Danish Energy Agency

Technology Brief

Update of hydrogen production via electrolysis in the Technology Catalogue (Jan 24)

The Danish Energy Agency published an updated Technology Catalogue chapter for hydrogen production via electrolysers in January 2024. The chapter now contains a detailed description of the different components that together make up a green hydrogen production plant as well as presents updated techno-economic data. Since the original publication in 2021, the expectations surrounding hydrogen production via electrolysers have changed significantly – both related to the technology itself as well as the development of the industry in the short term:

- The investment cost (CAPEX) estimates for 2025 for a 100 MW green hydrogen production plant has risen app. 60 % and 25% for respectively Alkaline and PEMEC technology compared to the previous chapter.

- Plant efficiencies are lowered – 2025 efficiency has been reduced app. 10 % thus increasing estimated costs for power consumption.

- In the end of 2023, global installed capacity stood at only 1 GW – of which roughly a quarter in the EU – a stark contrast compared to expectations a few years back when the European Union in 2020 envisioned installing 6 GW of renewable hydrogen electrolysers in the EU by 2024 and 40 GW by 2030.

- Multiple reasons are likely driving the slower-than-expected development. Stakeholders often cite key factors such as increased plant CAPEX and complexity in project development, rising capital costs alongside challenging funding conditions, a shortage of new renewable energy sources, insufficient long-term offtake agreements, and delays in regulatory frameworks.

The next section highlights updated data and new features such as detailed description of plant components and associated CAPEX breakdown as well as illustration of cost changes.

Major changes in updated Technology Catalogue

Based on detailed project design and in-depth knowledge of concrete projects accumulated through the last couple of years, a much more detailed understanding of the technical and economical prerequisites for development of green hydrogen plants have materialized. Generally speaking, it has become more evident that the complexity of establishing a green hydrogen plant, which involves many different sub-components was likely not fully understood or acknowledged by the broader audience a couple of years ago.

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As illustrated in figure 1, the electrolyser unit is merely one – albeit central – component out of many in a green hydrogen production plant.

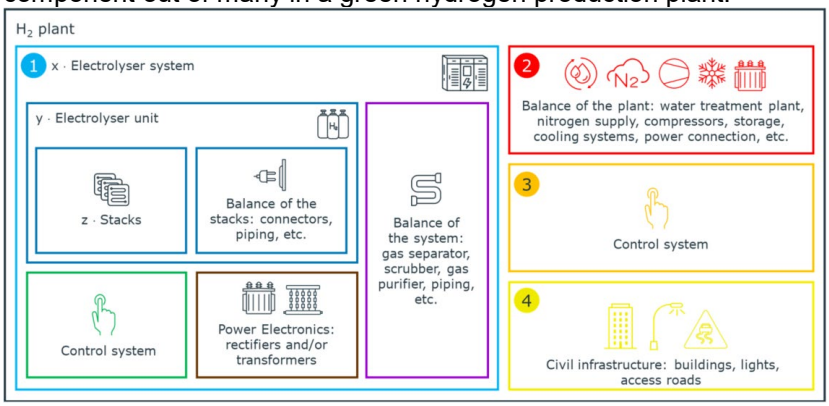

Figure 1: Hydrogen plant general components categorized into four main component groups: 1) electrolyser system(s), 2) balance of the plant, 3) control system, and 4) civil infrastructure.

CAPEX of the electrolyser stacks represents only about 20 percent of total CAPEX for a 100 MW alkaline plant in 2025 as shown in figure 2. Costs related to the balance of the plant i.e. water treatment, nitrogen supply, cooling system etc. as well as control system, infrastructure and indirect cost primarily in the form or EPC cost could account for roughly 1/3 of the overall CAPEX.

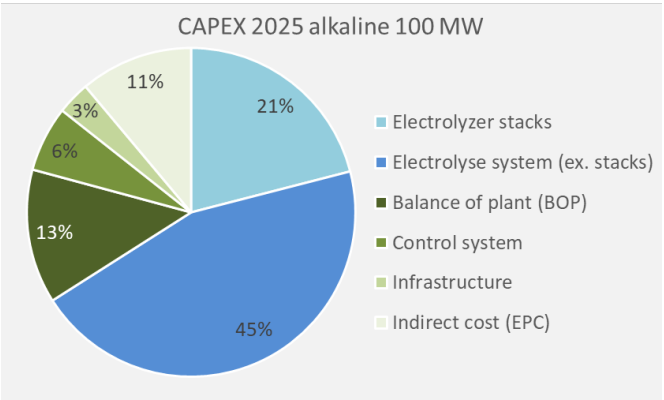

Figure 2: CAPEX breakdown for a 100 MW alkaline plant (2025 CAPEX).

The updated knowledge show that previous techno-economic plant assumptions have been too optimistic in terms of investment cost in the short term and overall plant efficiency. In figure 3, an example of cost estimates (LCoH) of producing green hydrogen (for a 100 MW AEC) have changed from the previous version to the updated version of the Technology Catalogue.

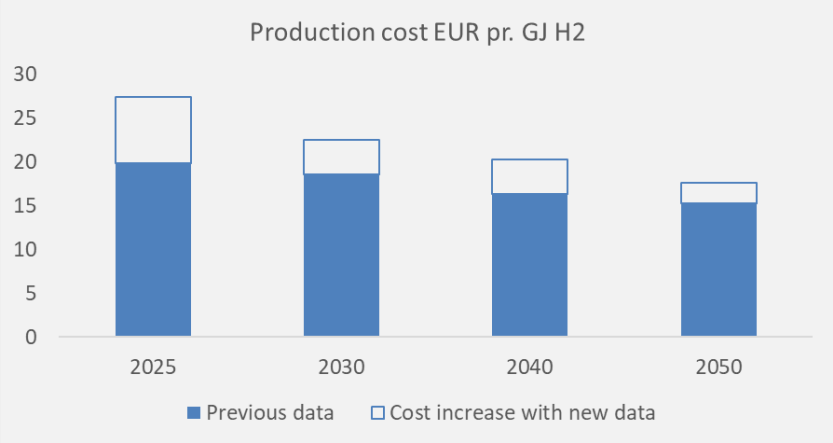

Figure 3: Estimates (LCoH) of producing green hydrogen (for a 100 MW AEC)

The updated chapter also provides estimates on how scaling of the plant affects CAPEX, highlighting that the majority of cost savings are realized once the plants reach a capacity of around 100 MW in power input. Beyond this size, limited cost savings on plant level are expected from scaling. Cost and accessibility to main input (power) and output (hydrogen) can be significantly influences by the size of the hydrogen plant. Given limited cost savings in plant CAPEX pr. MW beyond 100 MW cost and accessibility to input and output should be seen in this context.

Power cost - still the main cost component

Despite increased CAPEX estimates for 2025, cost related to power consumption still makes up a very significant and often majority of the total cost. This result also reflects lowered expectations related to efficiency. Figure 4 illustrates LCoH for three different cases, with varying full load hours (FLH) and power cost.

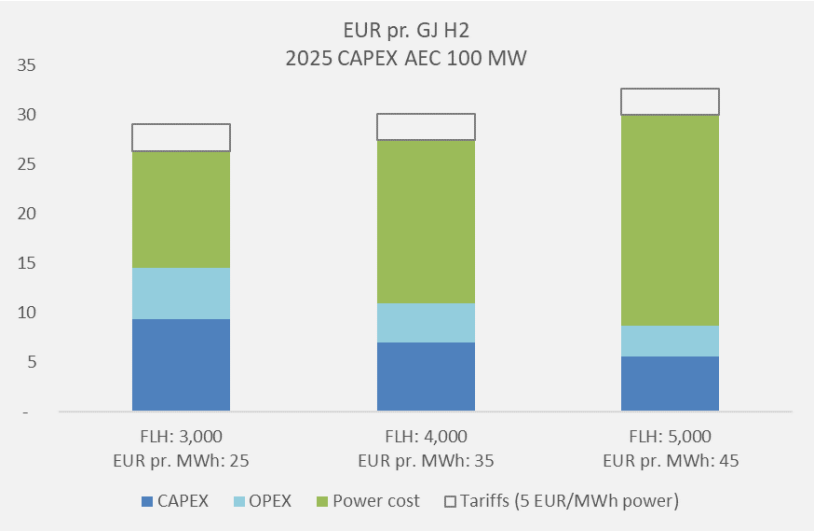

Figure 4: LCoH for three different cases with varying FLH and power cost (2025 CAPEX for 100 MW AEC)

Thus, an absolute key prerequisite for producing cost competitive green hydrogen is access to:

a) new low-cost renewable power that can be sourced behind-the-meter and/or

b) access to power from the grid that:

    a. fulfill the definition of renewable fuels of non-biological origin (RFNBO)

    b. generally have large number of low-price hours or availability of low-cost PPAs

    c. cost true and competitive tariff design (for large power consumers)

Power market and cost perspective for Denmark

With the current plans for very significant offshore wind build-out in Denmark as well as possible quadrupling of onshore renewable energy (RE) capacity towards 2030, power production in Denmark could double towards 2030. This will likely bring Denmark's share of RE in the grid past 90 % already in a few years from now qualifying hydrogen produced from on-grid power as RFNBO - and give access to a lot of RE capacity that can be sourced behind-the-meter. Power consumed through the grid will happen at relatively low tariffs due to recent modernization of the tariff design in Denmark. This coupled with relatively low wholesale power prices driven by high share of RE and large import capabilities from Norway and Sweden makes the Danish market for large power consumers interesting.