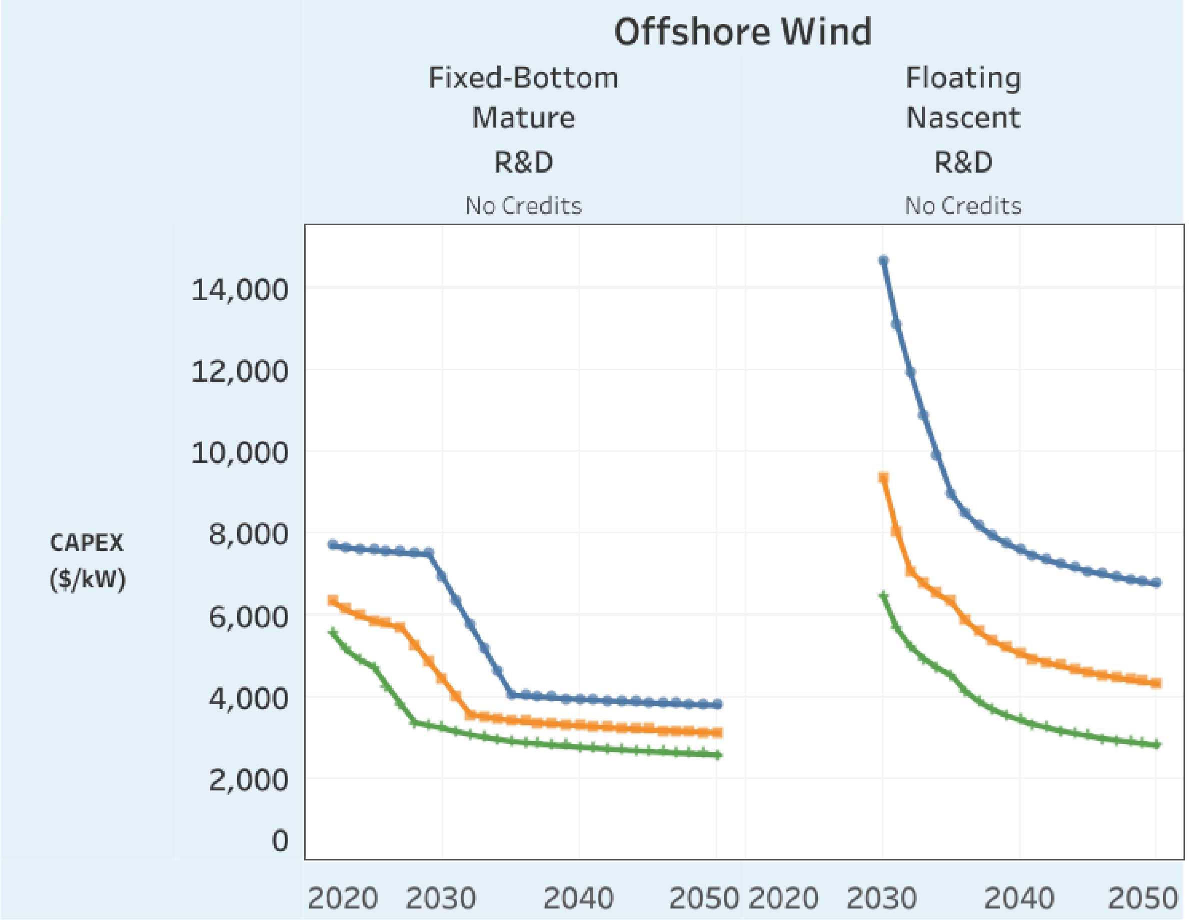
Scenario
All

Financials
◯ Market
◉ R&D

Cost Recovery Period
30 years

Technology Maturity
All

Technology Detail
Multiple values



data updated: 07/19/2024 v4.20

NREL

ATB data for technologies on the website: https://atb.nrel.gov/

Conservative ●
Moderate ■
Advanced ✚

Parameter value projections by scenario, financial case, cost recovery period, and technological detail.

Select the parameter (LCOE, CAPEX, Fixed O&M, Capacity Factor, and FCR [fixed charge rate]), OCC, CFC, GCC, scenario, financial case, cost recovery period, and technological detail. The year represents the commercial online date. The default technology detail best aligns with recent or anticipated near-term installations.

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Operations and Maintenance (O&M) Cost Components

Fixed-Bottom and Floating Turbine Assumptions:

- Hub height: 137m
- Rotor diameter: 216m
- Specific power: 327 W/m^2
- Turbine rating: 12 MW

Figure. O&M Cost Components for Offshore Wind in the ATB

Fixed Costs	Administrative fees
	Administrative labor
	Insurance
	Land lease payments
	Legal fees
	Operating labor
	Other
	Property taxes
	Site security
	Taxes
Fixed Costs Component	Project management
	Condition monitoring
	Weather forecasting
Large Component	Blades
	Gearboxes
	Generators
Maintenance	General maintenance
	Scheduled maintenance over technical life
	Unscheduled maintenance over technical life
Maintenance Component	Transformers

All Technologies
OffShoreWind

Inclusions in O&M

Technology-specific items are shown in orange, and items included for all technologies projected in the ATB are shown in blue.

ATB data for technologies on the website: https://atb.nrel.gov/

Source: NREL (2024)

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Operations and Maintenance (O&M) Cost Projections

Fixed-Bottom:

Resource Class 3

Floating:

Resource Class 12

Values in 2020 USD.

Source: NREL (2024)

Figure. O&M Cost Projections for Offshore Wind in the ATB

Parameter
Fixed O&M

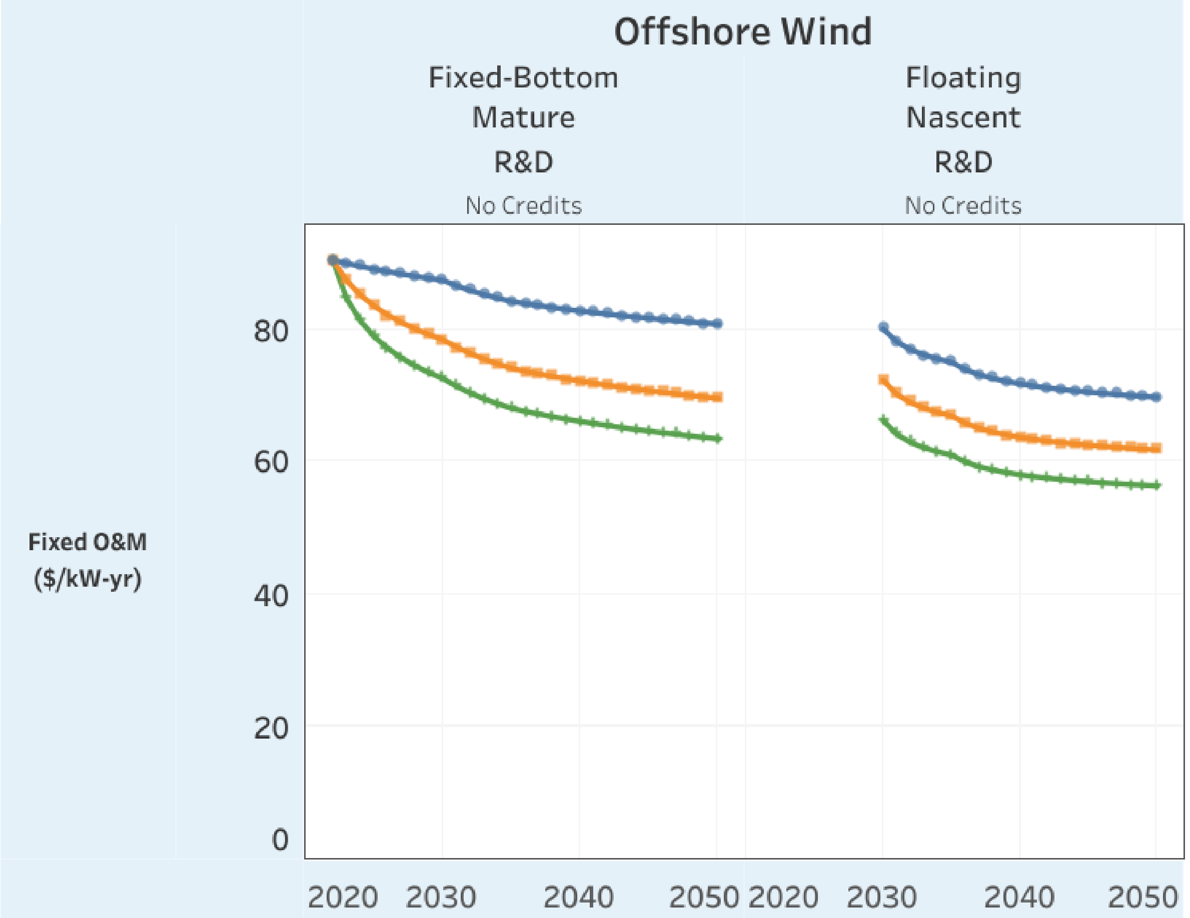
Scenario
All

Financials
Market
R&D

Cost Recovery Period
30 years

Technology Maturity
All

Technology Detail
Multiple values



Conservative
Moderate
Advanced

Parameter value projections by scenario, financial case, cost recovery period, and technological detail.

Select the parameter (LCOE, CAPEX, Fixed O&M, Capacity Factor, and FCR [fixed charge rate]), OCC, CFC, GCC, scenario, financial case, cost recovery period, and technological detail. The year represents the commercial online date. The default technology detail best aligns with recent or anticipated near-term installations.

data updated: 07/19/2024 v4.20

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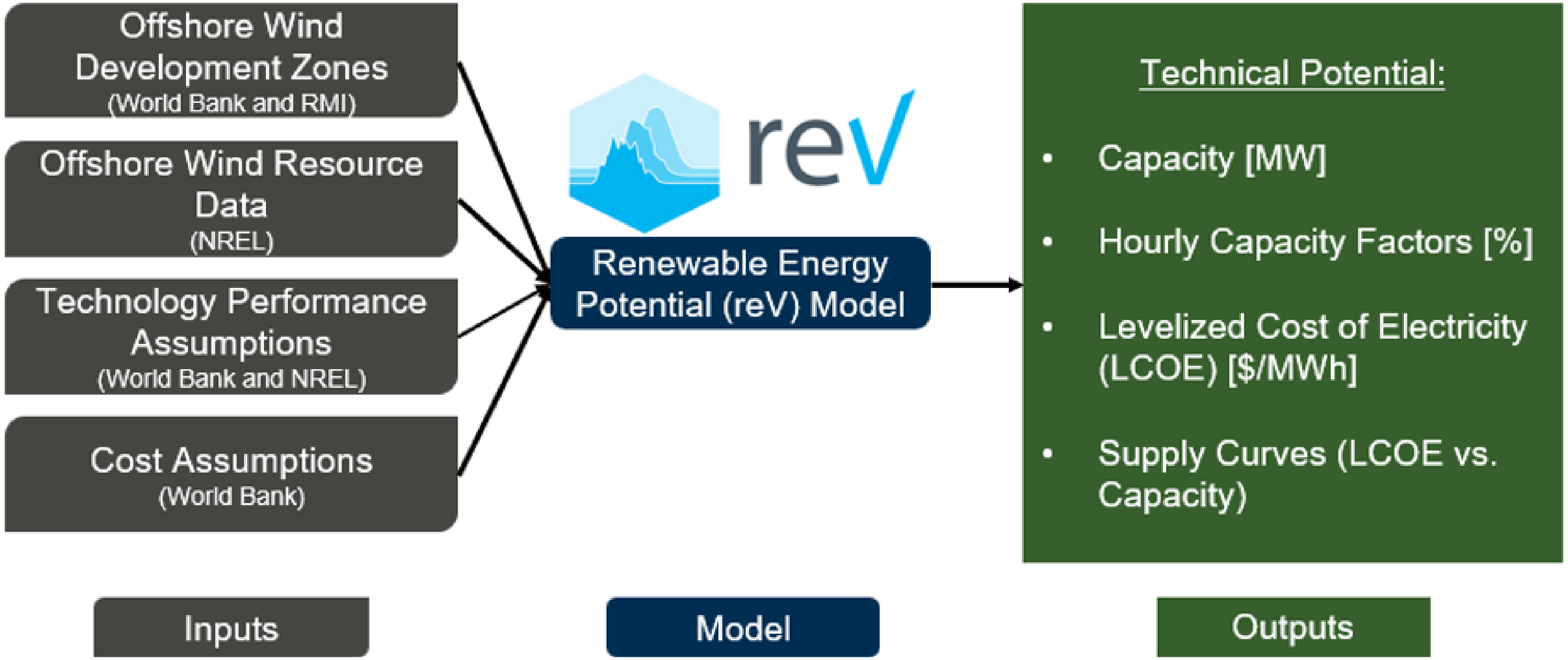
Cost Assumptions for Offshore Wind in the Philippines

Philippines Offshore Wind Analysis

Figure. Methodology for Offshore Wind Analysis in the Philippines



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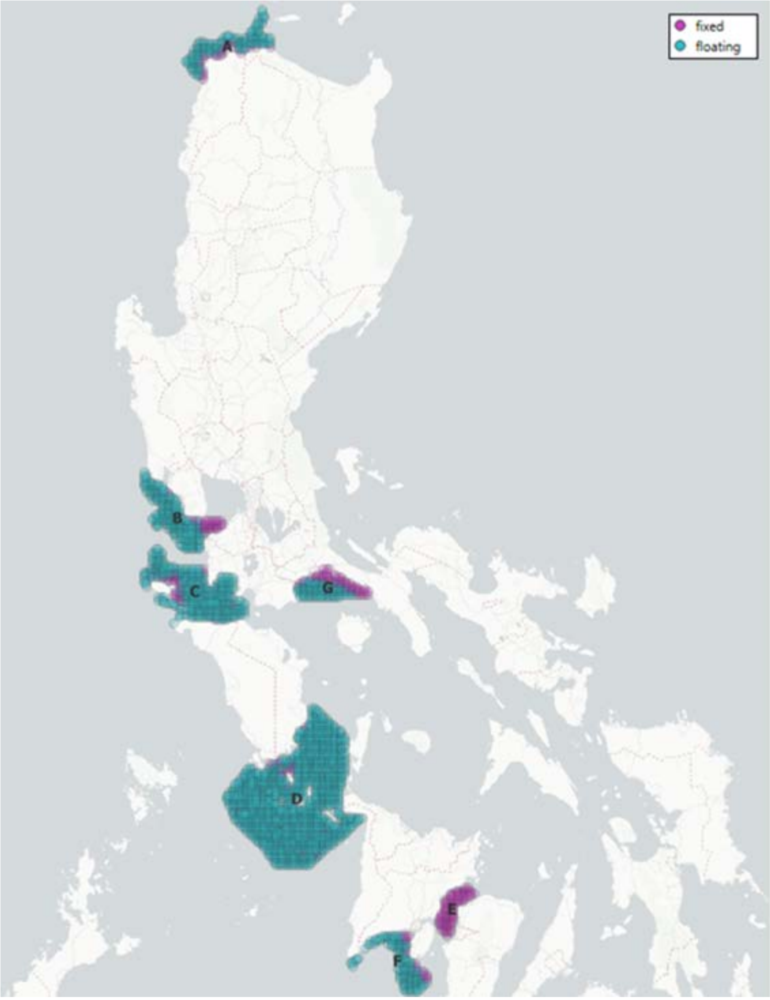
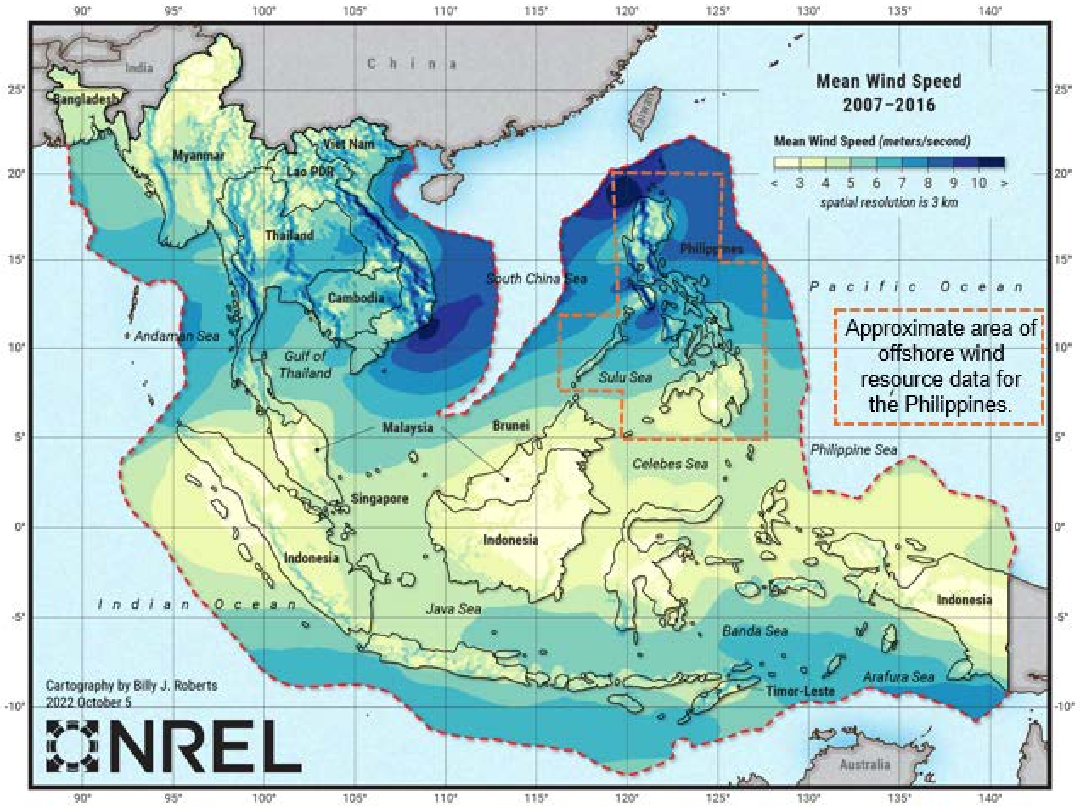
Offshore Wind Zones and Resource Data

Figure. Potential Offshore Wind Development Zones in the Philippines



Source: World Bank (2024)

Figure. Southeast Asia Wind Resource Data



Source: NREL (2023)

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Technology and Cost Assumptions

Table. Offshore Wind Technology Performance Assumptions

Technology Type	Turbine Rating (MW)	Turbine Rotor Diameter (m)	Turbine Hub Height (m)	Losses (%)	Water Depth	Distance to Shore
Fixed Foundation	20	252	168	15	≤ 50m	< 200km
Floating Foundation	20	252	168	15	> 50m, < 1000m	< 200km

The turbine rating (MW), water depth, and distance to shore values are based on World Bank assumptions. The turbine diameter (m) and turbine hub height (m) values are based on NREL assumptions using standard reV configurations for offshore wind. The losses (%) are based on assumptions from Beiter et al. (2020).

Table. Offshore Wind Cost Assumptions

Technology Type	Capital Cost (USD/MW)	Fixed O&M Cost (USD/MW-year)	Grid Connection Cost: Offshore Cables (USD/km-MW)	Grid Connection Cost: Onshore Cables (USD/km-MW)
Fixed Foundation	$2,463,870	$64,430	$1,619.05	$1,580.50
Floating Foundation	$3,871,980	$76,657	$1,619.05	$1,580.50

The capital cost (USD/MW) includes the following: project development, turbine, foundation, array cables, installation of generating assets, offshore substation, and installation of transmission assets. The fixed operation and maintenance (O&M) cost includes the following: operation, planned maintenance, and unplanned service.

Source: World Bank (2024), Beiter et al. (2020)

Preliminary Capacity Factor Results

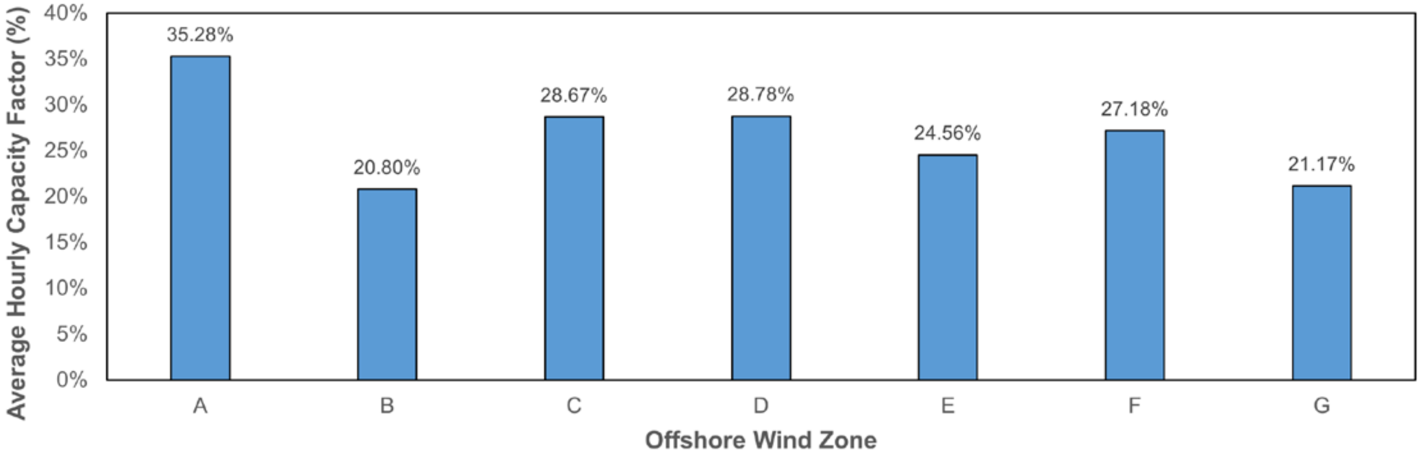
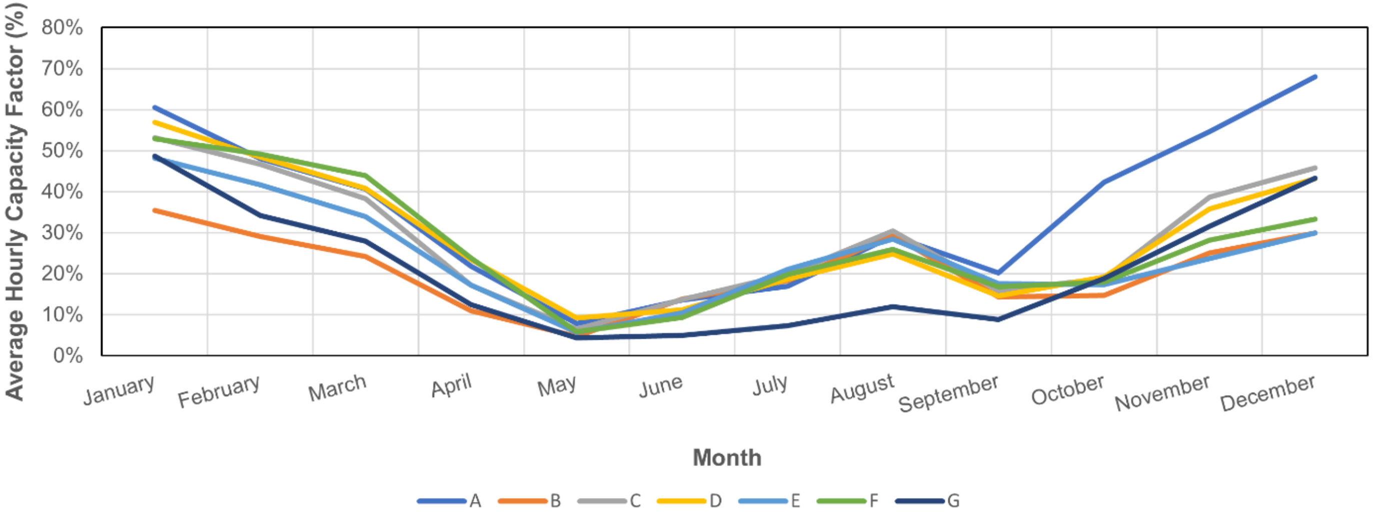


Figure. Average Offshore Wind Capacity Factors (%) for Each Offshore Wind Zone (2009-2021)

Figure. Average Offshore Wind Capacity Factors (%) per Month for Each Offshore Wind Zone (2009-2021)



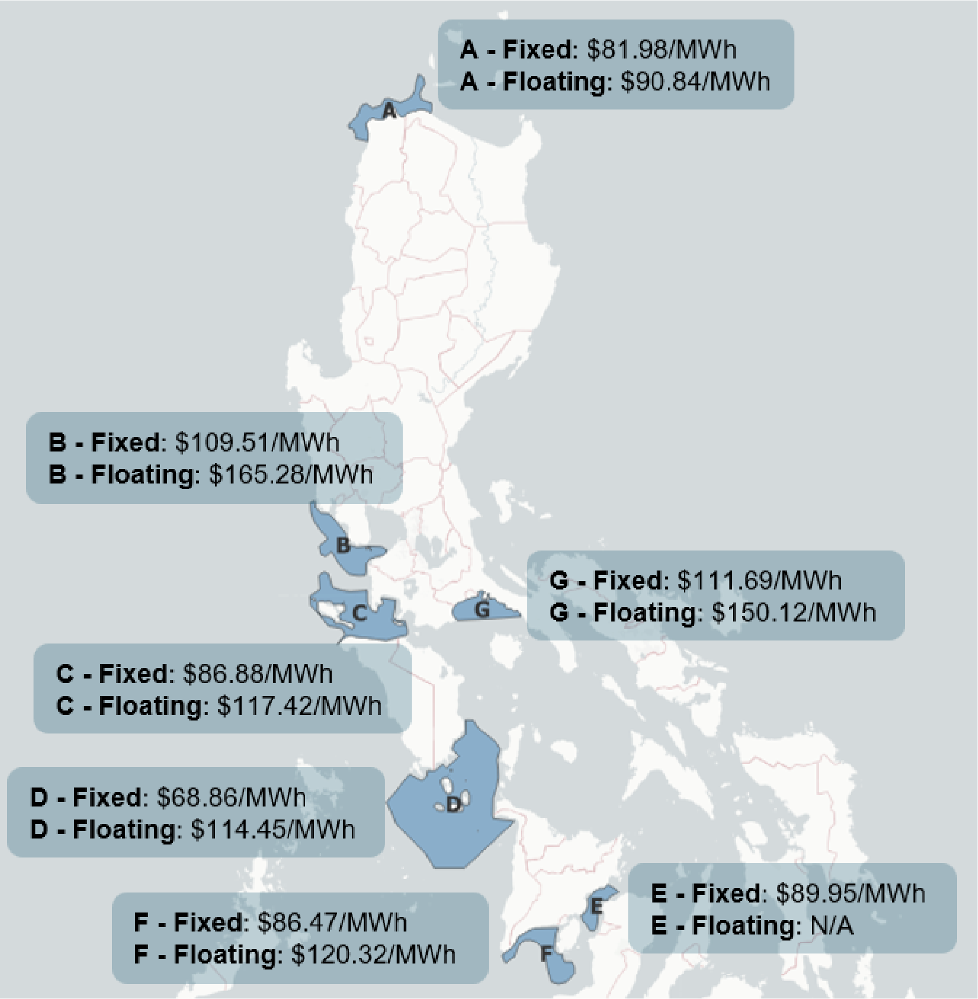
Preliminary LCOE Results

Table. Details of Offshore Wind Zones

Offshore Wind Zone	Name	Turbine Type	Area (km²)	Capacity Density (MW/km²)	Source
A	Northwest Luzon (NL)	Floating	1,571	2.25	World Bank
B	Manila Area (MA)	Fixed & Floating	2,281	0.65	World Bank
C	Northern Mindoro (NM)	Floating	3,606	1.80	World Bank
D	Southern Mindoro (SM)	Floating	11,669	2.40	World Bank
E	Guimaras Strait (GS)	Fixed	689	0.75	World Bank
F	Negros/Panay West (NPW)	Floating	1,534	1.65	World Bank
G	Tayabas Bay (TB)	Fixed and Floating	1,335	1.58	RMI

Source: World Bank (2024), Buescher et al. (2024)

Table. Average Total LCOE ($/MWh) for Each Offshore Wind Zone



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Q&A and Discussion

Thank You!

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NREL/PR-7A40-92111

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This work was authored, in part, by the National Renewable Energy Laboratory (NREL), operated by Alliance for Sustainable Energy, LLC, for the U.S. Department of Energy (DOE) under Contract No. DE-AC36-08GO28308. Funding provided by the United States Agency for International Development (USAID) under Contract No. IAG-19-2115. The views expressed in this report do not necessarily represent the views of the DOE or the U.S. Government, or any agency thereof, including USAID.

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