

Ammonia Production From Wind Power

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RE has beaten coal – Next frontier: Beat Oil and Gas

Direct electrification in some sectors. Electro-fuels in other.





Why ammonia looks to be the most promising e-fuel candidate?

Ammonia is a transportable, scalable, carbon-free fossil fuel replacement which can be created with RE



Commercial feasibility \rightarrow Continuous cost reduction is expected

Cost gap to fossil ammonia and fuel is expected to be closed towards year 2030

E-fuel plant lifetime costs

Expected development in e-fuel ammonia price ²⁾

PFM/Alkaline SOEC E-fuel plant design E-fuel plant design 51% **Electricity cost** Million €,NPV 500 2% Other Costs Fossil ammonia 11% 69 **OPEX** / ton Diesel / Marine diesel 36% CAPEX 2018 (basis) 0 Year 2028 2029 2030 2018 2019 2020 2021 2022 2023 2024 2025 2026 2027 20 year lifetime Plant size: 100 MW Plant utilization rate/CF: 80% Diesel/Marine Diesel E-fuel ammonia

Comments

- CAPEX to decrease significantly
- E-fuel to be competitive towards 2030
- Conventional ammonia market is a promising stepping stone towards efuel
- Renewable energy based e-fuel is expected to be sold at a premium compared to fossil fuel
- Fuel and ammonia prices are highly fluctuating & varies geographically

Vestas

1) Current low bid auction level

2) Development is based on expected electrolysis development (source: Haldor Topsøe, NEL) and plant costs and RE electricity cost are assumed to decrease 3 % per year

Fossil Ammonia

Case: Marine e-fuel market projection through 2050

Scale comfortably within reach



■ Wind installation [GW/y] ■ Electrolysis installation [GW/y]

Perspective case

- With current technology the energy need from a local shipping company: ~42 GW Wind
- Danish EFKM has conservatively pointed out areas to install 50 GW offshore wind
- · Good synergy with hydropower resources in Nordic region to balance wind





Main take aways

If nothing else, this is what to remember

Hydrogen is a stepping stone to something else that can store bulk amounts of energy. Ammonia is such a chemical that can be used in shipping and other large industry sectors transferring away from fossil fuels.

Making ammonia from renewable energy in general is **not new** and the task at hand is to **scale and deploy** to get prices down. Despite of what you may be told it is **not R&D efforts or small scale demos** that are needed.

Do not forget the offtaker and the end user.

Cost of ammonia as a fuel will come at **premium cost** to start with, but we do have line of site to **get on par with fossil fuels** in forseable future.

This is not scaling to an extend we cannot manage, the **wind industry alone has magnitude to make this** happen



Thank you for your attention

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