Technology costs for the first wave of wind farms in Vietnam: Paying extra for better wind nearshore

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Abstract

Technology analysts often dichotomize wind power projects as onshore vs offshore. They neglect nearshore projects installed in the intertidal flats. We explore the characteristics of this intermediate category using an original sample of Vietnam's wind power projects for the 2018-2021 period. The median investment for onshore wind power projects in Vietnam is 1 695 USD/kW. It is 2 011 USD/kW for nearshore projects. Nearshore wind-power generation capacity requires about 20% more investment per MW than onshore, inter-quartile range of 0% – 45%. Nevertheless, nearshore projects remain much less capital-intensive than far-offshore projects – projected at 3 150 USD/kWh in Vietnam based on experience in OECD countries with fixed-bottom projects. Escaping the onshore vs offshore dichotomy allows us to consider a different policy direction for the industry. Rather than pursuing bluefield mega-projects far offshore, a "small steps" policy to extend nearshore wind farms may be cheaper, faster, and more institutionally feasible.

Keywords

Energy policy; Wind power; Nearshore; Investment cost; Vietnam

JEL Classification codes

Q42; D24

Highlights

- We observe a quasi-cross-sectional sample of wind power projects in Vietnam.
- Fifty-four projects are neither onshore nor offshore but nearshore in shallow waters.
- The median investment for onshore wind power projects in Vietnam is 1 695 /kW.
- The median investment for nearshore wind power projects in Vietnam is 2 011 USD/kW.
- Nearshore wind power requires 20% (IQR 0%-45%) more investment than onshore.

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1. Introduction

According to REN21 (2022, p. 145), additions of new wind power generation capacity reached about 102 GW worldwide in 2021, including more than 83 GW onshore and almost 19 GW offshore. The REN21 also reports that "*By year's end, total global wind power capacity rose 13.5% over 2020 to surpass 845 GW (791 GW onshore and the rest offshore)*". But should we take for granted that the wind industry should be organized into only two sectors: onshore and offshore? How about nearshore wind power projects, those built on intertidal flats or close to the coastline? This short communication shows the importance of nearshore wind projects in the case of Vietnam and characterizes their difference from the other two categories.

(EREA and DEA, 2021, p. 90) defines nearshore wind farms as those built in waters below 20 m in-depth and a distance to shore less than 50 km. Wind farms located in the intertidal zone, for example, are nearshore.

They have pros and cons compared to onshore or offshore ones. Winds over the sea tend to be stronger and more regular than over the continent. Land use and terrain constrain less the project design. Machines can be accessed on foot from the shore at low tide. Access to the wind turbines at high tide remains possible with a causeway. While access to nearshore stations by sea is more straightforward than reaching remote hilltops by road, the build requires specialized barges and is more at risk from weather. Undeveloped tidal areas can have more biodiversity than open sea or anthropized land surfaces. Erecting towers on wet sand is more complicated than on solid rock. Furthermore, as the electric grid mostly runs over land, nearshore projects may be further away on average, so building the connection line can be more expensive.

This letter presents a comprehensive historical sample of Vietnam's wind power industry, which ranked fourth globally in 2021 for capacity additions (REN21, 2022, p. 148). Then we compute the nominal investment costs of projects in USD per kW of installed capacity onshore and nearshore in Vietnam. Our estimate of the investment cost per kWh onshore is another data point in the literature on wind technology cost. We then show that projects nearshore are significantly much more investment intensive per kWh than projects onshore. They are a distinct category not only from an engineering perspective but also from an economic perspective. Our estimate of nearshore wind power technology cost fills a gap in the literature, undoubtedly caused by the scarcity of nearshore projects in western countries. The final section compares our results to previously published estimates. We conclude with an example of a policy question showcasing the relevance of a three-way categorization of wind projects for Vietnam's market.

2. Dataset

We extracted the sample from the Vietnam wind power dataset described in a companion data paper (Ha-Duong, 2021), summarized in Table 1. The key features of the source dataset are:

- It aims to provide a comprehensive historical record of the wind power sector in Vietnam.
- It has investment costs for all projects currently in operation or at the implementation stage.
- It includes projects onshore, offshore and nearshore.
- Publicly available sources justify all records (see columns Z to AL in the dataset).

Most projects in our dataset aimed for commercial delivery in October 2021. That makes our sample quasi-cross-sectional. Unlike in many countries, where renewable energy sources have entered the market progressively over many years, the expansion of wind power in Vietnam fits better as a step function than an exponential. In September 2018, after fifteen years of trials with negligible installed capacities (about 150 MW for the whole country), the government revised the feed-in tariff (Nguyễn, 2018, p. 39), and three years later, more than 4 GW were delivered by October 2021 (Do et al., 2021). Table 1 shows Vietnam has 3 791 MW of commercially operational onshore wind power plants and 1 072 MW nearshore.

We selected projects with more than 5 MW capacity for which the "location type" and "investment cost" fields were available for this study. This criterion includes all projects at the Operation and Implementation scale. The sample, shown in Figure 1, comprises 132 onshore, 54 nearshore, and 16 offshore records. Projects cluster at 30 MW, 50 MW and 100 MW. The 30 MW level is a regulatory threshold. The 50 MW and 100 MW projects are mostly phases of a larger project implemented sequentially. Figure 1 shows that nearshore projects (yellow stars) have higher investment costs per MW of generation capacity than onshore projects (green dots). Only one offshore project (blue disc) is visible in the figure because most are above 300 MW capacity and thus outside the plot area (see Figure 2).

Table 1: Wind power industry projects pipeline in Vietnam, October 2022. Source author (Ha-Duong, 2021).

Number of projects Total nameplate capacity	Onshore	Nearshore	Offshore	***Total***
D – Operation (Licensed to generate electricity)	70 3 791 MW	21 1 072 MW		***91*** ***4 862 MW***
C – Implementation (PPA signed, construction permitted)	34 1 977 MW	24 1 420 MW		***58*** ***3 252 MW***
B – Development (Decision on Investment granted)	27 2 341 MW	17 1 738 MW	2 700 MW	***46*** ***4 779 MW***
A – Preliminary (Site exclusivity letter signed)	102 8 684 MW	25 3 114 MW	36 38 062 MW	***157*** ***49 860 MW***
Total	***231*** ***16 793 MW***	***83*** ***7 343 MW***	***38*** ***38 762 MW***	***352*** ***62 898 MW***

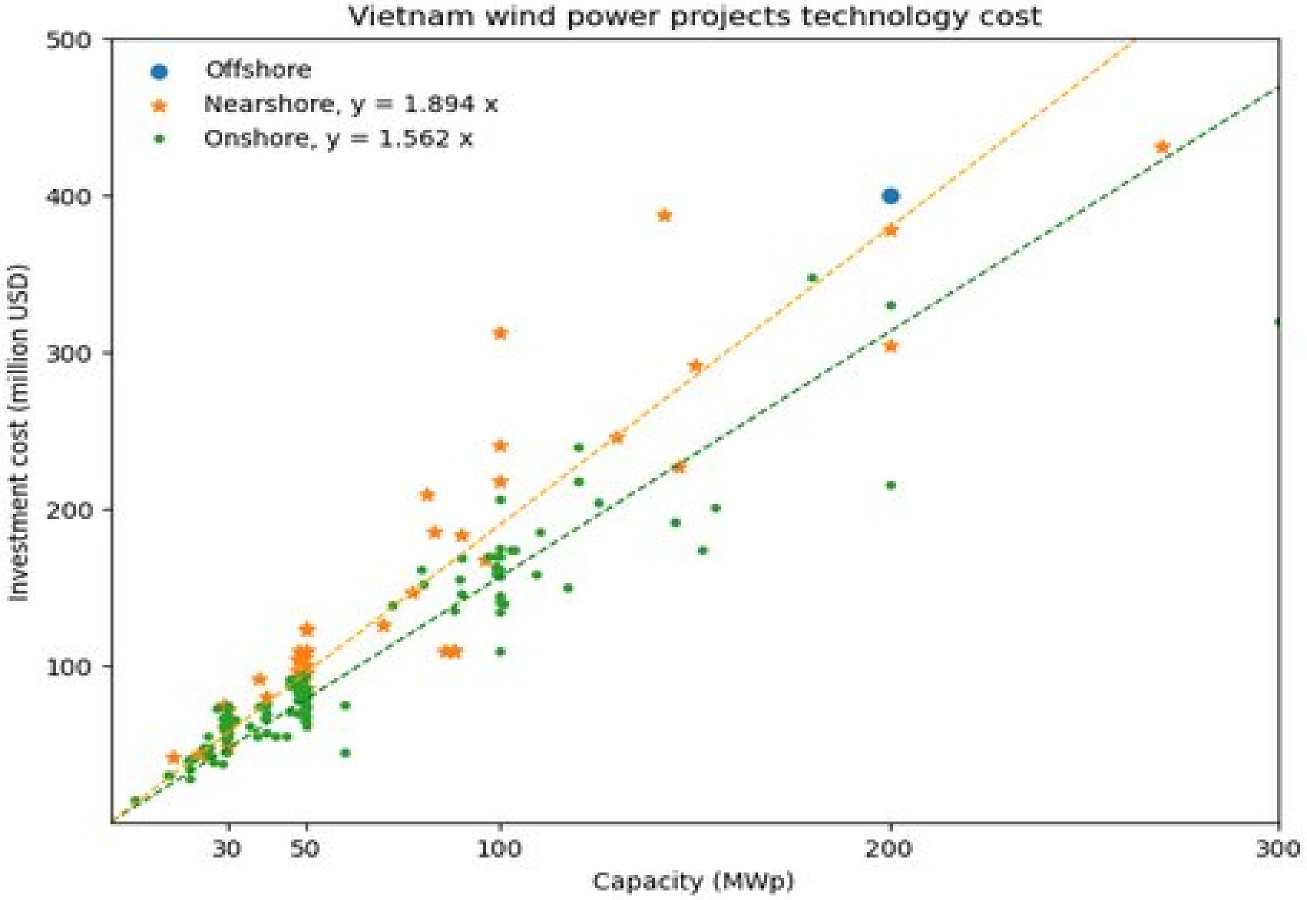

Figure 1: Cost and capacity of wind power projects in Vietnam. Source: Author

3. Results

We define "technology cost" as a project's investment cost divided by its installed capacity: a standard energy economics metric that drives electricity production costs for electricity generation technologies that do not use fuels. Results are in current USD around 2019 when the projects investment certificates were granted, they do not reflect the 2021-2023 inflation.

Figure 2, top panel, compares the three types of wind power projects in terms of technology cost. The median technology cost for an onshore project is 1 695 USD/kWh (interquartile range 1 483 – 1 901). The median technology cost for a nearshore project is 2 011 USD/kWh (interquartile range 1 800 – 2 207). The difference between the distribution of nearshore technology costs and onshore technology costs is statistically very significant (Mann Whitney U test $p = 5.2\ 10^{-8}$, Kolmogorov Smirnov test $p = 5{,}0\ 10^{-8}$).

The middle and bottom panels in Figure 2 show that the distribution of nearshore projects is similar to that of onshore projects in terms of installed total capacity and total investment cost. The joint analysis on the top panel shows that nearshore projects tend to be more investment intensive. How much more intensive? We used three approaches to answer.

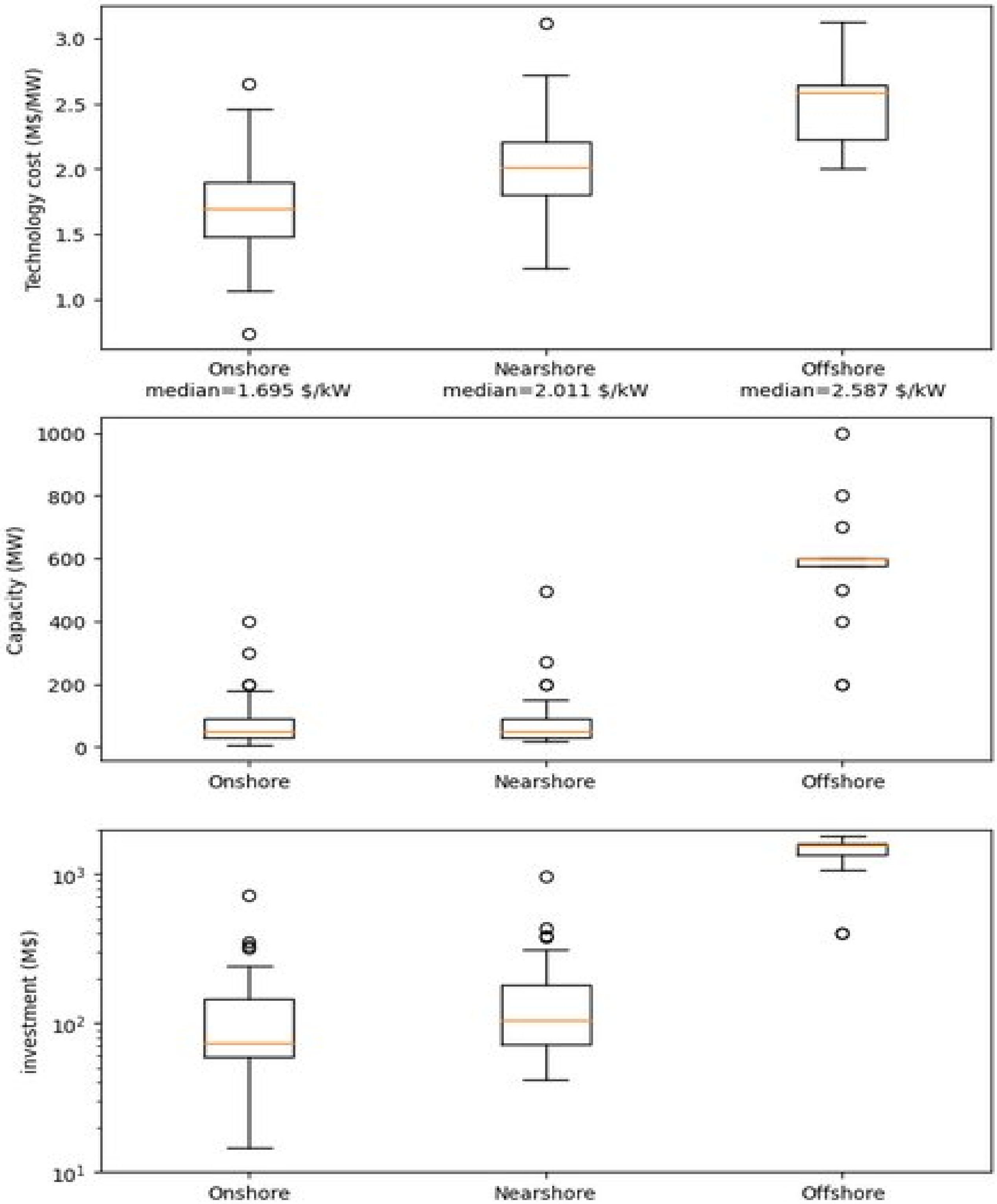

Figure 2: Distribution of wind power project characteristics for different location categories in Vietnam. Top: Technology cost in M$/MW. Middle: Capacity in MW. Bottom: Investment in M$. Source: Author.

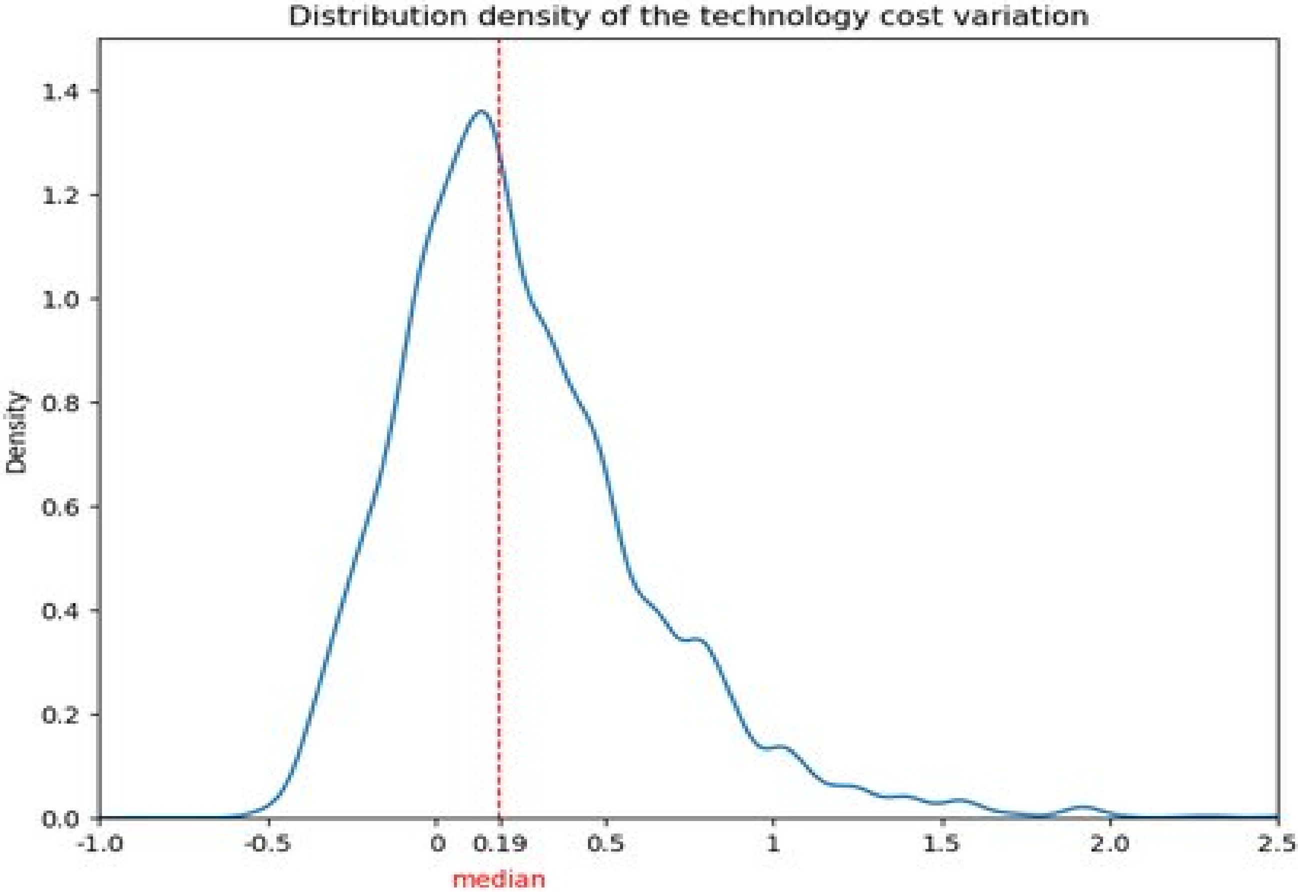

Figure 3: Monte Carlo analysis of the cost variation between a kW of wind power generation capacity installed nearshore versus onshore in Vietnam. Source: Author

The first is to compare the slopes when explaining investment (in M$) by capacity (in MW); see Figure 1. The intercept is insignificant for the nearshore ordinary least squares regression model, so we omit it in both models for simplicity.

Onshore projects: Investment = 1.562 * Capacity

Nearshore projects: Investment = 1.894 * Capacity

The regression approach suggests that the extra technology cost is 21%, the relative variation from 1.562 to 1.894.

The second is to compare median technology costs, see Figure 2. Nearshore is more expensive by 19%, the relative variation from 1 695 USD/kWh to 2 011 USD/kWh.

Third, we recognize that the answer to the question "How much more investment per kWh does a wind power project needs nearshore compared to onshore?" is probabilistic. We empirically estimated the relative variation distribution using the Monte Carlo method. The procedure was to repeat 30 000 times: draw one random MW onshore and one random MW nearshore and then compute their relative cost variation. Figure 3 shows the probability density distribution of the outcome. The median technology cost ratio is 19%, and the average is 25%. The inter-quartile range of 0% - 45% means that the nearshore project requires more investment per kWh than the onshore project three times out of four and that one time out of four, the extra was over 45%.

4. Discussion and concluding remarks

Our sample found that wind power requires about 20% more investment per kWh nearshore than onshore. Within each technology, the variability of costs between projects was greater than the difference across the two technologies. The median technology cost among the 132 onshore wind power projects started in Vietnam around 2018-2019 was 1 695 USD/kW of generation capacity. The median for 54 nearshore projects was 2 011 USD/kWh.

These cost estimates are in line with previously published results. REN21 (2019, p. 131) reports that onshore wind power technology cost for projects commissioned in 2017 was, on average, 1 173 USD/kW for China (min-max range 1 099 – 1 261). We conjecture that projects in Vietnam were more expensive because, despite four years of technological progress, the market was less mature, projects were smaller sized, used imported turbines and went to hilltops instead of flatlands in China. REN21 reports a technology cost of 2 237 USD/kW for Asia, excluding China and India (min-max range 1 783 – 2 565), which exceeds our results for Vietnam. Unsurprisingly, costs observed in Vietnam were higher than in China but lower than in wealthier countries like Japan, Thailand, South Korea and Taiwan.

Lundsager, Nguyễn, and Togeby (2019) published a Vietnam-specific official technology catalogue based on engineering and analogues. They estimate (page 63) the technology cost for wind power onshore in 2020 to be 1 600 USD/kW (uncertainty range 1 400 – 2 000). This number declined to 1 500 USD/kW in the 2021 technology catalogue update (EREA and DEA, 2021). Our econometric estimate for onshore projects is very close to theirs.

We need more time to observe a putative profitability differential between onshore and nearshore wind farms. Income is the product of the quantity sold times the price. In Vietnam, the feed-in tariff for wind power was 8.5 UScent/kWh for projects on land and 9.8 UScent/kWh for projects on the sea (Nguyễn, 2018). The government defined the latter as *"Projects with wind turbines constructed and operated offshore - outside the lowest mean high water for many years (18.6) years."* Thus, nearshore wind projects have a better income than onshore because of a better capacity factor and a 15% better tariff.

Figure 2 shows that offshore projects differ from the rest in two aspects, their size and their investment costs. One is 200 MW, and all others are 400 MW or more. Our sample's offshore project did not intend to meet the end of October 2021 deadline. Thus, the announced investment costs for offshore recorded in our dataset are aspirational. Critical project parameters, such as financial market rates, the responsibility for the power line to the shore or the local contents requirements, are unknown. It is too early to discuss empirical estimates of offshore wind project costs in Vietnam.

In front of the low reliability of our 2 587 USD/kW median investment cost for offshore, we turn to the 2021 technology catalogue (EREA and DEA, 2021, p. 106). The catalogue reports offshore wind power technology costs of 3 150 USD/kW (fixed-bottom), compared to 2 000 USD/kW for nearshore (op. cit. p. 105). The cost is comparably higher than in Europe or the US, as Vietnam has yet to install its first far offshore project. Contingent on learning-by-doing, the offshore wind investment costs in Vietnam could catch-up with the industry's norms elsewhere, declining to 2 150 USD/kW by 2030 according to the technology catalogue.

To conclude, here is an example to illustrate that reasoning only in the traditional onshore vs offshore dichotomy is insufficient to analyze the sector's dynamics in Vietnam. Major international players seek to enter the market with far-offshore mega-projects. Enterprize has a 3.4 GW proposal in Kê Gà, CIP 3.5 GW in La Gàn, Ørsted 3.9 GW in Hải Phòng. These are greenfield –more aptly named "bluefield"– mega-projects. The oil and gas industry history show that developing offshore mega-projects in Vietnam is politically tricky and subject to a high risk of delays. Vietnam is not institutionally ready to give a FIT to GW-scale offshore wind farms. Expanding from nearshore projects may be a more feasible business plan. For example, the Mainstream project in Phu Cuong starts with a 200 MW phase 4km from the coast. It does not push the envelope compared to existing nearshore wind farms. Progressive extension of nearshore projects may be easier to finance, faster to build, and a better fit in a technology-neutral renewable energy auction scheme than offshore wind proposals.

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Data availability statement

The data supporting this study's findings are available in the *Zenodo* repository at DOI http://doi.org/10.5281/zenodo.3698080 (latest version). This supplementary material includes the dataset spreadsheet, the data paper describing the dataset, and the source code for the table, figures and other statistics presented in this paper.

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