Technical University of Denmark

Nearshore Versus Offshore: Comparative Cost and Competitive Advantages

Klinge Jacobsen, Henrik; Hevia Koch, Pablo Alejandro; Wolter, Christoph

Published in:
I A E E Energy Forum

Publication date:
2016

Document Version
Publisher's PDF, also known as Version of record

Citation (APA):
Klinge Jacobsen, H., Hevia Koch, P. A., & Wolter, C. (2016). Nearshore Versus Offshore: Comparative Cost and Competitive Advantages. I A E E Energy Forum, (Bergen Special 2016), 17-19.

Nearshore Versus Offshore: Comparative Cost and Competitive Advantages

By Henrik Klinge Jacobsen, Pablo Hevia-Koch and Christoph Wolter

Henrik Klinge Jacobsen, Pablo Hevia-Koch and Christoph Wolter are with the Technical University of Denmark, DTU Management Engineering, Systems Analysis Division, Denmark, jhja@dtu.dk,

BACKGROUND

Currently there exist high expectations for the development of wind energy, particularly in Europe, out of which offshore wind turbine developments will be central as tools to achieve current energy targets. The choice between nearshore and (far)-offshore is particularly relevant, both because of increased public resistance due to visual disamenities produced by nearshore projects, and because of the potential cost reduction benefits attained by building wind farms closer to the shore.

Based on this need, an analysis of the differences between costs and cost drivers for both offshore and nearshore is needed, as well as an exploration towards other possible factors that might affect the relative advantage of nearshore compared to offshore projects. We compare Danish nearshore sites with further ashore wind potentials in Denmark and elsewhere. Costs for nearshore are expected to be lower due to fewer costs of connection, foundation, and to some extent, operation and maintenance. These lower costs must be balanced by the less favourable wind conditions and the costs associated with public resistance. Carefully selecting the nearshore sites with low resistance and low cost characteristics can hopefully reduce the cost of expanding the offshore wind capacity in Denmark where there is a considerable amount of coast line compared to the area of the country.

METHODS

We define nearshore wind as turbines that are up to 15 km off the coast. The distance is not the only important cost driver, but it is the attribute related both to cost advantages for nearshore development and disadvantages arising from public preferences against close to shore wind turbines. We begin by analysing the main cost drivers for offshore wind turbine projects, disaggregating by variables including site conditions (wind potentials, distance to shore, depth of sea bed) and construction variables (size of wind turbines, capacity, foundation). Then we compare the influence of the most important drivers for both offshore and nearshore projects. Based on some Danish nearshore sites we examine the cost ranges and compare to the cost range from comparable further ashore sites in Denmark.

To quantify the potential cost advantages, we use one international source (EEA, 2009) that provides scaling factors based on only distance to shore and water depth. We then recalculate and calibrate based on investment data from one Danish wind farm.

Water depth\ Distance from shore	4 km	8 km	10 km	12 km	15 km	20 km	25 km
5m							
10m	0.967	0.974	0.978	0.982	0.988	0.998	1.008
15m	1.000	1.008	1.012	1.016	1.022	1.033	1.043
20m	1.034	1.042	1.046	1.050	1.056	1.067	1.078
25m	1.067	1.075	1.080	1.084	1.090	1.102	1.113
30m	1.124	1.133	1.137	1.141	1.148	1.160	1.172
35m	1.237	1.247	1.252	1.257	1.264	1.277	1.290

Table 1 Investment cost scaling factors used for DK comparison
Source: Calculated based on EEA, 2009 (Table 6.4)

FINDINGS

Denmark is probably positioned in the low end of the international average cost for off-shore wind development. This is evident from a comparison of levelised cost of offshore wind energy (LCOE) including projections from major agencies and associations in the wind sector. In Figure 1 we compare cost levels across the projections of several reports. The wideness of the cost range for each source reflects both the uncertainty in technology development and the underlying difference in cost driving characteristics within the area examined (country/region). The Danish Energy Agency numbers and forecasts are at the lowest level compared to the levels provided by other sources. Therefore, we must expect that the cost benefits from moving wind farms from average off-shore to nearshore locations in Denmark is less than for most other countries (in line with the generally shallow seabed conditions in Denmark).

The cost projections in Figure 1 assume a considerable cost reduction over time, but it is

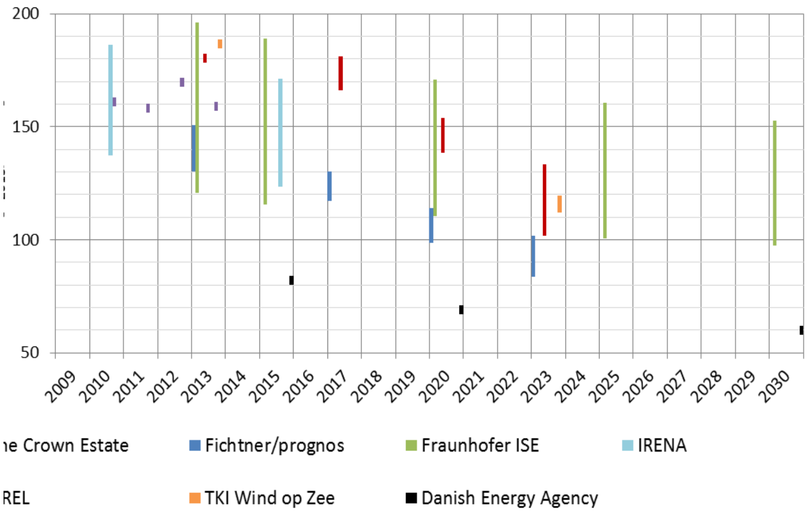

Figure 1 Comparison of levelised cost estimates and ranges for offshore wind in the literature

not clear whether this is expected to cover mainly the far off-shore projects in deeper waters. If cost decreases are expected to be dominated by foundation technology improvement and installation cost reductions, then the nearshore projects may benefit less and thus the relative cost advantage of nearshore wind will decline over time.

The ability to generalise the cost curves from a Danish sample of nearshore wind farm sites, was investigated but it is very difficult to characterise other potential sites in DK depending on the few cost drivers that can be extracted from existing developments/projects. The historical data are covering many years and a tremendous development in turbine size and technology. The amount of local conditions affecting the optimal farm layout, seabed characteristic differences and connection costs seems to dominate the generalizable cost drivers. The connection costs for example vary more among nearshore Danish sites than between average nearshore and average offshore DK sites.

However, we illustrate the potential cost advantage based on one of the international sources of cost drivers (EEA, 2009). We calibrate the scaling factors from Table 1 to one particular Danish wind farm development (Rødsand II, 2010) and then compare to other Danish wind farm developments.

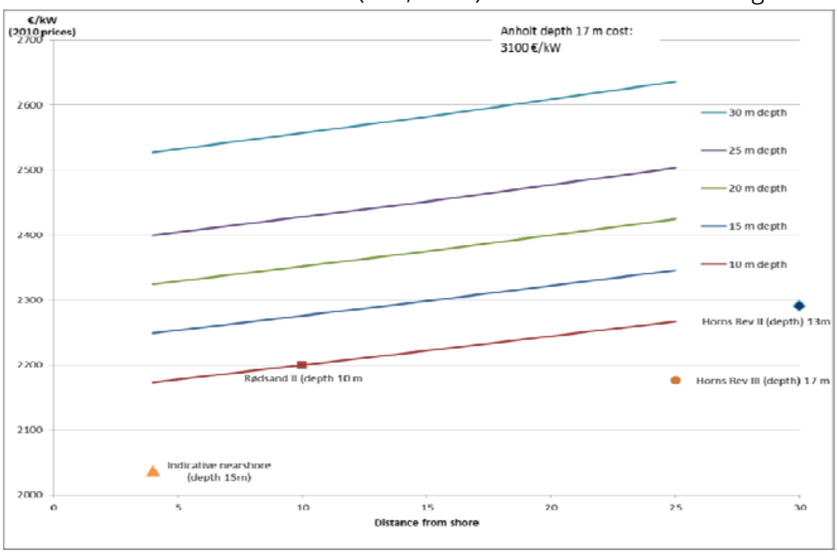

Figure 2 Investment cost illustration for DK in 2010 with indicative benefit (Based on investment cost for Rødsand II and EEA scaling factors in Table 1)

The shares of cost components are different for near-shore and far offshore wind farms, but the cost drivers are basically the same. Connection cabling, as well as installation (and mostly foundations) represent a smaller cost share for nearshore wind, but due to the more varying local conditions for connection, the distance from shore is less important as cost driver compared to the depth. The sea depth and wind conditions are the main drivers, similar to far offshore, and the turbines/steel costs are providing similar cost impacts for the two categories. We therefore chose to illustrate a potential cost advantage based on two cost drivers only as given in Table 1.

The illustration for potential benefits in DK clearly shows that the main cost benefit will be achieved if it is possible to reduce the water depth by locating the wind farms closer to shore (moving left and down in the figure). If water depth is not reduced, then the cost reduction of moving from a location similar to Horns Rev III to a location just 4-5km from shore will be only 4% (just moving left). If conditions regarding water depth like Horns Rev III (approx. 17m) are very scarce, the relevant comparison might be between average water depths of 25m versus water depths similar to some DK nearshore sites, of around 15m. The benefit in this case will be around 10% reduction of CAPEX

CONCLUSIONS

Nearshore wind potentials exist in Denmark, and they have potentially lower costs than further offshore, but the cost advantage is probably lower than in other countries, because offshore costs are comparatively lower in Denmark due to shallow waters. The nearshore potentials are smaller, and possible wind farm sizing is also limited for some sites in Denmark. However, there are still potentials with lower costs than further ashore sites. It is difficult to identify one main contribution as e.g. more shallow water as the source of expected lower costs based on a small sample of data examined for Denmark. Significant cost advantages are however only expected if water depth is considerably lower than at more offshore sites.

An illustrative calculation of benefits indicates that cost could be only 4% lower nearshore if no reduction in water depth is achieved. Compared to this, moving from 25 km distance at the same time as reducing water depth from 25m to 15m may provide cost reductions of around 10%.

Finally, the smaller possible size of the projects may facilitate more competition, especially from domestic developers, but it may also lead to less participation from the global offshore developers that exploit economies of scale in wind farms. If dominated by the first, this produces a more competitive environment for the bidding process of the smaller nearshore projects that may allow new entrants into the offshore development and eventually pushes for lower prices.

References

Fichtner, P. (2013). *Cost Reduction Potentials of Offshore Wind Power in Germany.* Retrieved from http://www.offshorestiftung.com/60005/Uploaded/SOW_Download%7CStudy_LongVersion_CostReductionPotentialsofOffshoreWindPowerinGermany.pdf

Fraunhofer ISE. (2013). *Levelized Cost of Electricity Renewable Energy Technology.* Retrieved from https://www.ise.fraunhofer.de/en/publications/veroeffentlichungen-pdf-dateien-en/studien-und-konzeptpapiere/study-levelized-cost-of-electricity-renewable-energies.pdf

IRENA. (2012). *Renewable Energy Technologies: Cost Analysis Series* (Vol. 1).

Kitzing, L & Morthorst, PE 2015, 'Trends in offshore wind economics – the past and the future'. in Proceedings - 14th Wind Integration Workshop.

The Crown Estate. (2012). Offshore Wind Cost Reduction Pathways Study. Retrieved from http://www.thecrownestate.co.uk/media/5493/ei-offshore-wind-cost-reduction-pathways-study.pdf

EEA. (2009). Europe's onshore and offshore wind energy potential. EEA Te**chnical report (Vol. 6). http://doi.org/10.2800/11373**

Rolf Golombek, Finn Roar Aune and Hilde Hallre Le Tissier (continued from page 12)

References

Aune, F., R. Golombek, S. A. C. Kittelsen and K. E. Rosendahl (2008). *Liberalizing European Energy Markets: An Economic Analysis.* Cheltenham, UK and Northampton, US. : Edward Elgar Publishing.

Aune, Finn Roar, Rolf Golombek and Hilde Hallre (2015), "Phasing out Nuclear Power in Europe", *CESifo Working Paper No. 5403, June 2015.*

Brekke, K.A., R. Golombek, M. Kaut, S. Kittelsen and S. Wallace (2013): *The impact of uncertainty on the European energy market: The scenario aggregation method*. CREE working paper 4/2013.

Golombek, R., K. A. Brekke and S.A.C. Kittelsen (2013): Is electricity more important than natural gas? Partial liberalizations of the Western European energy markets. E*conomic Modelling*, 35, 99-111.

LIBEMOD (2014). Documentation of the model and data sources. http://www.frisch.uio.no/ressurser/LIBEMOD/