OFFSHORE WIND: CAN LEARNING BE ASSUMED?

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Overview

The Norwegian government aims to allocate area on the Norwegian Continental Shelf (NCS) for companies to commission 30 GW of offshore wind by 2040. For context, this will double the aggregate electricity generation in Norway – around 140 TWh. Recent analyses suggest that the net present value (NPV), i.e. the business economic profitability, of bottom-fixed offshore wind farms is strained (Osmundsen et al., 2024), and that the levelized cost of electricity (LCOE) is high. To ensure the interest of companies, subsidies have been offered. The first project, Sørlig Nordsjø II is subject to a contract for difference strike price of 115 øre/kWh for up to 23 billion NOK.

The Norwegian Water Resources and Energy Directorate (NVE) assumes LCOE of offshore wind farms will decrease in the years to come due Wright's law or the learning curve. This has likely contributed to politicians such as the Minister of Energy of Norway – Terje Aasland – to expect upcoming projects to be profitable and not in need of subsidies. Without cost reductions, the ambition of 30 GW is unlikely to be realized. This begs the question, how likely are cost reductions?

Despite the importance of this assumption, it is largely lacking in its documentation. NVE, the primary provider of analyses for political decision-makers, base their assumption of decreasing costs on a report by the consultancy company AFRY. In a similar manner, AFRY is also assuming a learning curve a priori, and provides a reference to the consultancy company DNV. DNV establishes a learning curve by surveying the beliefs of individuals in the industry.

Expert opinion is a commonly applied methodological approach in the absence of any empirical data. However, there are 39 wind farms constructed on the United Kingdom Continental Shelf (UKCS) over the span of over two decades. To complement the expert opinion surveys, we conduct an econometric analysis of the drivers of CAPEX/MW in offshore, bottom-fixed wind farm in UK from 2000 to 2023 in order to determine the elasticity of the learning curve. Research of this type is scant. To the best of our knowledge, only one prior study can be found on the topic (Dismukes and Upton, 2015), which found no evidence of a positive learning rate. We build on the works of Dismukes and Upton (2015) by using a lager dataset for UK. With this larger sample, we are able to run a more rigorous econometric analysis.

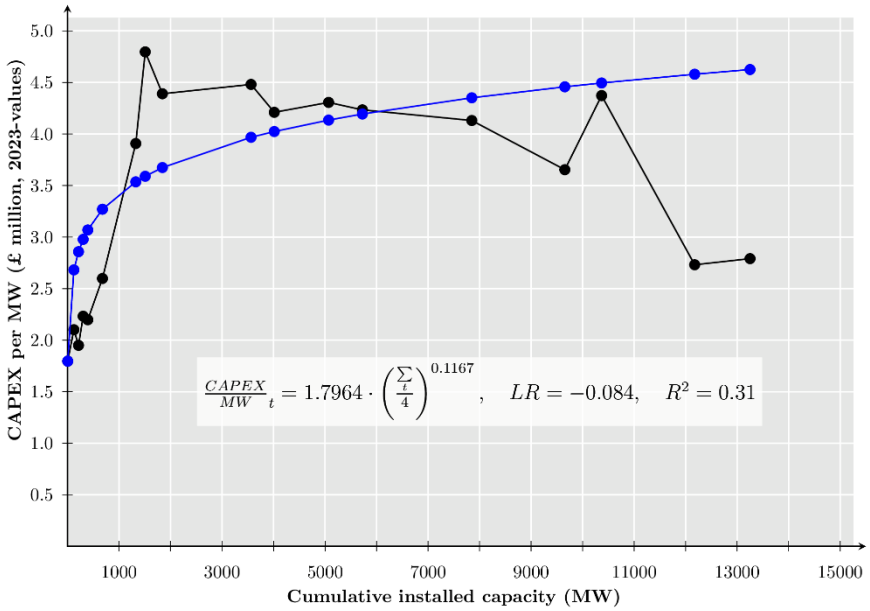
Methods

Our regression model includes four variables: water depth – a well-known cost driver (Ioannou et al., 2018), the installed capacity of the wind farm to capture the effect of economics of scale, the capacity of the wind turbine generators as proxy for technological innovation (Lorentzen et al., 2024), and the cumulative installed capacity to capture the learning-by-doing effect (Wright, 1936).

$$CapacityUnitCost_i = \beta_0 + \beta_1 WaterDepth_i + \beta_2 WindFarmMW_i + \beta_3 TurbineMW_i + \beta_4 Experience_i + \varepsilon_i \quad (1)$$

Results

The model has a R-sqr of 0.65 and all variables are statistically significant at a 5%-level. Conforming to the findings of Ioannou et al. (2018), increased water depth increases costs and increased turbine capacity decreases cost. Dismukes and Upton (2015) found economics of scale but failed to identify any learning effects. Quite on the contrary, they found a negative learning rate. Similarly, we find evidence of economics of scale and negative learning rate. In other words, two of the variables tend to decrease the costs and two variables tend to increase cost. As shown in the figure below, when the sample is viewed as a whole, the cost increasing factors has dominated.



Our analysis indicates that learning and effects and technological advances have dominated maturity on the NCS, so that the technical success rate is still increasing.

Conclusions

Our findings demonstrate that cost reductions from learning-by-doing, i.e. the learning curve or Wright's law, cannot be assumed. UK experienced cost escalations from 2000 to 2009. Afterwords, a stable cost level from 2009 to 2021 was observed – somewhat declining, but statistically insignificant. From 2021 to 2022 a major cost reduction was observed. In the final year of the sample, a minor uptick in cost is observed and preliminary data suggest that costs for 2024 are also higher. Despite period of cost reductions, the cost level at the end of the sample is higher than at the beginning of the sample. Wright's law is not a scientific law, it is an economic law – a stylized fact. With proof by contradiction, we show that Wright's law cannot be taken for granted.

References

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