COLOMBIA'S OFFSHORE WIND ROADMAP

launch

Executive summary

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EXECUTIVE SUMMARY

This roadmap provides strategic analysis of the offshore wind development potential in Colombia, considering the opportunities and challenges under different, hypothetical, growth scenarios. It is intended to provide evidence to support the Government of Colombia in establishing policy, regulations, processes, and infrastructure to enable successful growth of this new industry.

It was initiated by the World Bank country team in Colombia under the umbrella of the World Bank Group's Offshore Wind Development Program—which aims to accelerate offshore wind development in emerging markets—and was funded by the Energy Sector Management Assistance Program (ESMAP) in partnership with the International Finance Corporation (IFC).

RATIONALE FOR OFFSHORE WIND IN COLOMBIA

Colombia has some of the best natural conditions for offshore wind in the world and there is already abundant private sector interest in developing projects. Colombia has an opportunity to use this indigenous energy resource as part of the transition to net-zero carbon and to help manage the country's energy trilemma:

- **Security of supply:** With close to 70 percent of Colombia's electricity being supplied by hydropower, the country is heavily reliant on its water reserves and is exposed to potential shocks caused by droughts – which are becoming more frequent as the impacts of climate change are felt. Diversification of the electricity supply will provide greater security of supply. Offshore wind's high, and less variable, output, in comparison to other non-conventional renewable energy (NCRE) resources such as solar PV and onshore wind, make it well suited to diversify the electricity mix at scale.

- **Sustainability:** Colombia's New Energy Plan[1] estimates that around 19 gigawatts (GW) of new NCRE will need to be added between 2020 and 2050. More ambitious NCRE needs have been also announced in the context of Colombia's carbon neutrality by 2050 strategy. According to this strategy, Colombia's electricity use needs to increase from 18 percent of total energy consumption in 2020 of as much as 70 percent by 2050[2]. Offshore wind could contribute some of this new NCRE capacity, as it uses less land than other forms of variable renewable energy and may be more acceptable to Colombia's citizens.

- **Equity:** Colombia's electricity supply needs to be affordable and avoid being susceptible to price increases caused by droughts or rising costs of imported fossil fuels. While the cost of energy for offshore wind is greater than that for solar or onshore wind, it can be competitive in the medium to long-term[3] when deployed at scale and its lower variability is likely to mean that electricity balancing costs will be lower, thereby reducing the overall cost to consumers.

Beyond the energy trilemma, the development of offshore wind could contribute other benefits to Colombia, including:

- **Economic benefits:** The development of offshore wind in Colombia could also generate numerous economic benefits. Under this roadmap's high growth development scenario, for example, by 2050 offshore wind could support up to 26,000 full-time equivalent (FTE) jobs and add around US$3 billion to Colombia's economy per annum. The rapid development of the global offshore wind industry will also provide some regional export opportunities for Colombia's supply chain, especially for projects in the southern-USA and elsewhere in Latin America.

- **Investments:** The development of 9 GW of offshore wind by 2050 would also require significant investments from international and domestic sources, both to finance the build-out of projects and to develop the local supply chain and industry.

- **Infrastructure upgrades:** Large-scale offshore wind development will catalyze investment into Colombia's port and grid infrastructure. These upgrades will exploit infrastructure sector synergies, having positive impacts outside of the offshore wind sector, for example by improving grid strength and reliability, or supporting the improvement of port infrastructure.

- **Decarbonization and exports:** Low-cost, large-scale offshore wind could be used to produce green hydrogen and other zero-carbon energy vectors

1. National Energy Plan 2020-2050, UPME & Minenergía
2. Gobierno de Colombia. (2021). Estrategia climática de largo plazo de Colombia E2050 para cumplir con el Acuerdo de París https://unfccc.int/sites/default/files/resource/COL_LTS_Nov2021.pdf
3. In some specific cases, offshore wind projects could already be cost competitive with existing fossil-fuelled generation.

such as ammonia. These products could not only enable the decarbonization of local industry such as agriculture and transportation, but could potentially be exported to other consumers. The economics of this opportunity will need to be assessed as the technology for producing green hydrogen matures. In addition, with increased, future electrical interconnection to neighboring systems, excess electricity from offshore wind could also be exported.

COLOMBIA'S OFFSHORE WIND POTENTIAL

Colombia's Caribbean coastline[4] has abundant, energetic offshore wind resources with a total technical potential[5] resource estimated[6] at 109 GW. Wind speeds, particularly in La Guajira region, consistently exceed 10 meters per second (see Figure ES.1) and the estimated net capacity factors for representative projects –how much electricity these could produce compared to their theoretical full potential – approach 70% and are among the highest in the world.

This coastline, however, features many protected areas, critical habitats, and environmental sensitivities. Its waters are used by commercial and artisanal fisheries, and onshore lands are important to indigenous communities. Furthermore, there are areas allocated for hydrocarbon activities, as well as routes heavily traversed by shipping. Analysis for this roadmap used existing spatial data to further characterize Colombia's offshore wind resources and these potential constraints to development. It assessed a wide range of environmental, social, and technical issues to identify technically attractive initial exploration areas that, based on the data available, are likely to have lower negative impacts associated with development.

Taking into consideration environmental, social, and technical constraints, the potential development is estimated at about 50 GW, equivalent to 2.8 times the total existing generation capacity in the country. Of the 13 initial exploration areas shown in Figure ES.2, five are in shallow water (<70 meters) suited to fixed-foundation offshore wind, representing over 27 GW of potential across 6,800 km2, and eight are in deeper water (+70 meters) suited to floating-foundation offshore wind, representing over 21 GW of potential across 5,400 km2 (See Table ES.1). Stakeholder engagement and further data will be required to better understand these areas; the roadmap recommends this as one of the priority next steps.

4. Typically, average wind speeds greater than 7 meters per second are required for economically viable offshore wind projects. Offshore wind resources in other parts of Colombia's waters, such as along the Pacific coast, are not as energetic as the Caribbean coast, so are not considered in this roadmap.
5. The offshore wind technical potential is an estimate of the amount of generation capacity that could be technically feasible, considering only wind speed and water depth. This is intended as an initial, high-level estimate and does not consider other technical, environmental, social, or economic constraints.
6. ESMAP (2020), Offshore Wind Technical Potential in Colombia https://documents1.worldbank.org/curated/en/719501586846928298/pdf/Technical-Potential-for-Offshore-Wind-in-Colombia-Map.pdf

FIGURE ES.1: MAP OF COLOMBIA'S OFFSHORE WIND POTENTIAL

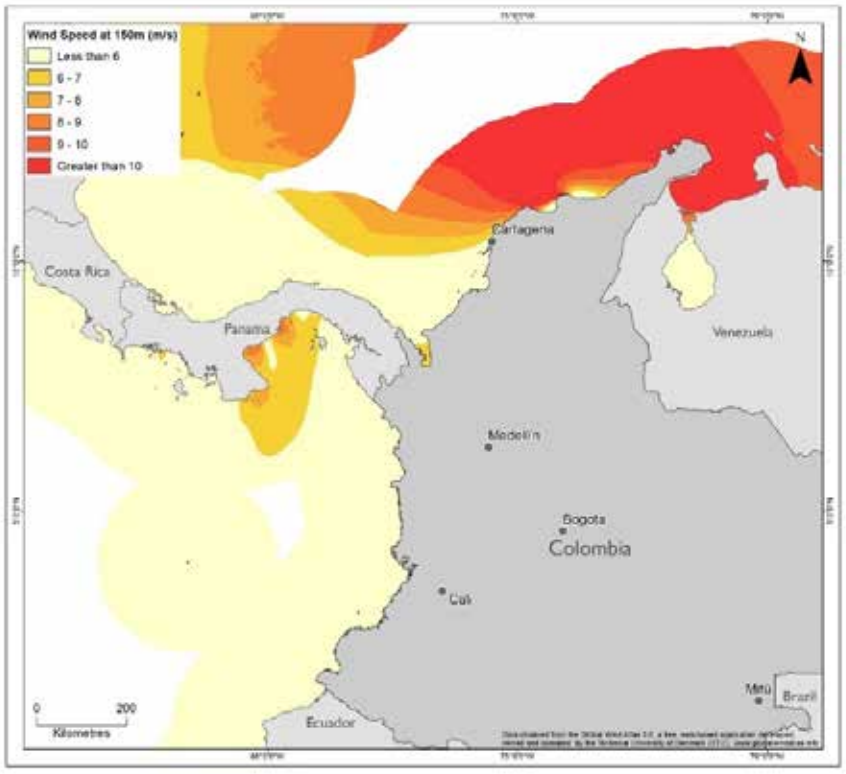


FIGURE ES.2: MAP OF INITIAL EXPLORATION AREAS FOR OFFSHORE WIND

TABLE ES. 1: OFFSHORE WIND DEVELOPMENT POTENTIAL IN THE INITIAL EXPLORATION AREAS

Site ID	Area (km2)	Nominal reference capacity (MW)
FX-1	550	2,200
FX-3	1,150	4,600
FX-4	1,400	5,600
FX-5	1,200	4,800
FX-6	2,500	10,000
Fixed Foundation Wind Potential	6,800	27,200
FL-1	350	1,400
FL-2	200	800
FL-3	200	800
FL-4	800	3,200
FL-5	1,550	6,200
FL-6	1,550	6,200
FL-7	350	1,400
FL-8	400	1,600
Floating Foundation Wind Potential	5,400	21,600
Reference Capacity Potential (MW)	**~50,000**	

Source: Author's estimate. Based on a nominal power density assumption of 4MW/km2 per WBG ESMAP.

SCENARIOS FOR OFFSHORE WIND DEVELOPMENT

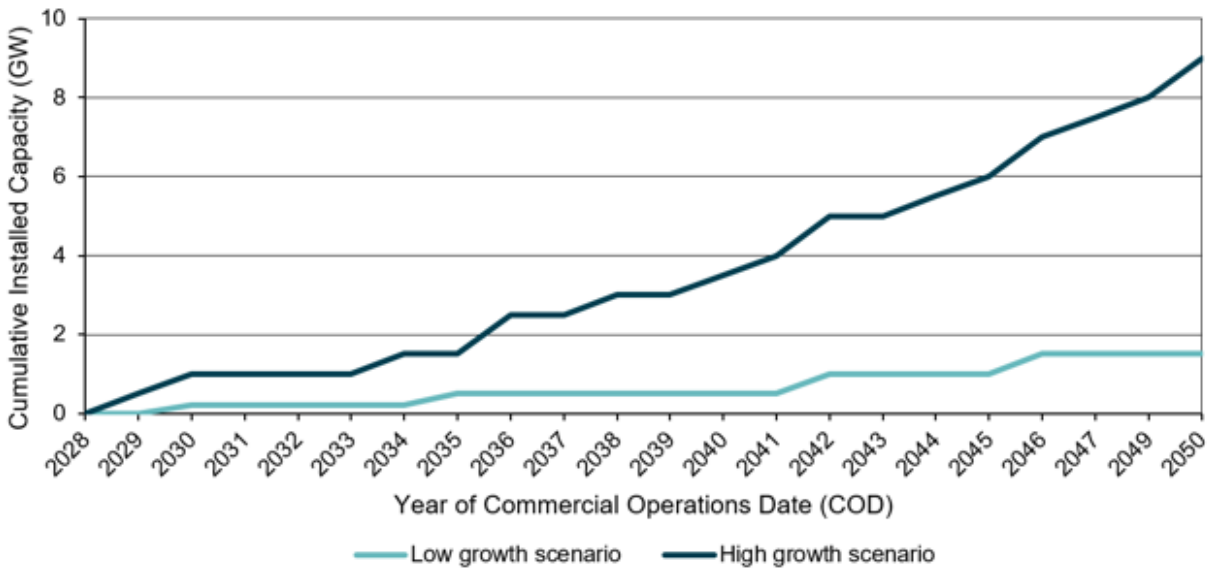
The analysis underpinning this roadmap is based on two possible growth scenarios for Colombia's offshore wind industry. The purpose of these scenarios is to be able to illustrate the potential effect of industry scale on cost, consumer benefit, environmental and social risks, and economic impact. The scenarios were not established (and have not been tested) through a least-cost power generation expansion exercise; the roadmap recommends this as another one of the priority next steps.

The two development scenarios are summarized as:

- **Low growth:** assumes that offshore wind is developed and procured in limited cases, with smaller project sizes (e.g. <500MW) and without a specific offshore wind national strategy or dedicated procurement program. This scenario can be achieved within the base-case transmission expansion plan, making use of connection capacity through business-as-usual grid reinforcements, and concentrating deployment closer to the load centers of Cartagena, Barranquilla, and Santa Marta. Under this scenario local economic benefits will be limited as there is insufficient scale to warrant substantial investment in the local supply chain. The small scale of projects and the requirement to import equipment and services, increases the cost of energy and limits the cost reduction potential. The cumulative deployment of capacity under this scenario is shown in Figure ES.3.

- **High growth:** assumes that offshore wind is developed on a large-scale, with large +1GW projects, through a dedicated technology-specific procurement program. Significant, and pro-active transmission upgrades will be required to make large capacity grid connections available, particularly in the La Guajira region. Under this scenario local economic benefits will be greater than the low growth scenario as the larger industry scale drives investment in the local supply chain. The larger scale of projects and use of local content, helps to reduce the cost of energy and drives down costs as the industry develops.

FIGURE ES. 3: CUMULATIVE OPERATING CAPACITY UNDER THE TWO SCENARIOS



The low growth scenario could be achieved with little action by the government other than to make minor modifications to existing regulations to enable the construction and operation of offshore wind in Colombia's waters. Under this scenario, offshore wind would only make a relatively minor contribution to Colombia's future energy mix, Therefore, large-scale (+17 GW) onshore wind and solar development would be required to achieve these targets.

The high growth scenario would require substantial government action to prioritize offshore wind development and establish a transmission development plan to connect the targeted capacity. These actions would provide the private sector with the certainty needed to invest and deliver large volumes of offshore wind, subsequently improving the cost competitiveness of electricity and generating substantial local economic benefits. More detail on the recommended actions is provided in the corresponding sections that follow.

These two scenarios are hypothetical and were devised to demonstrate the impacts of government policy and actions. Therefore, the actual volumes of offshore wind installed in Colombia will likely differ from these scenarios, both in terms of overall volume and phasing of installation. The high growth scenario should not be seen as a ceiling; should the government and other actors follow the recommendations in this roadmap, there is potential for offshore wind to far exceed this scenario.

CHALLENGES FOR DEVELOPING OFFSHORE WIND

This roadmap demonstrates that offshore wind could deliver substantial value to Colombia but that there are many challenges faced in establishing a successful industry at a large scale. Some of the main challenges include:

Cost of energy – purely on a levelized cost of energy basis, offshore wind is more expensive than NCRE such as onshore wind and solar PV, but can be competitive with the cost of conventional, thermal generation. Special treatment could be required– ideally by launching a technology-specific auction.

- **Scale** – to drive down the cost of energy, large capacity projects are required to achieve economies of scale. The large scale of these projects can pose numerous associated challenges, including the following two points.

- **Transmission** –Colombia's most energetic offshore wind resources are distant from major demand centers and will require lengthy new transmission lines and upgrades. In certain areas, close to some of the main demand centers on the Caribbean coast, short distances and existing transmission may already allow the connection of projects and could provide opportunities to deliver capacity in the short- to medium-term.

- **Environmental and social impacts** – with increased scale, the risks of adverse environmental and social impacts rise, especially when cumulative impacts from multiple projects are considered. Data,

stakeholder engagement, and careful marine spatial planning will be required to minimize environmental and social impacts.

- **Limited local supply chain** – although the comparative scale of the industry is large in the Colombian context, it is not large enough to establish a complete local supply chain. Thus, many components will need to be imported. The size of the market will determine the proportion of local content; with a larger market size attracting greater investment in the local supply chain and associated infrastructure (e.g. ports).

- **Financing and bankability** – while Colombia has experience in attracting large-scale, international financing for infrastructure projects, the high risks associated with offshore wind will require careful risk management and mitigation measures to ensure bankability and to minimize the cost of capital.

RECOMMENDED ACTIONS

From the analysis and findings of this roadmap study, we recommend 34 actions that are required to deliver the high growth scenario. Each of these recommendations is described in more detail in Section 3 of the full roadmap report and evidence is provided in the Supporting Information found within Sections 4 through to 12 of the roadmap.

The following points summarize the roadmap's 34 recommended actions, including 6 priority actions:

Vision and Volume Targets

1. MME to establish offshore wind vision and capacity targets for 2030 and 2040 informed by UPME's indicative generation planning. [Priority Action]

2. MME engage with international offshore wind community to provide orientation to local practices and encourage interest in the market. [Priority Action]

Planning, Leasing and Permitting

3. MinInterior to initiate stakeholder engagement to establish open dialogues with communities that will be impacted by the development of the offshore wind industry in Colombia.

4. DIMAR to lead the review of the Plan de Ordenamiento Marino Costero, government-led marine spatial planning (MSP), to analyze the compatibility of commercial offshore wind deployment with other sea users. [Priority Action]

5. Identify priority areas for commercial offshore wind deployment in Colombia.

6. ANLA to include the identified priority areas for commercial offshore wind deployment in the Regionalización exercise.

7. MinCultura and MADS to map protected landscapes to assist evaluating visual impact.

8. ANLA and MADS to publish general terms of reference for the development of the environmental and social impact studies (ESIA) for offshore wind projects.

9. MME and DIMAR to develop a pre-qualification standard prior to initiation of a Seabed Leasing competition for the interested developers.

10. DIMAR to define and administer the seabed leasing process, which shall be coordinated with the MME and UPME and shall award leases as part of a competitive process. [Priority Action]

11. DIMAR to re-evaluate the Maritime Concession regulation for non-conventional renewable energy.

12. MME to lead the work on the regulatory framework at Decreto/Ley level encompassing the process for offshore wind leasing, permitting, grid connection and support mechanisms in Colombia. [Priority Action]

13. Develop a centralized data portal to streamline the access and availability of the public to the existing public-domain information held by the different government entities.

14. Encourage joint government-industry collaboration efforts to target strategic offshore data collection, including environmental, biodiversity and social baseline surveys, seabed and metocean measurements including wind resource.

Grid Connection and Transmission Planning

15. UPME to formulate grid expansion plans in alignment with the vision and capacity targets announced for offshore wind and the priority areas identified for this technology in the MSPs.

16. Grid connection requests shall become an integral part of the permitting process for offshore wind projects, which shall also help prevent speculation.

Port Infrastructure

17. DIMAR and MinTransporte, through the Agencia Nacional de Infraestructura (ANI), to evaluate development and investment needs of the local port infrastructure.

18. Assess the suitability of existing shipyards for; staging and assembly activities; the fabrication of offshore substation topsides and foundations; and servicing offshore supply and construction vessels.

19. Develop policies to encourage offshore wind industrial clusters to be created and evolve around selected ports.

Supply Chain development

20. MME to enhance local supply chain development by mechanisms such as fiscal incentives.

21. MME to engage with export credit agencies (ECAs), such as Denmark's Eksport Kredit Fonden, UK Export Finance and Germany's Euler-Hermes, who can offer trade finance and other services.

22. MinTrabajo and MME to assess the potential transferability of local industries to offshore wind.

23. Create networking opportunities for local supply chain to identify synergies and establish alliances to help promote the local supply chain development for the offshore wind industry.

24. Undertake a supply chain readiness assessment and create a supply chain database to help understand the skills of current and potential future suppliers.

Financing

25. Initiate contacts with experienced international financers to help the government understand lender requirements for offshore wind.

26. Create incentives to increase participation of the Colombian banking sector in the financing of offshore wind projects.

27. Leverage concessional finance programs and partnerships to reduce cost of financing.

Offtake and Revenue

28. MME to analyze potential offtake and revenue support mechanisms most suitable for offshore wind projects to provide long-term visibility and certainty on revenues. [Priority Action]

29. MME to decide on the process to award offtake agreements, which shall include the type of support mechanism chosen and when in a project's development process it will take place.

30. MME to assess the synergies between offshore wind and green hydrogen generation guided by Colombia's Hydrogen Roadmap.

31. CREG to evaluate the viability of awarding Firm Energy Obligations (OEF) to future offshore wind projects under the existing Reliability Charge mechanism (Cargo por Confiabilidad).

Health, Safety and Training

32. MinTrabajo and MME to develop health and safety (H&S) guidelines and training to promote the safe start of the offshore wind industry.

33. Review national safety legislation and perform a gap analysis to integrate other widely adopted international standards for offshore wind H&S.

34. MME to facilitate training in offshore wind project development for personnel in the governmental agencies responsible for developing the regulatory framework required for offshore wind.