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UNLOCKING THE POTENTIAL OF OFFSHORE WIND POWER FOR SCALING UP RENEWABLE ENERGY IN BANGLADESH

Abstract

Globally wind power is the leading renewable energy technology after hydropower with an installed capacity exceeding 650 gigawatt (GW) by the end of 2019. In Bangladesh, contribution of wind power is insignificant with an installed capacity of only 2.9 megawatt (MW). Available data shows the predominance of low wind speeds on lands. Apart from low wind speeds, lack of bankable wind data and land constraints can be attributed to the stagnation of development of utility scale onshore wind power plants in the country resulting in low share of wind power in the energy mix. Fulfilling the targets of Sustainable Development Goals (SDGs) and Nationally Determined Contributions (NDC) under the Paris Agreement, to which Bangladesh is a signatory, requires substantial increase of renewable energy in the energy mix. The paper endeavours to identify the prospects of developing offshore wind power in Bangladesh as offshore wind technology has come of age in the recent years. Drawing on the global experience, the paper argues that an investment-grade feasibility study is essential for unlocking the potential of offshore wind. This upfront investment can help achieve national renewable energy targets as well as leverage significant economic and environmental benefits.

Keywords: Bay of Bengal, Blue Economy, Maritime Spatial Planning, Offshore Wind, Renewable Energy

1. Introduction

The adoption of the United Nation's 2030 Agenda for Sustainable Development, and in particular Sustainable Development Goal 7 (SDG 7) has led to a global consensus that the share of renewable energy in the global energy mix needs to be substantially increased.[1] Fulfilling the target of Nationally Determined Contributions (NDC) under the Paris Agreement to which Bangladesh is a signatory, also calls for increasing the share of renewable energy in the energy mix as it emits no greenhouse gas on a net basis.

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[1] United Nations, "Transforming Our World: The 2030 Agenda for Sustainable Development", available at https://sustainabledevelopment.un.org/content/documents/21252030%20Agenda%20for%20Sustainable%20Development%20web.pdf, accessed on 08 November 2020.

Renewable Energy Policy of Bangladesh mandates the sourcing of 10 per cent electricity from renewables by 2020.[2] The Power System Master Plan (PSMP) 2016 estimated the power generation potential from renewable energy in Bangladesh to the tune of 3666 MW.[3] Currently, the total installed capacity of renewable power in Bangladesh stands at around 648 megawatt (MW) comprising less than 3 per cent share of total electricity generation, which falls far short of its target.[4] Apart from 230 MW hydropower, almost all of the capacity addition is from solar energy. Given wide availability and rapidly declining cost of solar energy, substantial amount of solar power is yet to be generated because of the competing demand of land for agriculture or other uses in Bangladesh.

Under the circumstances, portfolio of renewable energy needs to be expanded alongside solar energy. Information on availability of renewable energy resources is a prerequisite to their utilization and scaling up. Renewable energy resource assessment and mapping can provide this information. Resource assessment for wind energy was carried out in Bangladesh to some extent over the last few decades. Assessments conducted at lower hub heights ($\leq$50m) suggested that Bangladesh belonged to a low wind regime. The latest systematic wind resource assessment was done by the U.S. Department of Energy's National Renewable Energy Laboratory (NREL). The NREL's report styled "Assessing the Wind Energy Potential in Bangladesh: Enabling Wind Energy Development with Data Products", identified potential windy areas of the country.[5] However, the data of the the report is not bankable, thus, necessitating further study for commercial project development as wind is an intermittent and site-specific source of energy. Lack of bankable data and land constraints limit massive expansion of utility scale onshore wind power.

Against this backdrop, evolution of offshore wind power technology opens up opportunities for Bangladesh to complement onshore wind power generation by utilizing its coastal area. To date, Bangladesh has little experience with onshore wind power but when it comes to offshore wind, the country lacks experience. The objective of the paper is to examine how Bangladesh can explore its offshore wind power potential taking lessons from global experience. This paper is exploratory in nature and based on secondary data and information. Secondary data sources include government policies and plans related to power and energy, published government

[2] Power Division, *Renewable Energy Policy of Bangladesh 2008*, Dhaka: Ministry of Power Energy and Mineral Resources, 2008, p. 5.
[3] Power Division, Ministry of Power, Energy and Mineral Resources, *Power System Master Plan 2016*, Dhaka: Power Division, 2016, pp.1-61.
[4] Available at http://www.sreda.gov.bd/index.php/site/re_present_status, accessed on 16 August 2020.
[5] Mark D. Jacobson, Caroline Draxl, Tony Jimenez, Barbara O'Neill, Taj Capozzola, Jared A. Lee, Francois Vandenberghe, and Sue Ellen Haupt, *Assessing the Wind Energy Potential in Bangladesh: Enabling Wind Energy Development with Data Products*, Dhaka: USAID-NREL, 2018.

documents, intergovernmental organizations' reports, journals, articles and internet resources.

For the convenience of the discussion, the paper is organized into six sections. Following introduction, second section takes stock of the initiatives for wind resource assessment as well as wind power development in Bangladesh. The third section sheds light on the development of offshore wind power technology across the globe together with its pros and cons including cost of energy. The fourth section looks into global experience of offshore wind power development. The fifth section examines the scope of offshore wind power generation in Bangladesh. The sixth section concludes the paper.

2. Wind Resource Assessment Initiatives and Wind Power Development in Bangladesh

The Bangladesh Meteorological Department (BMD) has been collecting various weather data, including wind properties, from its weather stations throughout the country at low elevation. These data have been recorded by vertical type cup anemometers and made available since 1961. The BMD data, showing an average wind speed below 2.5 meters per second (m/s), were meant for weather forecasting and hence, can hardly be the basis for assessing wind power potential.

Realizing the limitations of the BMD data, a number of studies were carried out by various organizations at different sites and heights to explore the potential of wind power in Bangladesh. Table 1 provides a brief account of wind resource assessment initiatives at hub heights from 10 to 50 metres.

Table 1: Wind Resource Assessment Initiatives in Bangladesh[6]

Sl	Name of the Organization	Data Collection Period	Location	Measurement Height and Instrument	No of Sites	Average Wind Speed
1	Wind Energy Study Project (WEST)- Conducted by Bangladesh Center for Advanced Studies (BCAS). Supported by Energy Technical Support Unit (ETSU) of the United Kingdom (UK) & Local Government Engineering Department (LGED).	1995-1997	(i) Patenga (ii) Cox's Bazar (iii) Kutubdia (iv) Teknaf (v) Noakhali (vi) Kuakata (vii) Char Fasson	Cup anemometer with data logger collected at 10m and 25m.	7	The average annual wind speed values at 25m height for the seven stations vary from 2.96m/sec to 4.54m/sec. The highest average annual value (4.54m/sec) was observed in Kuakata and the lowest value (2.96m/sec) was observed in Teknaf and Noakhali.
2	Technical Expertise for Renewable Application Project (TERNA)- Conducted by Bangladesh Atomic Energy Commission (BAEC). Supported by REVB1 of GIZ.	1995-1997	(i) Patenga (ii) Anwara (iii) Teknaf (iv) Feni	Cup anemometer with data logger- 20m anemometer height.	4	Average wind speed at Teknaf is 4.3m/s. Other sites have low wind speed.

[6] "The Alternative Power and Energy Plan for Bangladesh", available at http://www.sreda.gov.bd/index.php/site/page/2f45-680b-877b-3ec8-7bdc-f44a-721d-ac4b-1ff8-856c, accessed on 20 September 2020.

3	Bangladesh Council for Scientific and Industrial Research (BCSIR) & IFRD.	Jan 2001-Apr 2002	(i) Saint Martin, (ii) Teknaf (iii) Meghnaghat	Cup anemometer with data logger at 10m, and 30m.	3	Highest at Saint Martin at 30m: 4.7m/s and lowest at Teknaf at 10m: 3.5m/s.
4	Wind Energy Resource Mapping Project (WERM)- Conducted by LGED.	2003-2006	A total of 20 sites including 7 sites of WEST project.	Cup anemometer with data logger at 20m, 30m, and 40m.	20	Kuakata at 30m: 4.2m/s Kutubdia at 20m: 3.6m/s. Other sites have considerably low wind speed at 20m, 30m and 40m.
5	Wind Resource Assessment Program (WRAP) of BPDB- Conducted by Pan Asia Power Services Ltd.	One year of data between 2003 and 2005	(i) Muhuri Dam (ii) Mognamaghat (iii) Parky Beach (iv) Kuakata	Cup anemometer with data logger at 50m.	4	6.5-6.9m/s.

Inconsistencies of data can easily be observed in the above studies conducted by different agencies. For example, WREM data were found to be somewhat lower than those observed by WEST. Inconsistencies were also found in the studies conducted by WEST and TERNA for overlapping data. Data obtained from Pan Asia Power Services Limited indicated existence of good wind resources in the four coastal areas. However, conflicting information from previous wind resource studies necessitate comprehensive wind resource assessment.

Apart from the studies mentioned, some were also conducted by private entities. For example, ReGen Powertech Private Limited of India signed a Memorandum of Understanding (MoU) with the Power Division on 12 February 2012 to perform Wind Resource Assessment (WRA) at five prospective areas of Bangladesh. ReGen Powertech Private Limited could complete WRA at two sites: Mognamaghat of Cox's Bazar and Muhuri Dam of Feni. Mean wind speed at Muhuri Dam and Mognamaghat was found to be 4.96m/s and 5.09m/s respectively at 85m.[7] Vestas Asia-Pacific Wind Technology Private Limited signed another MoU with the

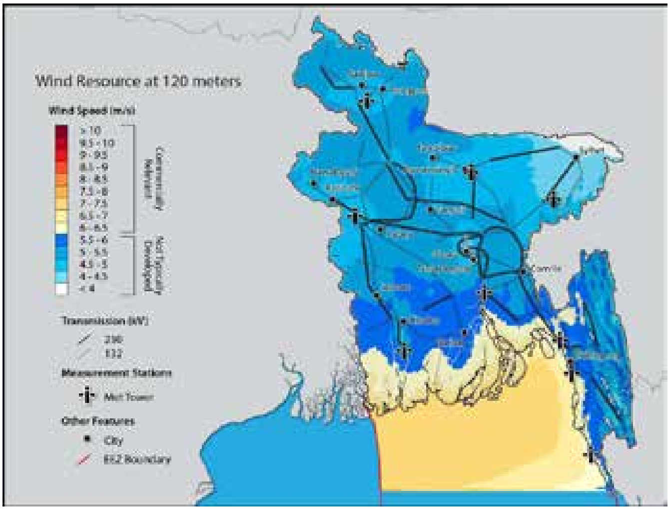
[7] Ibid.

Power Division on 12 October 2015 to conduct WRA in Patuakhali district but did not submit any report as per the MoU.[8]

The Bangladesh Power Development Board (BPDB) implemented a pilot project in 2005 for the first time in Bangladesh to generate electricity from wind energy at Muhuri Dam area in Feni district with an installed capacity of 0.9 MW. Afterwards, two more pilot projects of 2 MW installed capacity were implemented at Kutubdia Upazila in Cox's Bazar district raising the total installed capacity of wind power in the country to 2.9 MW.

Meanwhile, based on the expression of interest (EoI), the BPDB signed a Power Purchase Agreement (PPA) with US-DK Green Energy (BD) Limited on 15 May 2014 to build 60 MW wind power plant in Cox's Bazar. As per the PPA, the commercial operation date (CoD) of the plant was 14 March 2015. Despite repeated time extensions, the project is yet to be implemented. On the proposal of the consortium of PIA Group LCC, Spain and Bangladesh Alternative Energy Systems Limited (BAES), the BPDB issued a Letter of Intent (LoI) on 17 December 2013 for the development of a 100 MW wind power plant in Anowara of Chattogram. Following the LoI, till now the consortium remained unable to sign a PPA as of today, let alone establishment of the power plant.

Figure 1: Wind Resource Map of Bangladesh and Measurement Locations[9]



[8] Power Division, Ministry of Power, Energy and Mineral Resources, Government of the People's Republic of Bangladesh.
[9] Mark D. Jacobson et al., op. cit., p. iii.

The preliminary technical potential analysis calculates gross potential of wind power in Bangladesh. Table 2 demonstrates that for wind speeds of 5.75 -7.75m/s, there are more than 20,000 Km^2 of land with a gross wind power potential of over 30,000 MW. But how much of the potential can be realized will depend on actual amount of land that can be utilized for wind power generation.

The Power Division initiated a project titled "Technical Assistance Project for Wind Resources Mapping" to conduct more comprehensive wind resource assessment. This project was implemented by the US Department of Energy's NREL in cooperation with USAID Bangladesh and the Power Division. Under this project, wind measurement stations were set up at nine places with seven meteorological (MET) towers and a SoDAR (Sonic Ranging and Detection) moved between two other locations. Six of the MET towers were 80m tall, and one was 60m tall. The measurement campaign spanned from June 2014 through December 2017. Data was collected for a minimum one year to a maximum 40 months across the nine measurement locations. The collected data were then incorporated into the modelling efforts to create the layers in NREL's renewable energy data explorer tool, which is web-based and accessible to all and helps users understand the wind resource in Bangladesh along with other important variables. Figure 1 is an example of wind resource map for Bangladesh that can be created with renewable energy data explorer.

Table 2: Potential of Wind Power in Bangladesh[10]

Wind Speed Range (m/s)	Square Kilometer (km^2)	Acres	Estimated MW (based on 0.6 Km^2 per MW)
0 to 4.75	14,769	3,647,943	24,320
4.75 to 5.25	51,966	12,835,602	85,571
5.25 to 5.75	37,728	9,318,816	62,125
5.75 to 6.25	12,276	3,032,172	20,214
6.25 to 6.75	6,093	1,504,971	10,033
6.75 to 7.25	2,196	542,412	3,616
7.25 to 7.75	162	40,014	267

Three power generation companies took initiatives for site-specific wind resource assessment. In 2016, Coal Power Generation Company of Bangladesh Limited (CPGCBL) commissioned a study for installation of wind farm in Matarbari island of Moheshkhali Upazilla under Cox's Bazar district. Wind data was recorded from February 2017 to February 2018. The mean wind speed observed to be 5.76m/s at 100m height. At the initiative of Electricity Generation Company of Bangladesh

[10] Final presentation of NREL's report at Bidyut Bhaban, Dhaka, 30 May 2018.

Limited (EGCB), a wind resource study was conducted in Sonagazi Upazilla of Feni district. Wind measurement instrument was LiDAR (Light Detection and Ranging) and measurement height 100m. Data collection spanned from June 2017 to September 2018. Average wind speed observed in the study was 5.38m/s at 100m. In 2017, North-West Power Generation Company Limited (NWPGCL) entrusted the Fujian Electric Power Survey and Design Institute (FEDI) of China to conduct WRA in Kalapara Upazilla under Patuakhali district to establish 50 MW wind power plant near NWPGCL's Payra thermal power plant. The preliminary report submitted by FEDI in November 2019 shows an annual average wind speed of 5.466m/s at a height of 120m**.**

Estimates of the wind resource are expressed in wind power classes ranging from Class 1 to Class 7, with each class representing a range of mean wind power density or equivalent mean wind speed at specified heights above the ground.

Table 3: Wind Power Class Based on Wind Speed and Wind Power Density[11]

	30m (98 ft)		50m (164 ft)	
Wind Power Class	**Wind Power Density (W/m2)**	**Wind Speed m/s (mph)**	**Wind Power Density (W/m2)**	**Wind Speed m/s (mph)**
1	≤ 160	≤ 5.1 (11.4)	≤ 200	≤ 5.6 (12.5)
2	≤ 240	≤ 5.9 (13.2)	≤ 300	≤ 6.4 (14.3)
3	≤ 320	≤ 6.5 (14.6)	≤ 400	≤ 7.0 (15.7)
4	≤ 400	≤ 7.0 (15.7)	≤ 500	≤ 7.5 (16.8)
5	≤ 480	≤ 7.4 (16.6)	≤ 600	≤ 8.0 (17.9)
6	≤ 640	≤ 8.2 (18.3)	≤ 800	≤ 8.8 (19.7)
7	≤ 1600	≤ 11.0 (24.7)	≤ 2000	≤ 11.9 (26.6)

Table 3 presents the wind power classes in terms of the upper limits of mean wind power density and mean wind speed at 30m (98 ft) and 50m (164 ft) above ground level.[12] Class 4 or greater are generally considered suitable for most wind turbine applications. Class 3 areas are suitable for wind energy development using tall (e.g., 50m hub height) turbines. Class 2 areas are marginal and Class 1 areas are unsuitable for wind energy development. In terms of wind power class as shown above, studies conducted so far reveal a moderate to low onshore wind resource in Bangladesh. The baseline study titled "Wind Energy Potential Bangladesh", commissioned by the Netherlands'

[11] NREL, *Wind Resource Assessment Handbook: Fundamentals for Conducting Successful Monitoring Program*, Cole Boulevard Golden, USA: National Renewable Energy Laboratory, 1997, p. 15.
[12] Ibid., p. 15.

Ministry of Foreign Affairs, also substantiates the findings of the earlier studies.[13] For the development of utility-scale commercial wind power plants, systematic and site-specific wind resource study is a prerequisite. Lack of bankable wind data and land constraints continue to be a challenge for Bangladesh to deploy utility-scale onshore wind power plants, hence, potentials of offshore wind power need to be explored for bulk power generation.

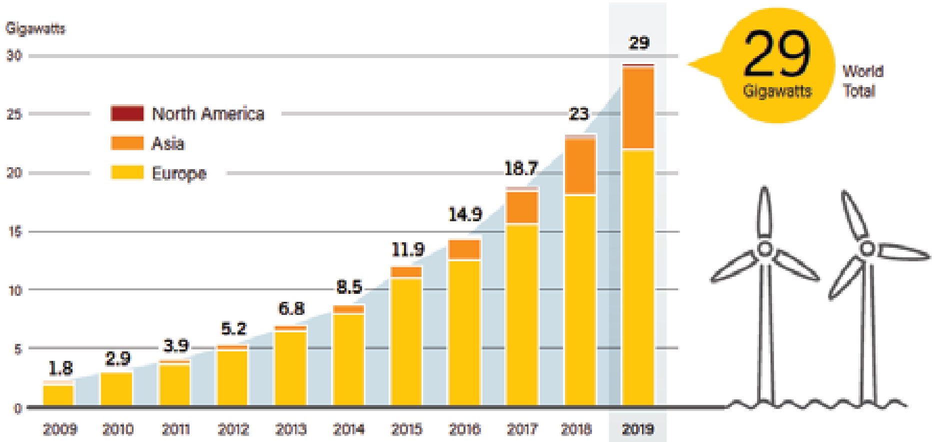
3. Evolution of Offshore Wind Power Technology and its Pros and Cons

Denmark commissioned world's first offshore wind power plant in 1991. Known as the Vindeby Offshore Wind Farm, this 5 MW facility, consisting of eleven 450 kW turbines, was built at a near-shore site in shallow waters. Since then, efforts have been made to unlock the potential of offshore wind power across Europe and elsewhere. In 2002, the first commercial-scale offshore wind power plant was also set up in Denmark with an installed capacity of 160 MW consisting of 80 turbines of 2 MW each, which was connected to the grid at Horns Rev off the coast of Denmark.[14] Outside of Europe, the first commercial offshore wind power plant, known as Donghai Bridge Wind Farm, was established in China in 2010 with an installed capacity of 102 MW.[15] The United States' first commercial offshore wind power plant, known as the Block Island Wind Farm, became operational in 2016. It comprises five 6 MW turbines with an installed capacity of 30 MW, which is located three miles off the coast of Block Island, Rhode Island in the Atlantic Ocean.[16] Another milestone was achieved in 2017 with the establishment of world's first floating offshore wind power plant in Scotland with an installed capacity of 30 MW. It comprises five 6 MW turbines installed on floating structures. Floating foundations offer two important opportunities: (i) they allow access to sites with water deeper than 60m, and (ii) they ease turbine set-up, even for mid-depth conditions (30–50m). Additionally, floating foundations generally offer environmental benefits compared to fixed-bottom designs due to less-invasive activity on the seabed during installation. The launch of the world's first floating offshore wind power plant is expected to be a game changer in exploitation of the enormous wind potential available in deeper waters. Since offshore wind power took its first steps in the 1990s, size of wind turbines increased gradually from 450 kW to 6 MW as of 2017. The growth in turbine size helps to increase output of wind power. Larger turbines with greater swept areas

[13] Ministry of Foreign Affairs, *Wind Energy Potential Bangladesh*, Hague: Netherlands Enterprise Agency, 2017.
[14] IRENA, *Innovation Outlook: Offshore Wind*, Abu Dhabi: International Renewable Energy Agency, 2016, p. 19.
[15] Available at https://en.wikipedia.org/wiki/Wind_power_in_China, accessed on 24 August 2020.
[16] AWEA, *U.S. Offshore Wind Power Economic Impact Assessment*, Washington, D.C.: American Wind Energy Association, 2020, p. 2.

yield higher capacity factors for the same resource quality. Turbine technology reached a new height in 2019 when offshore wind turbine of 10 MW capacity was made commercially available. With rapid technological improvement, offshore wind power has come of age in the last two-to-three years and has been growing exponentially. Figure 2 shows that by the end of 2019, a total of 18 countries (12 in Europe, 5 in Asia and 1 in North America) had offshore wind capacity in operation raising the total installed capacity to 29 GW.[17]

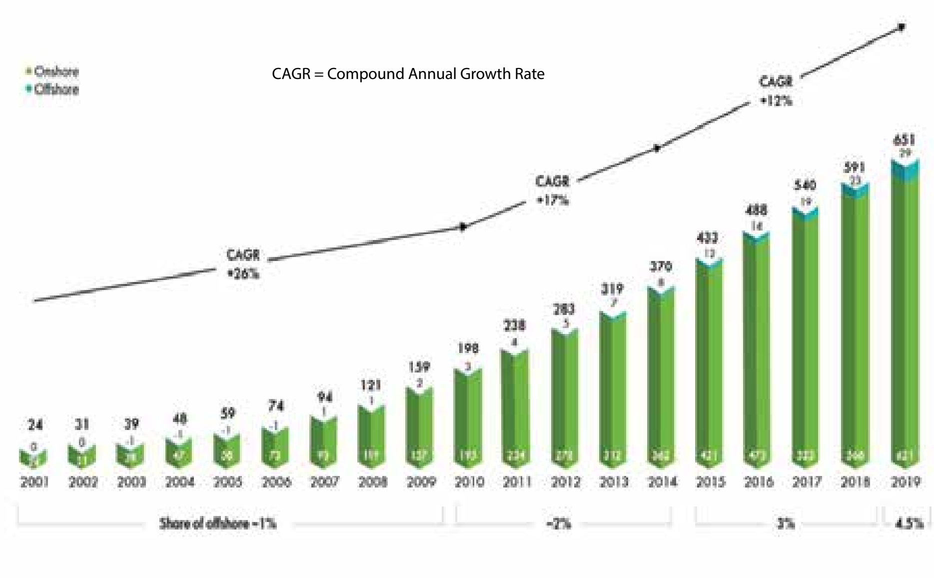
Figure 2: Global Installed Capacity of Offshore Wind Power by Region, 2009-2019[18]



According to the Global Wind Energy Council (GWEC), the world's installed offshore wind power capacity now represents 4.5 per cent of total cumulative wind power capacity (Figure 3).[19] The exponential growth of offshore wind power clearly indicates that technology has matured to be well-spread throughout the world. Meanwhile, major Asian economies such as China, Chinese Taipei, India, Indonesia, Japan, the Philippines, the Republic of Korea and Vietnam have set targets for installations of offshore wind power plant by 2030, cumulative capacity of which is 100 GW having potential to replace 300-350 metric tonnes of coal annually.[20] Neighbouring country India is implementing its first offshore wind power project with an installed capacity of 1 GW off the coast of Gujrat.[21]

[17] REN21, *Renewables 2020: Global Status Report*, Paris: REN21 Secretariat, 2020, p.137.
[18] Ibid.
[19] GWEC, *Global Wind Report 2019*, Brussels, Belgium: Global Wind Energy Council, 2020, p. 43.
[20] IRENA, *Future of wind: Deployment, Investment, Technology, Grid Integration and Socio-economic Aspects*, Abu Dhabi: International Renewable Energy Agency, 2019, p. 46.
[21] MNRE, Government of India, *Annual Report 2019-20*, New Delhi: Ministry of New and Renewable Energy, 2020, p. 57, available at https://mnre.gov.in/img/documents/uploads/file_f-1585710569965.pdf, accessed on 24 August 2020.

Figure 3: Historical Development of Wind Power (Onshore and Offshore)[22]



Given technological advances and falling costs, the global cumulative offshore wind capacity would increase almost ten-fold by 2030 and even more towards 2050 with total installation nearing 1000 GW by 2050, according to the International Renewable Energy Agency (IRENA).[23]

The offshore wind power technology has several advantages over its onshore equivalent. Firstly, there are better wind conditions: the winds are stronger and air is denser. Secondly, offshore wind has lower variability and higher capacity factor, which according to the International Energy Agency (IEA), ranges between 40 per cent to 50 per cent for new projects.[24] Thirdly, it can use the technologies which are developed over decades by the onshore wind industry. Fourthly, going offshore also allows for larger turbines to be installed that run for more operative hours. Finally, it has fewer physical constraints than onshore wind power generation in populated areas, such as turbine size, operating noise, and visual amenity.

However, offshore wind power development also comes with challenges. The main challenges are: ensuring optimum sites, environmental impact assessment, getting supply to the demand, enabling timely investment, and expanding the supply chain. Moreover, it takes more than a decade from the start

[22] GWEC, op..cit., p. 43.
[23] IRENA, op. cit., p. 43.
[24] IEA, *Offshore Wind Outlook 2019*, Paris, France: International Energy Agency, 2019, p. 12.

of wind power plant development to the completion of installation and start of electricity generation.

The main cost components for offshore wind power plants are the turbines (including towers), the foundations, the grid connection to shore and the installation. The turbine represents the largest cost component, accounting for up to 45 per cent of total installed costs for offshore wind.[25] Advances in technology together with increasing developer experience, industry maturity and economies of scale across the value chain have helped to drive down the cost of electricity from offshore wind power plants. Consequently, the global weighted-average installed costs for offshore wind power declined from USD 4650/kW to USD 3800/kW between 2010 and 2019, while its capacity factor[26] improved by nearly one-fifth over the last decade from 37 per cent in 2010 to 44 per cent in 2019. In 2019, the global weighted-average levelized cost of electricity (LCOE) of offshore wind had fallen to USD 0.115/kWh, from USD 0.161/kWh in 2010 (Figure 4).[27] Operation and maintenance costs similarly fell with larger turbine sizes, expanded service capacities, and the emergence of cost synergies across growing maritime wind-farm zones, although figure 4 shows a significant degree of year-on-year volatility in the total installed costs of newly commissioned offshore wind power plants. In any case, increased deployments and growing maturity of offshore wind markets in Europe and China between 2010 and 2019 have reduced risks and uncertainty for investors. That has led to increased interest in the offshore wind sector and has reduced cost of financing. Considering historical LCOE trends and PPA prices for projects being deployed up to 2030, IRENA anticipates a central LCOE estimate of USD 0.054/kWh in 2030.[28]

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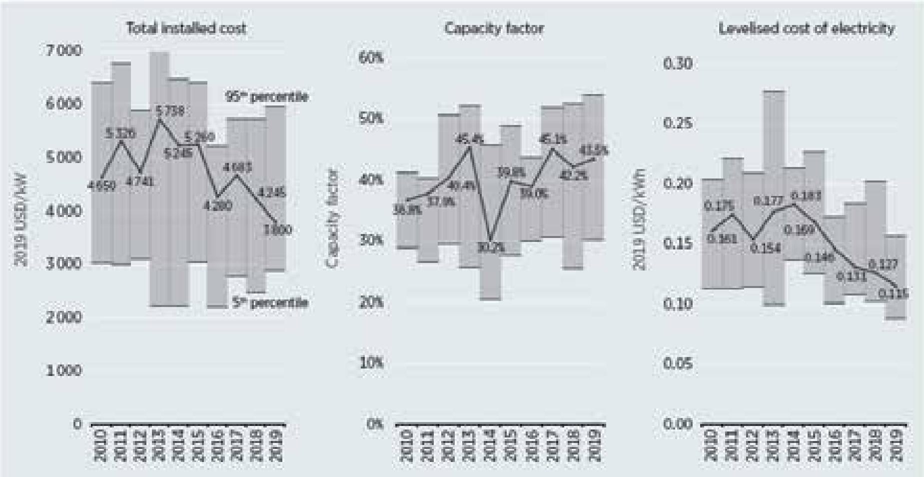
[25] IRENA, op. cit., p. 48.

[26] Capacity factor describes the average output over the year relative to the maximum rated power capacity.

[27] IRENA, *Renewable Power Generation Costs in 2019*, Abu Dhabi: International Renewable Energy Agency, 2020, p. 31.

[28] IRENA, *Global Renewables Outlook: Energy Transformation in 2050*, Abu Dhabi: International Renewable Energy Agency, 2020, p. 61.

Figure 4: Global Weighted Average Total Installed Costs, Capacity Factors and LCOE for Offshore Wind Power, 2010-19[29]



Despite improvement in capacity factor, declining total installed cost and LCOE for offshore wind, it is evident that offshore wind power is still a costly option as compared to onshore wind. Harnessing the offshore wind power is more expensive than that of onshore wind power due to both the preliminary expenses such as installation of foundations, more extensive safety measures and larger maintenance costs. For onshore wind, the global weighted-average total installed cost fell from USD 1949/kW to USD 1473/kW between 2010 and 2019. Figure 5 illustrates that over the same period, the global weighted-average cost of electricity from onshore wind projects fell by 39 per cent from USD 0.086/kWh to USD 0.053/kWh.[30]

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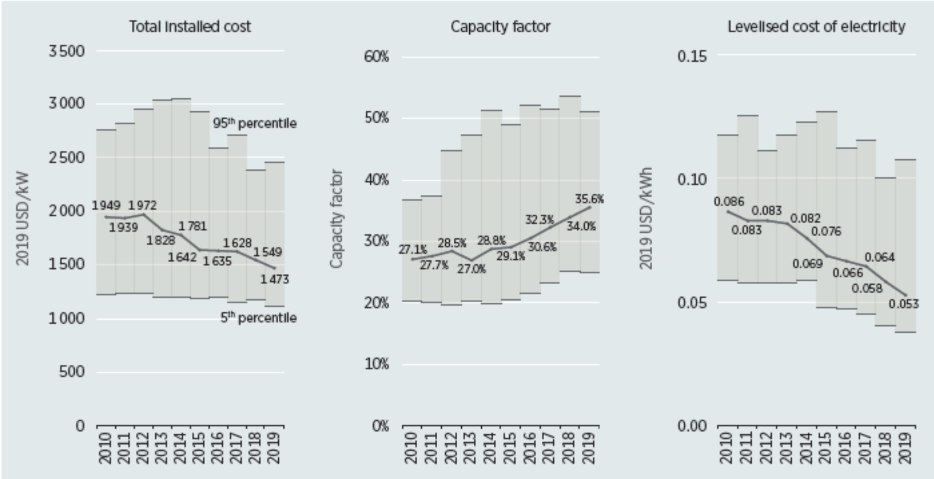
[29] Ibid., p. 29.

[30] Ibid., p. 31.

Figure 5: Global Weighted Average Total Installed Costs, Capacity Factors and LCOE for Onshore Wind Power, 2010-19[31]



The available data, as depicted in preceding section, shows predominance of low wind speeds on lands. Apart from low wind speeds, scarcity of land for onshore sites and future projection of significant cost reduction present a compelling case for Bangladesh to go for offshore wind power development.

4. Lessons from Global Experience of Offshore Wind Power Development

Bangladesh has no experience of offshore wind power development. This implies that a lot of knowledge and experience has to be learned from Europe where offshore wind power owes its origin. Europe, led by Denmark, Germany and United Kingdom have excelled in technology innovation as well as offshore wind power plant installations as evident from figure 6.[32] Through collaboration among European markets and experienced stakeholders, a robust offshore wind supply chain has been built in countries neighbouring the North Sea and Baltic Sea.[33] Consequently, in 2019, the region added more than 3.6 GW bringing the regional total installed capacity more than 22 GW.[34]

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[31] IRENA, op. cit., p. 29.

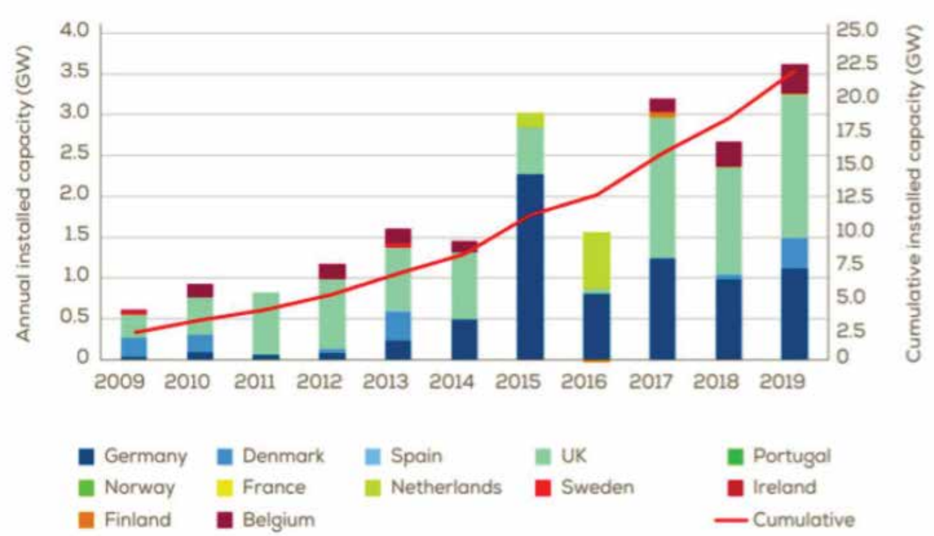
[32] Available at https://energyindustryreview.com/renewables/europes-new-record-for-offshore-wind-installations/, accessed on 02 September 2020.

[33] GWEC, op. cit., p. 15.

[34] REN21, op. cit., p. 137.

Apart from being the pioneer, Denmark has achieved tremendous success with the development of its offshore wind in spite of its small size. Since commissioning of the world's first offshore wind power in 1991, Danish offshore wind power farms have become much larger and cheaper. At the same time the large wind power farms have been moved further offshore to reduce the visual effects of the wind turbines. Denmark's natural resources such as a long coastline, excellent wind resources and shallow waters have provided a solid starting point. Denmark has one of the most developed permitting and siting procedures for offshore wind power plants, which were consistently improved over time. Wind energy has priority access to the grid in Denmark. The supportive environment set by the Danish government for renewable energy and the offshore wind industry through legislated renewable targets, taxes and tariffs and commitment to specific projects provides certainty for companies and investors to back offshore wind projects of the country. Denmark is now home to the world's largest offshore wind power company, Ørsted, with majority share of global offshore wind assets.

Figure 6: Annual Capacity Addition (Left Axis) and Cumulative Capacity (Right Axis) of Offshore Wind in EU Countries[35]



German journey for development of national offshore wind sector commenced with the publication of a strategy paper on offshore wind energy in 2002 titled "Die Bundesregierung 2002".[36] The then environmental protection laws

[35] Ibid.

[36] IRENA, *30 Years of Policies for Wind Energy: Lessons from 12 Wind Energy Markets*, Abu Dhabi: International Renewable Energy Agency, 2013, p. 65.

for Germany's coastal regions restricted the development of offshore wind power to the Exclusive Economic Zone (EEZ). This challenge prompted the German wind power industry to develop turbines that could withstand more difficult environmental conditions. Simultaneously, the government established and financed Research and Development (R&D) programmes for offshore wind power plant. The law that provided the initial stimulus for national wind market was the renewable Energy Sources Act (EEG), which came into effect in 2000.[37] The EEG obliged power utilities to purchase renewable energy at set tariffs over a period of 20 years. German government amended the EEG in January 2009 to include an increased initial tariff for both onshore and offshore wind energy. While experience in onshore wind power dates back to the early 90s, the country's first offshore wind farm Alpha Ventus was commissioned on 27 April 2010 with an installed capacity of 60 MW. German government has been customizing framework conditions and tariff system to respond to market dynamics and the level of technology maturity. Consequently, total offshore wind power capacity has risen to 7.5 GW, making Germany the second biggest offshore wind power market in the world after the UK.[38] A number of factors such as: (i) a skilled workforce available to manufacture a complex technology; (ii) the ability to finance R&D and (iii) a high entrepreneurial drive also contributed to this achievement. As part of the EEG, German government introduced the Offshore Wind Energy Act (WindSeeG) which entered into force on 01 January 2017. The WindSeeG stipulates that the level of funding for offshore wind-power installations is also to be determined by means of competitive auctions. In June 2020, Germany's Federal Cabinet has approved the amendment to the WindSeeG, which increased the 2030 offshore wind power generation target from 15 GW to 20 GW and established a long-term offshore wind power generation target of 40 GW by 2040.[39]

The UK stepped into offshore wind power through implementation of a 4 MW demonstration project in December 2000, off the Northumberland coast. The seabed around the UK is owned by The Crown Estate. Earlier in 1998, the British Wind Energy Association (now Renewable UK) had held discussions with the government and The Crown Estate to create a set of guidelines allowing establishment of offshore wind power plant. The published guidelines permitted companies to develop offshore wind power plants of an area up to 10 km and 30 turbines. This provided companies valuable development experience. In UK's Round 1 licensing round exercise, 17 projects were approved and given permission to proceed in April 2001. The first Round 1 project, North Hoyle, the UK's first commercial wind farm consisting of thirty 2 MW Vestas turbines on monopile foundations in about 12m water, was completed in 2003 which was followed by 10 projects, with a total of

[37] Ibid., p. 65.
[38] GWEC, op. cit., p. 41.
[39] Ibid., p. 16.

1.1 GW. Round 2 took place in 2003, with 15 projects awarded a total capacity of 7.2 GW.[40] In 2007, the government announced a strategic environmental assessment as an early step to Round 3 of seabed leasing by The Crown Estate. In 2010, the winners of The Crown Estate's Round 3 leasing competition were announced, the largest with capacity up to 10 GW. The year 2013 saw the first 7 MW turbine installed offshore in the Firth of Forth, Scotland. In the same year the Government also announced an intermediate step to a new auction market mechanism for offshore wind power, Contracts for Difference (CfD) as part of Electricity Market Reform.[41]

The CfD model has steadily delivered high volumes of offshore wind capacity while driving down costs, including grid charges, to below €46/MWh (£41.7) in the 2019 round 3, down from €154/MWh (£120) in the 2015 round 1 (Figure 7).[42] In 2017, the first wind farm (Rampion) from the UK leasing Round 3 started operation. Rampion, in the English Channel, consists of 130 turbines of 3.45 MW each. In 2019, the 1,218 MW Hornsea One wind farm began operation. It has become the world's largest offshore wind farm. In March 2019, the Industrial Strategy Offshore Wind Sector Deal was launched in the UK marking a significant deepening of the partnership between the government and the sector, reinforcing the aims of the government's industrial strategy. The trajectory of UK's offshore wind power is now guided by the Sector Deal outlining the target to reach 30 GW of offshore wind capacity by 2030, which was extended to an ambitious 40 GW by the end of 2019. The progress of the UK's offshore wind power development is phenomenal. From its first 4 MW pilot project in Blyth in 2000, UK's total installed offshore wind power capacity has reached at 9.7 GW today[43] making UK the biggest offshore wind power developer in the world.

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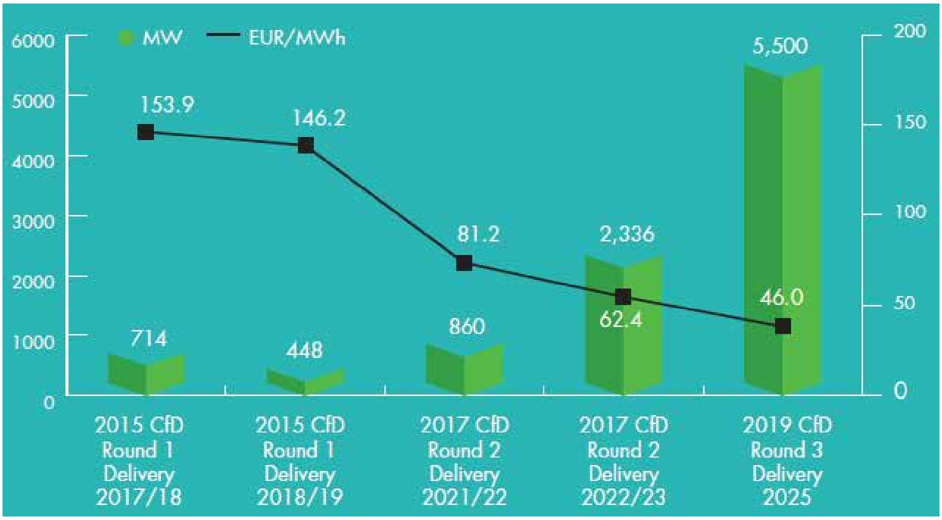
[40] Maf Smith, Ben Backwell and Nick Medic, *Offshore Wind Energy*, London: Renewable UK, pp. 10-12, available at https://events.renewableuk.com/images/Images/2019/GOW19/HAYNES-OFFSHORE-WEBSITE-VERSION.pdf, accessed on 03 September 2020.

[41] "UK offshore wind history", available at https://guidetoanoffshorewindfarm.com/offshore-wind-history accessed on 13 September 2020.

[42] GWEC, op. cit., p. 35.

[43] GWEC, op. cit., p. 47.

Figure 7: CfD Rounds Leading to Cost Reductions for Offshore Wind Power[44]

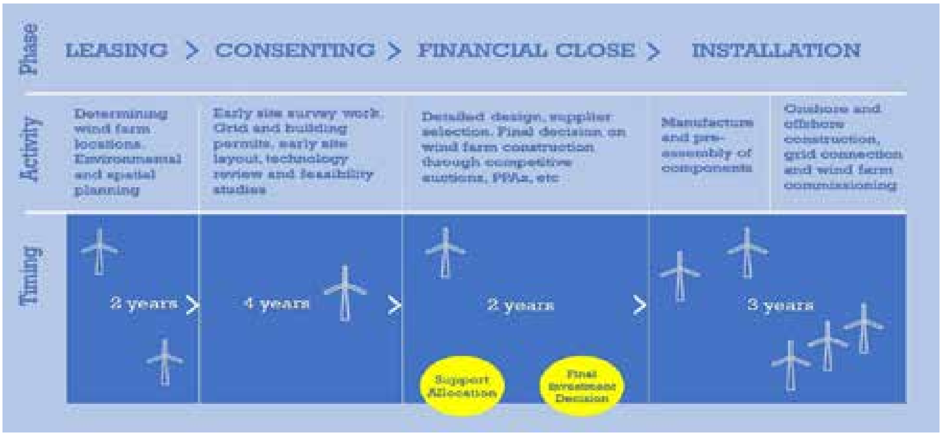


An analysis of the history of offshore wind power development in the UK reveals that its offshore wind power capacity has been largely achieved by harnessing the knowledge and expertise that had been developed in countries such as Denmark and Germany. The initial support for wind energy came from the National Fossil Fuel Obligation (NFFO) scheme. The Renewables Obligation (RO/ROC), a subsidy scheme for large renewable electricity projects applied in 2002, supported deployment following NFFO. The CfD scheme introduced in 2013 provided direct protection from volatile wholesale prices to consumers and developers while incentivizing the upfront investment costs for offshore project developers. The UK has used market-based mechanisms to promote wind energy, unlike the German support schemes. The UK has exemplified that with an increased market certainty and volume visibility, scale is one of the key inputs that support competition and innovation in the supply chain to drive competitiveness and reduce costs.[45] The support to wind energy has also been supplemented by the efforts to address climate change and to achieve energy independence.

It is also learnt from the field-proven experience of European countries that development of offshore wind power is a time-consuming venture. There are four different stages in the development of an offshore wind power plant. Each stage requires a specific time span for its completion. Figure 8 outlines the different stages and timing for the development of an offshore wind power plant.[46]

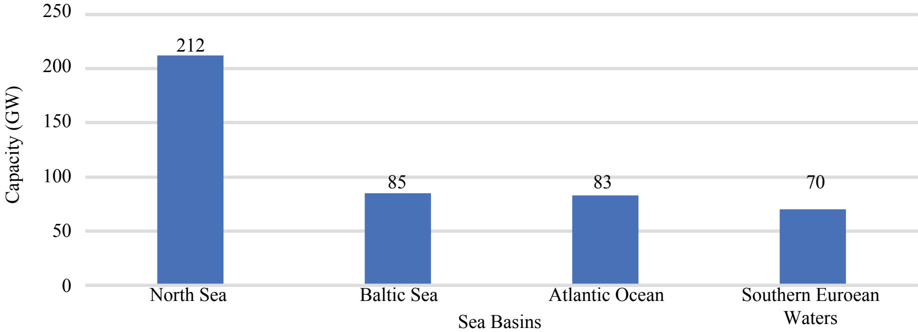
[44] GWEC, op. cit., p. 35.
[45] GWEC, op. cit., p. 47.
[46] Colin Walsh (ed.), *Our energy, Our Future: How Offshore Wind Will Help Europe Go Carbon-neutral*, Brussels, Belgium: Wind Europe, 2019, p. 31.

Figure 8: Offshore Wind Power Plant Development Stages[47]



Europe has one of the world's best offshore wind resources. In an effort to explore how to become carbon-neutral, Europe envisions to deploy 450 GW of offshore wind power by 2050. With a view to realizing this vision, development of 380 MW offshore wind power was allotted to the North Seas (the Atlantic off France, Ireland and the UK, the North Sea, Irish Sea and Baltic Sea) and 70 GW to Southern European waters (Figure 9). It is pertinent to mention that the total area of the North Seas needed for 380 GW of offshore wind power would be 76,000km^2,

Figure 9: Breakdown by Sea Basin of 450 GW Offshore Wind Power[48]



which is 2.8 per cent of the total area of the North Seas.[49] For ease of implementation, country/area wise allocation of 450 GW offshore wind power was also made on the basis of each country's EEZ and power demand by 2050. Sea basins

[47] Ibid.
[48] Ibid.
[49] Ibid.

are divided into sub-regions, upon an analysis of potentials, to uniquely identify the locations where to put offshore wind power plants. Figure 10 shows the sub-regions of Ireland, France, the UK, Denmark, Germany, Sweden and Finland.

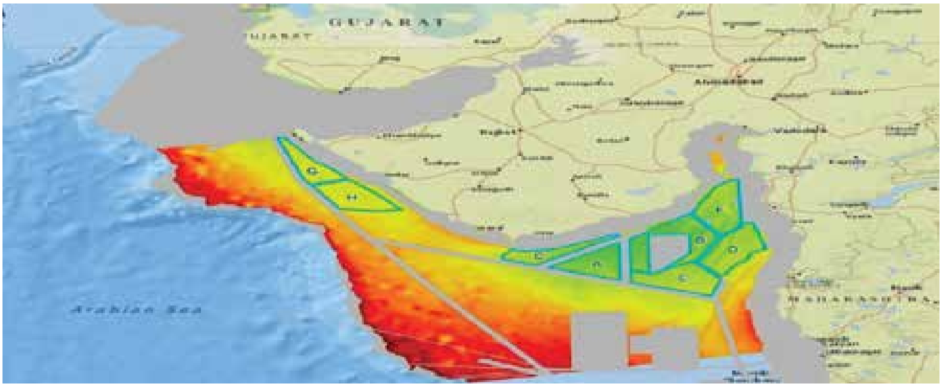
Figure 10: Sub-regions of Seven European Countries' EEZ[50]

Being one of the littoral states of the Bay of Bengal, the experience of India is also relevant for Bangladesh. India has identified eight zones in Tamil Nadu (Figure 11) and Gujarat (Figure 12) as potential zones for exploitation of offshore wind energy potential on the basis of preliminary assessment from satellite data and data available from other sources. Each potential zone, identified in the pre-feasibility study, has been further sub-divided into sub-zones. For example, zone A of Gujrat has been divided into 19 sub-zones (Figure 13) focusing on important parameters including met-ocean and geotechnical conditions in order to facilitate development of offshore wind power plant.

[50] Ibid., p. 14; Sub regions are labelled in the form "LLNN" where LL is the two-letter country code and NN is the two-number label for each sub-region.

Figure 11: Potential Zones for Offshore Wind Farm Development in Tamil Nadu (A-H)[51]

Figure 12: Potential Zones for Offshore Wind Farm Development in Gujrat (A-H)[52]



[51] FOWIND, "Pre-Feasibility Study for Wind Farm Development in Tamil Nadu", 2015, p. 26, available at http://www.gwec.net/wp-content/uploads/2015/06/prefeasabilityTN.pdf, accessed on 25 August 2020.
[52] FOWIND, "Pre-Feasibility Study for Wind Farm Development in Gujrat", 2015, available at https://www.dnvgl.com/publications/fowind-pre-feasibility-study-gujarat-123047, accessed on 25 August 2020.

Figure 13: Sub-zones of Gujrat's Zone A[53]

India proceeded to develop offshore wind power by establishing structural collaboration and knowledge sharing with the European Union (EU). This collaboration, effected through a project titled "Facilitating Offshore Wind in India (FOWIND)", was implemented by a consortium of national and international agencies led by GWEC. As offshore wind power development is a very capital-intensive venture, the government of India has announced its intention of developing 5 GW of offshore wind power project by 2022 and 30 GW by 2030 to attract large investments in the sector.[54]

Every national circumstance is different, but there are lessons to be learnt from each of the country. Europe's experience provides important insights for how offshore wind may grow in developing countries. It is evident that European countries have taken a systematic and coordinated effort by fixing time-bound target and allocating the same among countries to harness the offshore wind power. In Asia, excluding China, offshore wind power is at its early stage of development, hence, collaboration with European partners is essential for development of offshore wind power. India has teamed up with national and international agencies led by GWEC on its effort to explore offshore wind power.

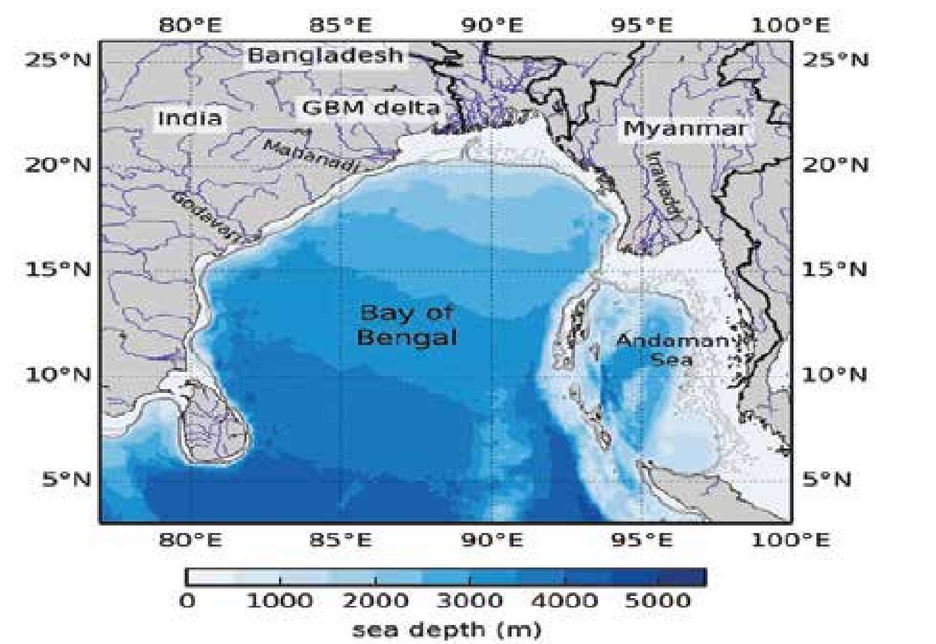
[53] FOWIND, "Feasibility Study for Wind Farm Development in Gujrat", 2018, available at http://gwec.net/wp-content/uploads/2018/03/FEASIBILITY-STUDY-FOR-OFFSHORE-WIND-FARM-DEVELOPMENT-IN-GUJARAT.pdf accessed on 25 August 2020.
[54] MNRE. op. cit., p. 55.

5. Scope for Development of Offshore Wind Power in Bangladesh

Bangladesh is bounded on the south by the Bay of Bengal, which is a northern extended arm of the Indian Ocean. The Ganges-Brahmaputra-Meghna (GBM) delta is the northern boundary of the Bay. The Bay is bounded on the west and northwest by India, on the east by Myanmar and the Andaman and Nicobar Islands of India. Its southern limit is a line between Sangaman Kanda, Sri Lanka and the north westernmost point of Indonesia's Sumatra (Figure 14). The width of the continental shelf off the coast of Bangladesh varies considerably. It is less than 100 km off the south coast of Bangladesh, between Hiron Point and the Swatch of No Ground and more than 250km off the coast of Cox's Bazar. Seabed evidence suggests that the dominant transport of fine-grained sediment on the continental shelf of Bangladesh is from south and west. Sediments are fine seaward and westward with the thickest accumulation of mud near the submarine canyon, Swatch of No Ground. Most of the continental shelf of Bangladesh is covered by silt and clay. The shallow part (less than 20m) of the continental shelf off the coast of Chittagong and Teknaf is covered by sand and the intertidal areas shows well-developed sandy beaches. Sand waves observed on the continental shelf in this area have considerable relief (3-5m), implying a high-energy environment. Even the shallower part of the southern continental shelf off the coast of the Sundarbans, Patuakhali and Noakhali is covered by silt and clay; and extensive muddy tidal flats are developed along the shoreline. This indicates that even under present oceanographic conditions, sediments are being tunnelled to the deeper part of the Bay of Bengal through the Swatch of No Ground.[55]

[55] Banglapedia, "Continental Shelf", available at http://en.banglapedia.org/index.php?title=Continental_Shelf, accessed on 06 September 2020.

Figure 14: Overview of the Bay of Bengal, Showing Bathymetry. Contours are Shown at 100m Intervals to 500m; Greater Depths are Shown by Colour Shading[56]



Bangladesh has a long coastline of about 710km extending from the living coral island St. Martin's in the southeast to the pristine Sundarbans mangrove forest in the south-west.[57] Once Bangladesh had unilateral access to its undisputed maritime area of around 50,000 square kilometres, but following the settlement of maritime boundary disputes with Myanmar and India, Bangladesh has now sovereign right to 118,813 square kilometres of sea area, comprising the territorial sea and EEZ in the northern Bay of Bengal (Figure 15).[58] Bangladesh's coast is characterized by the advantage of having wide, long continental shelf that can act as the barrier as well as plays a key role in flattening the waveform of the tsunami through defocusing.[59]

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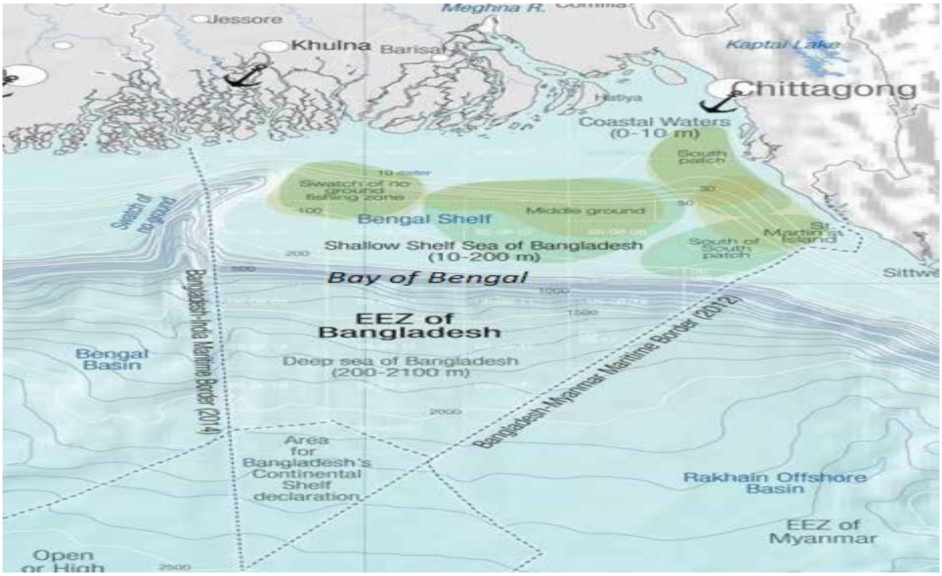
[56] Susan Kay, John Caesar and Tamara Janes, "Marine Dynamics and Productivity in the Bay of Bengal", in Robert J. Nicholls, Craig W. Hutton, W. Neil Adger, Susan E. Hanson, Md. Munsur Rahman and Mashfiqus Salehin (eds.), *Ecosystem Services for Well-Being in Deltas*, Cham: Palgrave Macmillan, 2018.

[57] Md. Shamsuddoha, and Mohammad Mahmudul Islam, *Bangladesh National Conservation Strategy, Coastal and Marine Resources*, Dhaka: Ministry of Environment and Forest, 2016, p. 2.

[58] Ibid., p. 4.

[59] Aftab Alam Khan, "Geo-resource Potential and Geohazard Status of the Bay of Bengal vis-à-vis Sustainable Development of Blue Economy", *Bangladesh Maritime Journal*, Vol. 3, No. 1, 2019, p. 56.

Figure 15: Marine Boundary of Bangladesh[60]

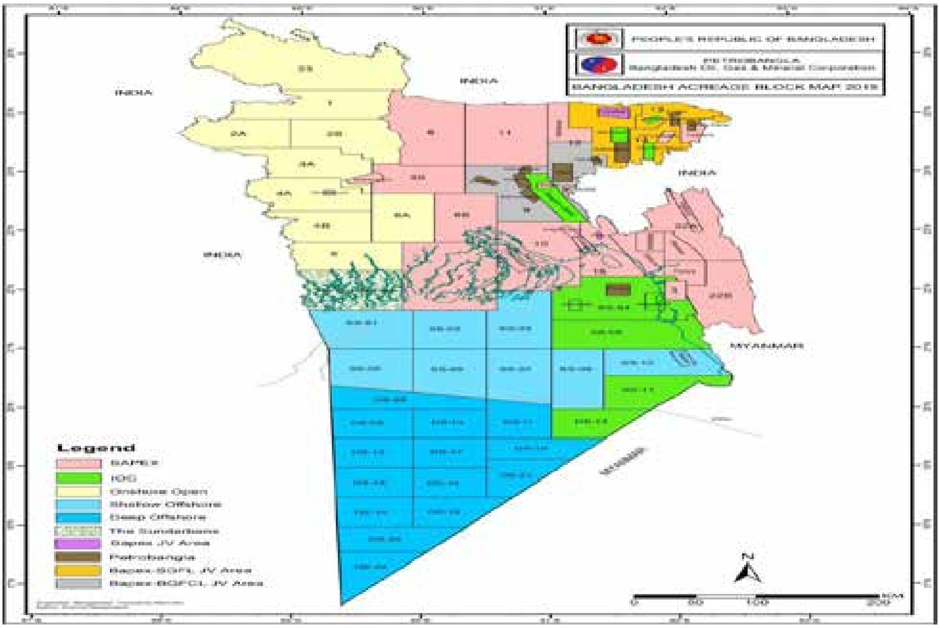


The Bay of Bengal is endowed with, among others, marine-based renewable energy resources such as wind, wave, tidal and ocean thermal. The offshore region of Bangladesh that occupies 63,000 km^2 area in water shallower than 200m is a southward extension of the Bengal Basin in the Bay of Bengal.[61] The long coastline along with abundance of shallow water could provide a solid starting point for offshore wind power development in Bangladesh. This is because greater depths are associated with higher costs and the use of more complex and specialized technologies, something that is reflected in the final investment of the offshore wind farm thus, reducing its profitability.[62] In any case, the optimum location for a wind farm to begin with is one that is as far as possible from the coastline while maintaining a low depth. A recent study estimated offshore wind power potential of 134 GW in Bangladesh, while estimated potential of onshore wind power is only 16 GW.[63] In Bangladesh's energy sector, initiative for exploration of gas in the offshore and deep-sea areas was undertaken on a limited scale (Figure 16). The wealth of expertise, products and services possessed by Bangladesh's gas sector can be adapted for offshore wind

[60] Adapted from S. R Chowdhury, Maritime Province of Bangladesh (map), University of Chittagong, Bangladesh, 2014.
[61] Aftab Alam Khan, op. cit., p. 44.
[62] Sergio Sánchez, José-Santos López-Gutiérrez, Vicente Negro and M. Dolores Esteban, "Foundations in Offshore Wind Farms: Evolutions, Characteristics and Range of Use: Analysis of Main Dimensional Parameters in Monopile Foundations", *Journal of Marine Science and Engineering*, Vol. 7, No. 441, 2019, p. 3.
[63] Dr. Sven Teske, Tom Morris and Kriti Nagrath, 1*00% Renewable Energy for Bangladesh-Access to Renewable Energy for Bangladesh Within One Generation*, Sydney: Institute for Sustainable Futures, 2019, p. 4.

power development. However, any initiative is yet to be taken for exploitation of offshore wind power. Although development of a strong renewable energy sector using ocean and atmospheric forces is one of the twelve actions mentioned in the 7th Five Year Plan of Bangladesh to create and maintain a prosperous sustainable blue economy.[64] A total of twenty-six maritime economic functions, e.g., fishery, maritime trade and shipping, energy, tourism, coastal protection, maritime safety and surveillance have been identified for development of blue economy in Bangladesh.[65]

Figure 16: Offshore and Onshore Gas Blocks for Exploration[66]



[64] Pawan G. Patil, John Virdin, Charles S. Colgan, M.G. Hussain, Pierre Failler and Tibor Vegh, *Toward a Blue Economy: A Pathway for Sustainable Growth in Bangladesh*, Washington, D.C: World Bank Group, 2018, p. 39.

[65] Md. Khurshed Alam, "Blue Economy: Development of Sea Resources for Bangladesh", available at https://mofa.gov.bd/site/page/8c5b2a3f-9873-4f27-8761-2737db83c2ec/OCEAN/BLUE-ECONOMY--FOR BANGLADESH#:~:text=To%20realise%20the%20necessary%20international,then%20second%20one%20 2017in%20Dhaka, accessed on 20 June 2020.

[66] Bangladesh Oil, Gas & Mineral Corporation (Petrobangla).

Offshore wind power plants cannot be seen in isolation from the natural and anthropogenic landscape in which they are constructed. This is why potential sites for offshore wind power development should be identified in agreement with maritime spatial planning (MSP) so that the areas for sand and gravel dredging, major shipping lanes, cable and pipelines routes, and military uses are excluded. Notably, offshore wind power plants can share sea with other activities such as aquaculture and some fishing techniques. MSP is a tool that government can use to organize and optimize their sea spaces. With MSP, authorities may allow different activities to take place within and around wind power plants in order to increase the functionality of the sea.[67]

European and Indian experience suggests that offshore wind power development could be a doable option for Bangladesh utilizing her enormous sea space. Translating this option into a reality requires coordinated effort of the key stakeholders. Each stakeholder can contribute by providing essential information and extending cooperation required for development of offshore wind power. For example, Bangladesh Oceanographic Research Institute (BORI) under the Ministry of Science and Technology can provide data and information on met-ocean, geophysical and geo-technical conditions. Ministry of Defence can identify the sea spaces required for military uses, which need to be excluded from MSP. Likewise, the Ministry of Shipping can identify the shipping lanes. Ministry of Fisheries and Livestock can assess impact of offshore wind power plant on marine fisheries as well as furnish information on aquaculture and fishing techniques. As a repository of renewable energy resources, Sustainable and Renewable Energy Development Authority (SREDA) can make wind resource data available for research. Universities and various agencies conducting research on maritime affairs may also provide useful information. Department of Environment under the Ministry of Environment, Forest and Climate Change has to play a pivotal role to lead the environmental impact assessment (EIA) including its impact on biodiversity and to provide environmental clearance to any power generation project. Maritime Affairs Unit of the Ministry of Foreign Affairs can facilitate establishing structural collaboration with relevant countries and international agencies to ensure international cooperation. Accredited Entities of the Green Climate Fund (GCF) can explore the feasibility of attracting global climate fund for this effort. The Blue Economy Cell established at the Energy and Mineral Resources Division of the Ministry of Power, Energy, and Mineral Resources is mandated to coordinate activities across sectoral ministries.

Experience of successful countries clearly shows that development of offshore wind power requires a visionary approach as it involves diverse stakeholders

[67] Colin Walsh, op. cit., p. 27.

and takes a relatively longer period of time. Adoption of an emerging technology like offshore wind power requires a range of activities to be undertaken by concerned agencies relating to resource assessment, surveys and studies within EEZ, demarcation of potential blocks, design of undersea cables for power evacuation. Thus, commissioning of an investment-grade feasibility study, with all stakeholders on board, is the need of the hour for unlocking the potential of offshore wind power in Bangladesh. Only after extensive feasibility study it will be possible to determine a price per kWh which would have to be location-specific.

6. Conclusion

Achieving Bangladesh's long-term development goal and scaling up of renewable energy may not be possible with the existing portfolio of renewable energy programs and their current pace of development. Expansion of renewable energy portfolio with addition of offshore wind power could become a crucial pillar in the energy mix adding sizeable amount of power to supplement the existing installed capacity.

Offshore wind power development is a very capital-intensive venture and the initial investment is very high. However, there is an anticipation that LCOE for offshore wind power would be as low as USD 0.054/kWh in 2030.[68] An investment-grade feasibility study will help seize cheap offshore wind power in the future by revealing its techno-economic potential in Bangladesh. Development of skilled manpower should also be undertaken alongside feasibility study to support offshore wind power development, construction, and maintenance as there remains a dearth of skilled manpower in the offshore wind sector. This upfront investment can not only leverage economic and environmental benefits but also help in fulfilling the pledges of SDG and the Paris Agreement to which Bangladesh is a signatory.

As per Rules of Business of the Government of Bangladesh, development of electrical energy falls under the responsibility of the Power Division of the Ministry of Power, Energy and Mineral Resources.[69] However, the Power Division alone cannot perform this responsibility because of the involvement of other ministries and agencies. The Blue Economy Cell may take an immediate initiative to commission an investment-grade feasibility study as it has a mandate to coordinate activities across sectoral ministries. With a coordinated and concerted effort Bangladesh can undertake and achieve the venture of offshore wind power development, benefitting the people and boosting economic development of the country.

[68] IRENA, op. cit., p. 61.
[69] SRO NO. 242-Law/2014, Bangladesh Gazette Extra Ordinary 22 October 2014.