*PUBLIC

OFFSHORE WIND FARM VESSELS CRITICAL FOR ASIA'S ENERGY TRANSITION

ENERGY FOUNDATION
能源基金会

AIIB ASIAN INFRASTRUCTURE INVESTMENT BANK

Greyfire

Contents

Executive Summary 2
The Need for Change 2
Climate issues are worsening, and Asia is most at risk 2
Substantial reduction in emissions needed to achieve net zero 3
Asia Pacific emissions are mostly from fossil fuel-focused power grids 3
Opportunity in Asia 5
Significant offshore wind potential 5
Conditions suit floating offshore wind 5
The Need for Offshore Wind Farm Vessels 7
Investment in wind-farm vessels remains constrained and poses a potential bottleneck to offshore wind expansion 7
Future vessels need to be ‘greener’ and more technically advanced 9
Opportunities for wind poor economies 10
Financing Aspects 11
Recent Investment Activity 11
Active Investment Funds 12
Final Thought 13
The need for a coordinated approach 13

EXECUTIVE SUMMARY

- Offshore wind generation and transmission is becoming an increasingly important part of the renewable energy transition with installed capacity to grow by ~15% p.a. out to 2050, reaching 1.6-1.8 terawatts (TW). Asia Pacific is set to become the leading global region in terms of installed capacity; China alone will have more than 600 gigawatts (GW).
- To enable this, investment in offshore wind farm vessels is critical with Clarksons' research suggesting that USD20 billion is required globally to build 200 new ships by 2030.[1] There is a particular need for investment in the specialised foundation installation vessels (FIVs), wind turbine installation vessels (WTIVs), commissioning service operations vessels and services operations vessels (SOVs), however there is also a need for investment in cable laying and other vessels.
- Both wind-rich (e.g., China, Korea, Japan, Viet Nam) and wind-poor (e.g., Singapore, Malaysia, Indonesia) countries have the potential to benefit from investment and focus on the design, build and operations of offshore wind farm vessels.
- Both public and private institutions have a role to play to support the development of offshore wind, reduce costs, and help create a more sustainable and reliable energy system across the region.

THE NEED FOR CHANGE

Climate issues are worsening, and Asia is most at risk

Greenhouse gas emissions released into the atmosphere trap the sun's energy and lead to global warming and climate change. Studies conclude that in recent times the temperature has been warming faster than at any point in recorded history. The follow-on effect causes shifts in weather patterns and disruption to ecosystems, posing major risks to all life on Earth.

Catastrophic damage to ecosystems and livelihoods is likely unless there is change.[2] The increased prevalence of extreme hot days and heat waves cause wildfires, impacts lifestyles, and induces illness. Increased evaporation from high temperatures is causing more severe storms, and periods of extreme rainfall and flooding. Rising sea levels are threatening inhabitants and species alike in low-lying lands. This culminates in mass impacts on food supply, to the overall population health and wellbeing, to extreme poverty and population displacement.

The Asia-Pacific region is likely to be one of, if not the most, severely impacted regions and the International Monetary Fund's estimate that rising sea levels alone will impact nearly a

[1] Clarksons: News and insights 2023
[2] IPCC Climate change: a threat to human wellbeing and health of the planet

billion people.[3] Megacities, such as Bangkok, Ho Chi Minh City, Jakarta, and Shanghai are flood prone and this is having a major impact on inhabitants that will only get worse.[4]

Southeast Asia is particularly climate vulnerable as much of the infrastructure and populations are in low lying coastal and river delta areas. According to Germanwatch's global climate risk index,[5] three of the top 10 countries affected by climate risks from 2000–2019 were Myanmar, the Philippines, and Thailand. Many of these countries are also heavily reliant on agriculture and natural resources, which are negatively impacted by changes in temperature, rainfall, and extreme weather events. Rising temperatures are expected to lead to decreased agricultural productivity, particularly in areas where crops are already close to their thermal limits.

Substantial reduction in emissions needed to achieve net zero

To keep global warming to no more than 1.5°C—as called for in the Paris Agreement—emissions need to be reduced by 45% by 2030 and reach net zero by 2050. While there has been considerable progress in terms of goal setting and investments, more must be done to speed up the transition and reduce reliance on fossil fuels, in particular energy generation. Analysis shows that current plans fall well short of the Paris target, and global emissions are on track to increase 10% by 2030.[6]

The Asia-Pacific region is responsible for about half of the world's CO_2 emissions. With economic development a primary concern for emerging and developing countries within Asia, it is critical to ensure development projects undertake thorough environmental impact assessments as well as putting in place environmental protection efforts for development projects. As indicated by the Asian Infrastructure Investment Bank (AIIB) in their Green Infrastructure thematic priority, meeting the Sustainable Development Goals (SDGs) by 2030 will require realising significant increases in economically, environmentally and socially sustainable investments across multiple sectors.[7]

Taking effective climate change action is no easy feat and requires strong leadership and commitment. According to the Intergovernmental Panel on Climate Change (IPCC), political commitment, inclusive governance, international cooperation, sharing diverse knowledge, and effective ecosystem stewardship are the critical enablers for effective climate action.[8] This is essential to give the region the best possible chance to meet the targets and protect the planet and future.

Asia Pacific emissions are mostly from fossil fuel-focused power grids

The world needs action on all fronts. However, the burning of fossil fuels, mainly for electricity, heat and transport contributes about 90% carbon dioxide emissions, and approximately 75% of global greenhouse gas emissions.[9] Action must be taken. The 'clean' alternatives to fossil fuels for energy generation are solar photovoltaic, wind (onshore and offshore), hydro and nuclear. Broadly speaking, replacing fossil fuels requires regions to use

---

[3] Asia's Climate Emergency, International Monetary Fund 2021
[4] IMF: Asia's Climate Emergency
[5] Germanwatch.org
[6] UN Climate Change News, October 26, 2022
[7] AIIB: Green Infrastructure – Investing in Climate Action
[8] IPCC Synthesis Report, Climate Change 2023
[9] UN.org: Causes and Effects of Climate Change

a mix that best suit their local conditions. Offshore wind is seen as a particularly promising solution for many countries in Asia.

Offshore wind is renewable and an infinite energy source that will play an essential role in future electricity generation. In addition to the well documented cost advantages of renewable energy generation over fossil fuels, offshore wind generation has several additional advantages and there is clear evidence that offshore wind generates more energy than onshore wind. Ocean winds are stronger and more consistent, and there are no obstacles that interfere with the wind flows.

Technological advances now enable wind farms to be in deeper waters and be farther out to sea, and installation and operations are well understood. They are also becoming viable at lower wind speeds and there are fewer capacity constraints. While solar photovoltaic (PV) and onshore wind are constrained by land availability, offshore wind is not as ~70% of the Earth's surface is water-covered, and many Asian economies have extensive coastlines. Another advantage is that they are generally not seen nor heard by the population, meaning the individual turbines and farms can be considerably larger.

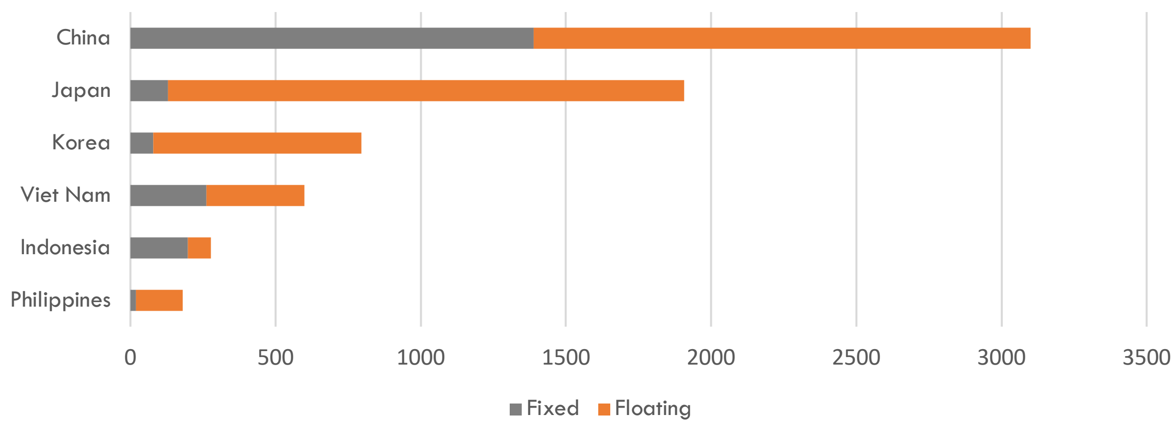
OPPORTUNITY IN ASIA

Significant offshore wind potential

Offshore wind technology was pioneered largely in Europe and the United Kingdom; however, it is China which has led the charge on offshore wind installations this decade. As of 2022, China's installed capacity was around 26GW compared to ~13GW in the UK and ~8GW in Germany. Other Asian economies are following China's lead and have big plans to expand offshore wind installations. Korea, Japan, Viet Nam, and the Philippines all have strong development pipelines for the next 5-10 years.

A study undertaken as part of the World Bank Group's Offshore Wind Development, led by the Energy Sector Management Assistance Program (ESMAP), calculated the technical potential for offshore wind development by country for fixed and floating foundations, with China and Japan having the most potential.

Figure 1: Offshore Wind Technical Potential (GW) in Asia[10]



There is, however, reason to believe that these numbers are conservative given assumptions will be challenged by improvements in technology. For example, the study assumes that wind speeds need to be at least 7 meters per second (m/s), however wind farms are viable for wind speeds between 5.5 and 7m/s (and potentially lower) using the newer, larger wind turbines that are now available. In addition, wind farms have the potential to be located further out to sea and in deeper waters. Technological advances are likely to create additional and new offshore wind generation opportunities across Asia, potentially including wind-poor economies like Malaysia and Thailand.

Conditions suit floating offshore wind

Floating offshore wind has the potential to significantly increase the renewable generation capacity in Asia. In comparison to Europe, where there is competent seabed stratum consisting of either sand, silt, or medium to hard clays, Asia has soft marine clays, hard

[10] Offshore Wind Technical Potential | Analysis and Maps. ESMAP

volcanic and sedimentary rocks, deep faulting and seismic activity.[11] These conditions are more suitable for floating offshore wind.

However, there are a set of challenges that must be overcome to reach this potential given the moving nature of floating wind turbines, the depth of the water and their distance from the coast. In contrast to fixed offshore wind, the floating offshore wind sector is still quite small and as a result, there is limited manufacturing and installation expertise. There are also a range of technical challenges that, while solvable, require more research and development to reach scale commercial viability. One example is that need for dynamic cable connections that are durable enough to remain intact as floating wind turbines constantly move.[12] Similarly, maintenance is more challenging. As a result, the performance and cost outcomes are not yet comparable to fixed however this is likely to change.

Overall, like many analysts, we remain bullish on the potential. This is particularly the case in Japan and Korea where ongoing investment should accelerate the technological advancement and take-up of floating installations across Asia.

[11] ARUP: Offshore wind: What can Asia learn from Europe
[12] EDF Energy: R&D up to the challenges of floating offshore wind

THE NEED FOR OFFSHORE WIND FARM VESSELS

Investment in wind-farm vessels remains constrained and poses a potential bottleneck to offshore wind expansion

With offshore wind to become an increasingly important part of the renewable energy transition, new vessels are needed to support the installation and ongoing operation and maintenance of farms. Key vessel types include foundation installation vessels (FIV), wind turbine installation vessels (WTIV), and service operations vessels (SOV). However, a range of other vessels that also play a critical role, for example cable laying vessels (CLV) and crew transfer vessels (CTV). Clarksons' research indicates 200 new vessels are required at a cost of USD20 billion by 2030.[13]

Table 1: Vessel types required for offshore wind farm installations and maintenance

Survey Vessels	Foundation Installation Vessels; Heavy Lift Vessels	Cable Laying Vessels and support vessels	Wind Turbine Installation Vessels	Service Operations Vessels	Other support vessels
Undertake geological surveys and seabed mapping to identify location and routes	Installation of fixed foundations e.g. monopiles, jackets Installation of offshore substations	Carry and install cable for connections between turbines substations and shore Accompanying vessels perform other functions including trenching, burial	Transport turbines from shore and install on fixed foundations Floating offshore wind systems can be towed by barges	Involved in the commissioning (CSOV) and ongoing operations and maintenance of offshore wind farms (SOV)	Other vessels including crew transfer vessels provide ferrying services to / from offshore wind farms

An important consideration when assessing the future supply and demand balance in vessels is the trend toward bigger wind turbines and larger wind farms. For example, between 2010 and 2023, the amount of wind power a turbine can harness has more than doubled from 3 MW to 6.5 MW, and by the end of the decade, more than half of turbines installed globally are projected to be > 8 MW.[14]

1. Wind Turbine Installation Vessels (WTIV)

WTIVs perform the role of transporting and installing wind turbine components. They function by self-elevating in shallow waters while in deeper waters they can operate as floating heavy-lift vessels. Newer, more modern, WTIVs capable of transporting and installing fixed foundations in certain conditions. Supply and demand for these vessels is

[13] Clarksons: News and insights 2023
[14] The Verge: Offshore wind projects are outpacing the ships that build them

finely balanced and dependent on a range of factors related to national targets, developer ambitions, project approval rates and advances in technology.

A range of studies have been undertaken to estimate how many WTIVs are needed to support the forecast growth of offshore wind out to 2030. Off the back of these studies, ~25 vessels are needed outside of China, and these will likely need the capability to handle a minimum of 8MW, but ideally 12MW+ wind turbines.

IHS Markit's Offshore Wind Turbine Installation Vessels Market Overview determined that the global 'in-service' WTIV fleet consists of 49 vessels; 33 of which serve China, 15 serve Europe and one serves Asia Pacific. This report goes on to determine that outside of China, the global WTIV fleet will struggle to cover global demand post 2026-2027.[15] Even with a growing pipeline of newbuilds and retrofitted vessels that could add 15-20 over next 10 years, the analysis indicates there is still likely to be a global deficit by 2030 given retirements; there is also a very strong case for the Asia Pacific region having its own dedicated WTIV fleet.

2. **Foundation Installation Vessels (FIV)**

A foundation installation vessel is a floating heavy lift vessel capable of carrying and installing large monopile turbine foundations. Floating heavy lift vessels are used extensively in the oil and gas sector. While 'jack-up' WTIVs have the capability to install monopile foundations, their crane capacity is limited and not suitable for the larger monopiles and jackets that are likely to make up the bulk of future wind farms. As a result, FIVs are critical for the realisation of planned and future wind farms that be larger, and installed in deeper waters, further offshore.

Outside of China, there are estimated to be around ~15-20 FIVs capable of installing monopile foundations for wind turbines with industry experts believing this is insufficient to support growing demand and that a deficit is likely around 2025-2027. Similar to WTIVs, the trend to larger wind turbines in deeper waters further offshore will make some of the existing fleet redundant and put further pressure on supply.

Recognising this supply shortfall, Asia-focused vessel provider Cyan Renewables has contracted Ulstein Design & Solutions BV to design a series of new floating foundation installation vessels (FFIV) dedicated its offshore wind aspirations in Asia.[16] Another example is Cadeler's USD345 million contract with COSCO Heavy Industries to build an F-class vessel foundation installation for the offshore industry's largest projects.[17]

3. Service Operation Vessels (SOV)

These vessels perform a critical role in both the commissioning and ongoing maintenance and support of the offshore wind farm. They are equipped with 'walk-to-work' gangways and small cranes to transfer equipment onto the platform's base. More advanced SOVs include launchable/retrievable support crafts that ferry turbine technicians to various locations at the wind farm. SOVs can stay at sea for extended periods with crews transferring on/off via smaller crew transfer vessels and can provide accommodation for 40+ personnel. These vessels are critical given the financial impact of wind turbine downtime.

There are around ~50 SOVs either operating or under construction outside of China, significantly less than what is required. Edda Wind in Norway, for example, raised its

[15] HIS Markit: Offshore Wind Turbine Installation Vessels (WTIV) Market Overview
[16] Ulstein: Cyan Renewables selects Ulstein FFIV design
[17] Cadeler: Cadeler signs 345 million USD contract with Cosco Heavy Industries l

estimate of the number of SOVs needed in the market by 2030 to 250+, excluding China—a number that far exceeds existing orderbooks.[18]

Outside of China, offshore wind capacity in Asia Pacific should reach ~20GW by 2030. While there are a range of variable impacting SOV demand—using Doggerbank's service ratio and an average 8MW turbine, the Asia Pacific region needs approximately 35-40 dedicated SOVs, and potentially much more if floating offshore wind really takes off. This represents a significant opportunity for vessel builders and operators.

4. **Other vessel types**

Cable Laying Vessels (CLV) carry and lay cables that connect wind farms and substations to shore. The newer designs are capable of operating as both cable-laying and repair ships, and often perform in concert with additional support vessels / submarines e.g., jet trenching.

Survey Vessels survey and gather meteorological data to inform the design of the substructures and the selection of wind turbines.

Barges transport offshore wind generation component parts from port to installation location. Also used to tow floating wind farms to installation location.

Subsea Rock Installation Vessels perform a stabilising and protecting function for subsea pipelines, cables and other structures at the seabed. For the offshore wind industry, the vessels also lay protective coverings of rock around turbine foundations to avoid scouring. These are highly specialized vessels; however, they have broad application in energy and telecommunications sectors.

Crew Transfer Vessels transfer crew from shore to offshore vessels, primarily the CSOV/SOVs.

Future vessels need to be 'greener' and more technically advanced

The shipping industry is currently a significant source of greenhouse gas emissions and other pollutants, and industry is looking to reduce the environmental impact of installation, maintenance, and operation of wind farm assets. Low-emission engines, battery storage, and wind-assisted propulsion are areas being explored.

Recent advancements include renewable propulsion alternatives like biofuels (e.g., biodiesel and bioethanol), hydrogen fuel cells that generate electricity on board, and battery systems that store excess energy generated by renewable sources, such as wind and solar power, and use it to power the ship's systems when needed.

While industry is yet to land on a set of standards or norms, some technologies are gaining significant traction. For example, the Ulstein HX118 heavy lift vessel design includes methanol powered generators, an optimised hull design and smart integration of battery systems ensure low emissions during operations and when in port.[19] This vessel design is expected to be in the water by 2025.

[18] Baird Maritime: The Wind Bubble Moves to Service Operations Vessels
[19] Ulstein: HX118 heavy lift crane vessel design

Similarly, Damen Shipyards, in cooperation with Windcat and CMB.TECH., is building their Elevation Series hydrogen powered CSOVs in their Viet Nam shipyard.[20] Two vessels are in production and will be ready for delivery to Windcat in 2025, with future orders expected.

Another example is UK based Artemis Technologies' 100% electric, high-speed foiling workboat for the crew transfer vessel market.[21] While still in the concept phase, the vessels have an advertised range of 60 nautical miles at 25 knots cruise speed and deliver energy savings of up to 90% compared to conventional fossil fuel workboats.

Newer and technically advanced vessels are also being designed to improve the efficiency and cost-effectiveness of offshore wind projects. Vessels equipped with dynamic positioning systems and subsea robotics, for example, can perform installation and maintenance tasks more quickly and accurately, reducing downtime and project costs.

Overall, we expect the demand for greener vessels to continue growing and become a source of competitive advantage as wind farm developers and other stakeholders increasingly prioritize sustainability and environmental responsibility.

Opportunities for wind poor economies

While many Asian economies will benefit directly from offshore wind generation, there are opportunities in the wind farm vessel sector for economies with less favorable offshore wind generation potential. This includes Singapore, Indonesia and Malaysia. These opportunities lie in industries and capabilities related to vessel design, vessel building, fleet management operations and crewing, technical support, and other support functions.

Singapore for example has strong marine and offshore engineering capabilities that are transferable from oil and gas to the offshore wind industry. Indonesia can benefit through vessel building, as well as offshore support vessel operations and crewing. In Malaysia, there is already an example of a large offshore wind vessel service provider leveraging their information technology expertise to support operations.

[20] Damen: Windcat Offshore and Damen Shipyards develop future-proof hydrogen CSOVs
[21] Artemis Technologies: The world's first commercially viable zero-emission 100% electric foiling workboats

FINANCING ASPECTS

Recent Investment Activity

The anticipated demand for vessels to support new offshore wind projects has already driven significant investment activity. Through 2021/22, several notable investments took place, with companies acquiring stakes in offshore wind businesses, or acquiring vessels, to boost their offshore wind vessel fleet.

Table 2: Notable acquisitions of offshore wind businesses[22]

Europe:	[2021] Eneti Inc, formerly a dry bulker owner, acquired Seajacks, a UK based offshore installation company that built and operated a fleet of self-propelled jack-up vessels equipped to service the offshore wind industry.[23] With the Seajacks acquisition, Eneti now has five WTIVs and another new build scheduled for delivery in 2024. [2022] Diversified marine service provider Purus Marine acquired HST Marine—a UK-based provider of Crew Transfer Vessels to the offshore wind industry. Purus Wind plans to offer its customers battery hybrid CTVs, battery hybrid offshore wind construction/service operation vessels. [2022] Harren & Partner Group acquired the 2010-built DP jack-up crane vessel Thor. Thor is a 108m long vessel is with a 500-t capacity, a high-outreach offshore crane and an accommodation block for up to 56 people.[24] With its partners—OWS Off-Shore Wind Solutions and Wind Multiplikator—Harren & Partner Group will deploy Thor for component exchange services at the Nordsea One wind farm.[25] Thor will also support other wind farms developments later in the year.
Asia	[2022] Singapore offshore vessel owner and operator Marco Polo Marine acquired PKR Offshore as part of the company's plan to bolster its presence in the country's offshore wind farm sector.[26] The acquisition added two vessels to its offshore wind services fleet.
North America	[2022] EnCap Investments is a growth capital fund focused on independent energy businesses. It invested in Houston-based Bleutec Industries, a builder, owner, and operator of Jones Act-compliant offshore wind turbine installation vessels.[27] Bleutec is aiming to develop a fleet of innovatively designed vessels that can act as cheaper alternatives to WTIV vessels.

[22] Sourced from a range of industry reports, Greyfire analysis
[23] Offshore Engineer, Eneti Wraps Seajacks Acquisition. Exits Drybulk Business
[24] Offshore Magazine, German logistics group acquires wind farm jackup vessel
[25] Portcare International
[26] Riviera, Marco Polo Marine completes acquisition of offshore wind company PKRO
[27] Offshore Magazine, Businesswire

Active Investment Funds

In addition to the M&A activity outlined above, there are a variety of investment funds that are raising and planning to deploy capital to finance wind farm vessels to service the growing demand from offshore wind farm developers.

Table 3: Recent M&A Activity[28]

Seraya Partners	Cyan Renewables was launched by Seraya Partners in 2022, marketing itself as the first pureplay operator focussed on offshore wind farm vessels in Asia. Their plan is to establish and operate a USD3 billion fleet of vessels within five years—including CTV, SOV, WTIV, FIV and CLV.
Pelagic Partners	A fund manager focused on investments in commercial vessels. Launched Wind Fund in Q2 2022 with a target AUM of USD 360 million.[29] It has plans to become a leading provider of supply vessels to the growing offshore wind industry. Pelagic Wind Fund has secured 2 Firm + 4 Optional (2 + 2 + 2) newbuild orders for Commissioning Service Operation Vessels (CSOVs) at Cochin Shipyard in India.[30]
Navigare Capital Partners	Copenhagen-based alternative investment fund manager with container ships, bulkers, tankers and LNG carriers in its portfolio.[31] It has partnered with the Norwegian company Norwind Offshore to invest in four of its newbuild commissioning service operation vessels (CSOVs) and one service operation vessel (SOV).
Eurazeo	French-based investment company. Their Eurazeo Sustainable Maritime Infrastructure (ESMI) fund focussed on the transition of the global maritime industry to a carbon-neutral economy by 2050. It has reportedly raised EUR200 million. The first transaction was the financing of the Harren & Partner Group jack-up vessel.

[28] Sourced from a range of industry reports, Greyfire analysis
[29] Pelagic Partners: New Pelagic Wind Fund kicks off with up to 6 CSOV newbuilding orders
[30] Pelagic Partners: New Pelagic Wind Fund kicks off with up to 6 CSOV newbuilding orders
[31] Splash247: Navigare Capital enters offshore wind support vessel

FINAL THOUGHT

The need for a coordinated approach

Both public and private institutions have a role to play to support the development of offshore wind, reduce costs, and help create a more sustainable and reliable energy system across the region. The sector will create economic benefits by creating jobs, attracting investment, and reducing dependence on imported energy sources. There are a number of ways to do this, including:

- Invest in research and development to help drive down the costs of offshore wind power, increase efficiency, and improve the technology. Also, invest in the necessary infrastructure to support offshore wind development, such as ports, transmission lines, and grid connections.
- Establish Asian-focused think tanks and collaborative bodies that support and foster investment in the offshore wind sector. This includes the manufacturing and supply chains for wind turbines, but also in the design, build and operations for an Asian fleet of offshore wind farm vessels.
- Set ambitious targets for offshore wind development and create policies to incentivise the industry. For example, a goal to generate a certain percentage of energy from offshore wind power or creating market mechanisms such as feed-in tariffs to stimulate investment and development.
- Reduce the time and cost of permitting by streamlining regulatory processes and creating a clear and predictable regulatory environment for developers.
- Provide financial incentives and support in the form of grants, subsidies, and loans to investors and developers.
- Encourage collaboration among industry stakeholders, such as developers, investors, and research institutions, to help drive innovation, knowledge-sharing, and cost reduction.

This work is a co-publication of the Asian Infrastructure Investment Bank and Energy Foundation China.

ABOUT AIIB

The Asian Infrastructure Investment Bank (AIIB) is a multilateral development bank whose mission is financing the Infrastructure for Tomorrow—infrastructure with sustainability at its core. We began operations in Beijing in January 2016 and have since grown to 109 approved members worldwide. We are capitalized at USD100 billion and Triple-A-rated by the major international credit rating agencies. Collaborating with partners, AIIB meets clients' needs by unlocking new capital and investing in infrastructure that is green, technology-enabled and promotes regional connectivity.

ABOUT EFC

Energy Foundation China is a professional grantmaking charitable organization registered in California, U.S. It has been working in China since 1999, and is dedicated to China's sustainable energy development. The foundation's China representative office is registered with the Beijing Municipal Public Security Bureau and supervised by the National Development and Reform Commission of China.

Cover Image: Offshore wind: new horizons demand new approach to operations - DNV