Memo

To Danish Energy Agency (DEA), hoeringenergioe@ens.dk

Reg. Public Consultation on the Economic Aspects of the Energy Islands[1]

From Christian Poll, representing the Sustainability Division at DTU Management

Response from DTU Management to the public consultation on the economic aspects of the energy islands

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The Technical University of Denmark - Department of Technology, Management and Economics - Sustainability Division thanks for the opportunity to respond to this consultation. We hereby present our comments based on selected knowledge in the division. The response covers only the division's expertise and is not coordinated with possible responses from other departments of DTU.

The following scientific staff have provided input to the response:

- Dogan Keles, professor, Head of Section, dogke@dtu.dk
  (covering energy prices, long-term supply curve, concepts for energy infrastructure)
- Marie Münster, professor MSO, maem@dtu.dk
  (covering energy system modelling and scenario analysis, concepts for energy infrastructure)
- Jacob Ladenburg, professor, jlad@dtu.dk
  (covering social cost and cost benefit-analyses)

Each expert may be contacted for further elaboration of our comments according to coverage of topics.

DTU Management seeks with this response to supplement on the needs for improving key assessments around the development and management of the coming energy islands.

[1] https://ens.dk/presse/energistyrelsen-inviterer-til-offentlig-hoering-om-de-oekonomiske-aspekter-energioeerne

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Our response is divided into the following topics:

1. Long term supply curve for offshore wind in the North Sea (DEA's memo 2)
2. Screening of potential concepts for energy infrastructure (DEA's memo 3)
3. Input to the cost-benefit analyses (DEA's memo 4)

Long term supply curve for offshore wind in the North Sea

The long term development curve is among other things calculated to assess the electricity price which wind developers may be able to receive in the long run. DTU Management suggests, that the methodology should be validated/compared to existing analyses done with Balmorel (e.g. from DTU[2], from EA Energy Analysis and Dansk Energi's electricity price outlook) and with BiD from Energinet.

A few unclear points:

- It is unclear what is assumed in terms of flexibility in the remaining system, where a system with high flexibility could ensure higher prices for the turbine owners. DTU Management suggests to highlight this - and to analyse scenarios with different levels of flexibility in the surrounding system.
- It is unclear how climate change is taken into account - e.g. in terms of more extreme weather conditions and rising sea levels, which could affect the future costs and production of offshore wind. DTU Management suggests a thorough assessment of these aspects to be included.

Many relevant factors are mentioned that should be considered for the long-term electricity price projections. One of these is VRE[3] expansion and availability of other supply capacities. Two more price driving factors should be added: CO2 prices and natural gas prices. These two price drivers will continue playing an important role until we have only carbon-neutral supply left in the energy system.

We support the idea considering the North Sea area's production and cost estimates for offshore wind, which will have a strong influence on electricity prices. However, DTU Management suggests a more comprehensive view of European electricity production, as PV electricity and PV-based hydrogen from the south of Europe will have a similar impact on prices as North Sea wind power. Furthermore, a global market for green hydrogen and synthetic fuels are expected to develop over the next decades, affecting the prices of these fuels and in turn electricity prices and the price for hydrogen from the North Sea. These aspects are also suggested for inclusion in the assessment.

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[2] https://www.nson-dk-project.dk/ and https://windenergy.dtu.dk/english/research/research-projects/lowwind

[3] VRE = Variable Renewable Energy

Furthermore, to evaluate the profitability of the energy islands, it might not be sufficient to project the annual average of electricity prices, but the inner-yearly distribution (hourly development) and especially their correlation with wind power generation within a future year. This is because the produced wind power must be sold on wholesale electricity markets on an hourly basis or at least its value must be determined based on this resolution. Hence, DTU Management suggests that the long-term projections need to be combined with econometric or other statistical models to capture the inner-yearly price dynamics. Although all of this additional work cannot be done in the analyses of fall 2021, they may be considered during further analyses.

DEA elaborates on the long-term equilibrium and price formation, resulting from the economic theory. The related LCOE[4] might be sufficient to build the wind supply curve in tenders, but other components of the energy islands, such as PtGtP[5] that might ensure generation adequacy, may need capacity payments/market prices to reduce full exposure to price risk that in turn may cause project financing issues.

Finally, although there are studies on cost estimates for PtX[6] technologies or LCOEs, a learning curve based approach can deliver more accurate estimates for possible cost reductions.

Screening of potential concepts for energy infrastructure

When constructing energy islands it is important to ensure that only the necessary infrastructure is built. It is unclear how the potential double infrastructure from electricity transmission and hydrogen transmission will be analysed.

It is not clear what results the screening of potential concepts for energy infrastructure will entail. Will it be qualitative or quantitative? A pure qualitative approach will make it impossible to include the different concepts in a cost-benefit analysis. Thus, DTU Management recommends to look into existing literature to assess costs of these concepts and do quantitative analyses, as e.g. offshore hubs or meshed offshore grids may provide lower costs than energy islands.

The scenario analysis aims to compare the energy island with an alternative as a combination of solar power, onshore wind and radially connected offshore wind parks.

There is an imperative need to address the isolated economic benefits and cost of the physical energy island in the North Sea. DTU Management suggests an alternative

[4] LCOE = Levelized cost of energy

[5] PtGtP = Power-to-gas-to-power

[6] PtX = Power-to-X

baseline line scenario – an equal amount of offshore expansion but with a more simple installation that can distribute the generated electricity to the relevant foreign market as in the energy island scenario. In this setup there will be no hydrogen or other energy production on the "small island", all these facilities are located at the harbours onshore.

Input to the Cost-benefit analyses

It is key that the cost-benefit of energy islands will be compared to a relevant reference/baseline case. Many good reflections are made, but it is not clear if/how these will be included in the final analyses. In that respect it is not clear:

- Whether the baseline case will include a case with offshore hubs or only radial connections. Here offshore hubs (installation with converter station) may be the lower-cost solution[7].
- With respect to the baseline scenarios (2 for DK and 3 for TYNDP[8], so six when combined) it is unclear which of these constellations the primary analysis scenario (energy island) analyses will be compared to, and the same goes for the "Analyse-scenarie". For the latter it is also not clear which variations will be analysed. The same question goes for the sensitivity analyses.
- To which extent environmental impacts, impacts related to acceptance of e.g. electricity transmission lines, impacts on export and local job creation will be included. Recent research within willingness-to-pay has demonstrated the feasibility of monetising such effects[9], and analyses should therefore take advantage of this, at least by including a sensitivity analysis where an attempt is made to include all relevant externalities rather than only describing them qualitatively as is often done.

DTU Management therefore suggest that the following is considered:

- The marginal welfare costs of the visual impacts from the wind turbines are decreasing with distance. Consequently, it is more beneficial to move an offshore wind farm from 12 to 13 km from shore than 69 to 70 km from the shore. As the cost of wind power increases with the distance from the shore, locating the energy island and the connected wind turbines closer to shore, might be more beneficial in a welfare economic perspective.

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[7] https://www.nson-dk-project.dk/

[8] Ten-Year Network Development Plan (TYNDP) 2020, developed by ENTSO-E (a cooperation between the European TSOs for electricity)

[9] https://orbit.dtu.dk/en/publications/economics-of-wind-integration-an-acceptance-costs-approach

- What are the expected impacts on the labour market and what is the associated welfare economic value?
- Are there negative impacts on the rent from fishing activities within the energy island area? Can the energy island area function as a fish sanctuary/breeding ground, which will increase the fishing rent on the fishing grounds close to the energy island area.

The positive external impacts in terms of reducing climate impacts are questionable because we can assume that the level of renewable energy will increase. If climate effects are included – this should only be done on substantial grounds, such as the extensive offshore wind power development will accelerate the share of renewable energy relative to other sources.