Wind Energ. Sci. Discuss.,
https://doi.org/10.5194/wes-2019-101-AC1, 2020


WESD

Interactive comment

# *Interactive comment on* "Exploitation of the far-offshore wind energy resource by fleets of energy ships. Part B. Cost of energy" *by* Aurélien Babarit et al.

**Aurélien Babarit et al.**

aurelien.babarit@ec-nantes.fr

Received and published: 28 February 2020

Dear anonymous referee #1.

Thanks for having read our paper and thanks for your comments. Please find below our answers and clarifications.

1. Choice of methanol rather than CO2-free fuels. We have already published a comparison of the various options in (Babarit et al., 2019) and it is summarized in the introduction of the companion paper of this paper: https://www.wind-energ-sci-discuss.net/wes-2019-100/ Nevertheless, we will add the following text in the intro-

Printer-friendly version

Discussion paper

duction of the revised version of the paper:

"In the proposed system, the fuel is methanol (see Babarit et al., submitted and Babarit et al., 2019 for detailed explanation of the choice of methanol rather than CO2-free fuels like hydrogen or ammonia)."

2. Contribution of each cost element to total cost. We will add a figure (see below) and the following discussion in section 4.1 in the paper's revision.

"Figure 3 shows the cost breakdown for an average cost scenario. One can see that the main cost sources are the financing cost (30% of total methanol cost), the FARWINDERs' capital cost (ship + power-to-methanol plant + integration, 25% of total methanol cost), and operation and maintenance cost of the FARWINDERs (24%). The total cost of energy storage - including the power-to-methanol plants, CO2 supply and tankers capital cost, and operation and maintenance cost - accounts for 25% of total cost."

3. Credibility of cost elements. We put a lot of effort in looking for reliable cost sources. It included consultation with possible suppliers and industry representatives. The cost data which is used in the paper is the best that we have been able to gather. Moreover, we included cost ranges in order to reflect uncertainties in some of the cost data. Therefore, we believe that the cost elements and the calculated range for the methanol cost are realistic. Nevertheless, note that according to IEA Wind TCP Task 37 Technical report "systems engineering in wind energy: WP2.1 reference wind turbines", May 2019, the total mass of a 3.4 MW land-based wind turbine is 820 tons and its initial capital cost is in the order of 3,800 k€İt corresponds to a 4.6 € / kg cost to mass ratio (respectively 1 120 € / kW cost to capacity ratio) whereas the range of cost to mass ratio in the paper is 13.0 – 22.3 € / kg for a FARWINDER prototype (4 800 - 8100) and 7.4 – 12.7 € / kg for the 112 FARWINDERs of the FARWIND system (2 700 - 4 650). As one can expect the cost to mass ratio (cost to capacity) is significantly greater for the FARWINDERs than for the wind turbine which can be explained by a greater

complexity.

4. Different learning rates depending on the cost elements. We agree that this refinement would be interesting, but we believe that it goes beyond the scope of the present paper which aims at providing first estimates for the medium and long term cost of energy.

5. Cost of kWh_el from the water turbine. The cost of power available to the power-to-methanol can be estimated to 44 – 99 € / MWh for the first FARWIND system, which is comparable to the cost of electricty from a conventional onshore or offshore wind farm. However, low cost methanol production requires both low cost of electricity and high capacity factor. This is discussed in the second paragraph of the introduction in the companion paper of this paper https://www.wind-energ-sci-discuss.net/wes-2019-100/ : "However, the main challenge faced by PtX products from renewable energy-based plants is cost competitiveness. Key economic drivers are the cost of input electricity to the PtX plant and the PtX plant capacity factor (Fasihi et al., 2016; Ioannou and Brennan, 2019)." The following text will also be added in section 4.2 in the paper's revision:

"As shown in (Fasihi et al., 2016; Ioannou and Brennan, 2019), the key economic drivers in power-to-gas or power-to-liquid processes are the cost of input electricity to the power-to-gas/liquid plant and the power-to-gas/liquid plant capacity factor. For FARWIND systems, the cost of input electricity LCOE can be estimated by using equation (1) but without taking into account costs related to energy storage (power-to-methanol plant, tankers, CO2 supply). It is found to be in the range 44 – 99 € / MWh for a first-of-a-kind FARWIND system, which is comparable to the cost of electricity from land-based and bottom-fixed offshore wind turbines. However, as the capacity factor of FARWIND systems is expected to be significantly greater, the cost of methanol produced by FARWIND systems is expected to be cheaper."

Interactive comment on Wind Energ. Sci. Discuss., https://doi.org/10.5194/wes-2019-101,

2020.

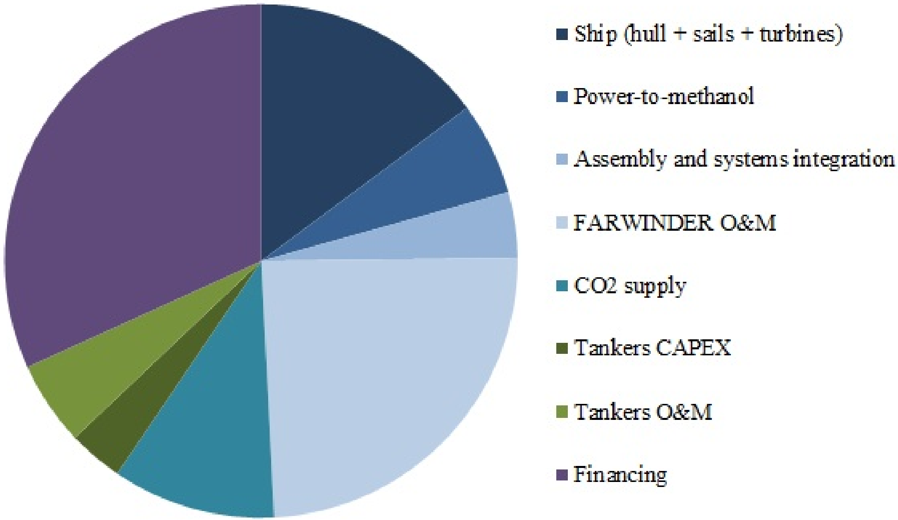


**Fig. 1.** Cost breakdown of methanol produced by FARWIND systems. The shown data corresponds to an average cost scenario (methanol cost equal to 1.48 €kg).