Facilitating the upscaling of hydrogen tech to meet the green demand

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Reliance on fossil fuels to power industry and long-haul road transport, shipping, and aviation persists because renewable electrification continues to pose significant challenges.

Alkaline electrolysis (the splitting of water molecules into hydrogen and oxygen) has been used in Norway for almost 100 years to obtain hydrogen gas. When these electrolysis plants are powered by renewable energy source, e.g., solar or wind, the produced hydrogen is referred to as "green hydrogen". Improvements in fuel cell and electrolyser technologies look to put green hydrogen at the centre of delivering the energy transition. Furthermore, safe storage, transport, and effective on-demand usage of green hydrogen would result in significant forward steps in mitigating anthropogenic climate change in a secure, affordable, and sustainable way. One way in which this could be feasible would be through the decarbonisation of heavy industry.

Why not focus on hydrogen cars?

The output of greenhouse gases from heavy industry is a greater environmental challenge than the output from citizens engaging in day-to-day activities. Take, for example, the average Norwegian travelling daily between Trondheim and Steinkjer by train. This person would emit approximately 630kg[1] of carbon dioxide per year through a series of journeys which consumes enough electricity to power the Eiffel Tower's lighting system for 9 days.

The differences are quickly apparent by comparing these numbers to just *one* potential heavy industry use of hydrogen power: steel production. According to the World Steel Association, in 2018, every tonne of steel produced requires 6940 kWh of electricity and emits on average 1850 kg of carbon dioxide. This would light the Eiffel Tower for over 1 month. For context, the EU's largest steel manufacturer, Germany, would require about 100 terawatt-hours (TWh) of renewable energy to fully decarbonise the annual production of 42 megatonnes (Mt) of steel; a 20% increase in total electricity demand.

To meet EU demands for energy security and affordability through the production of green hydrogen, as set out by the European Green Deal[2], Sweden has pledged to achieve 5GW of electrolysis capacity, Denmark 4-6GW, and Finland around 12 GW. For reference, 1 GW can

[1] Taking the train? Why EcoTree suggests contributing to the environment.

[2] Communication from the Commission to the European Parliament, the European Council, the Council, the European Economic and Social Committee and the Committee of the Regions — The European Green Deal (COM(2019) 640 final, 11.12.2019)

power 2000 Corvette Z06s[3] or 100 million LED lightbulbs[4]. 12 GW of power looks like 3720 utility scale wind turbines[5].

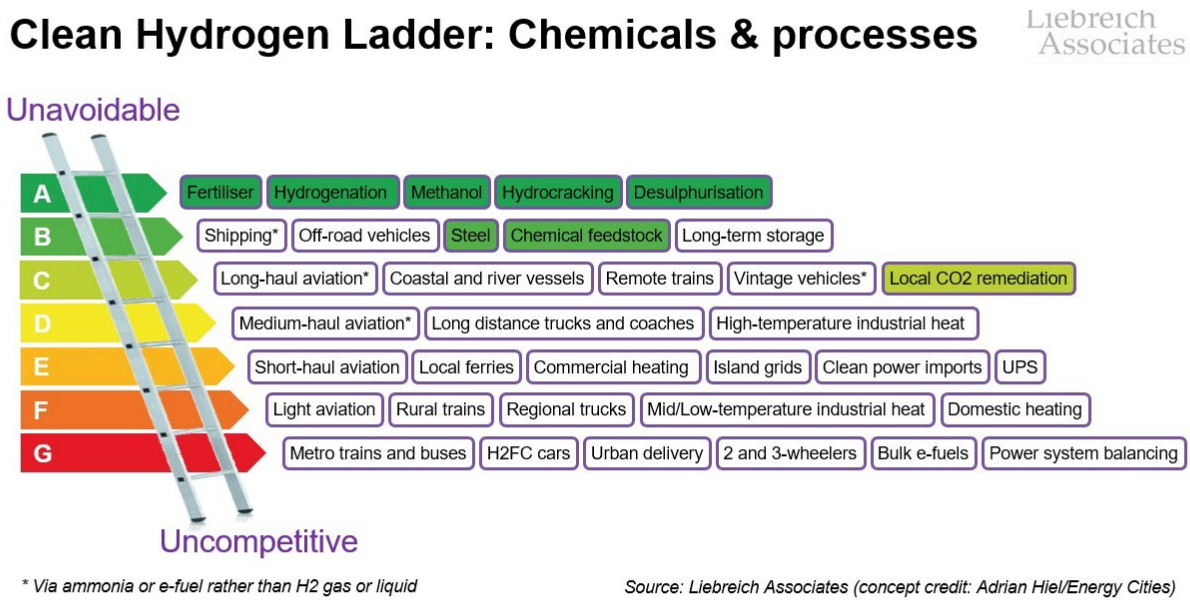

Figure 1 The Clean Hydrogen Ladder[6] shows that some possible applications of hydrogen as an energy carrier are more sensible than others. By focussing on just a handful of sectors at the top of the ladder, the scale of the challenge becomes apparent.

Green hydrogen looks great – what now?

Producing enough hydrogen for full decarbonisation of the steel industry alone would require a 20% increase in electricity production, according to a 2020 report conducted by the European Parliamentary Research Service[7].

Green hydrogen production transforms around 70-80% of electricity into the chemical energy in hydrogen gas. 1kg of hydrogen produced by electrolysis requires about 55kWh, and 50kg of hydrogen is required to produce 1 tonne of steel. If we can secure green hydrogen production by optimising the electrolysis process and corroborating hydrogen production with lulls in electricity demand then green hydrogen has massive potential in acting as an enabler for the energy transition, with the capacity to meet the demands of multiple industries.

However, for green hydrogen to have a significant impact in the heavy industry, rapid upscaling of electrolyser capacity is required. Current electrolysers and fuel cells rely on expensive components and complicated technologies that run at high temperatures. According to

[3] Chevy Corvette Z06 Supercar | Chevrolet Performance
[4] Adoption of Light-Emitting Diodes in Common Lighting Applications (energy.gov)
[5] Land-Based Wind Market Report: 2023 Edition | Department of Energy
[6] The Clean Hydrogen Ladder [Now updated to V4.1] - liebreich
[7] The potential of hydrogen for decarbonising steel production (europa.eu)

Hydrogen Europe's 2022 Hydrogen Report,[8] operational electrolyser capacity was 0.16 GW in August 2022, a far cry from the 120 GW of installed electrolyser capacity required to meet the target of 10 million tonnes of domestic green hydrogen production by 2030 set forth by the *REPowerEU Plan*.

Two promising green hydrogen production technologies are proton exchange membrane (PEM) water electrolysis and solid oxide electrolyser cells (SOEC). While these technologies are mature, they are currently expensive to implement. Platinum coated Titanium bipolar plates, necessary to overcome harshly acidic operating environments used in PEM water electrolysis, are costly, and interconnects used in SOEC are prone to degradation because they are made of uncoated stainless steel.

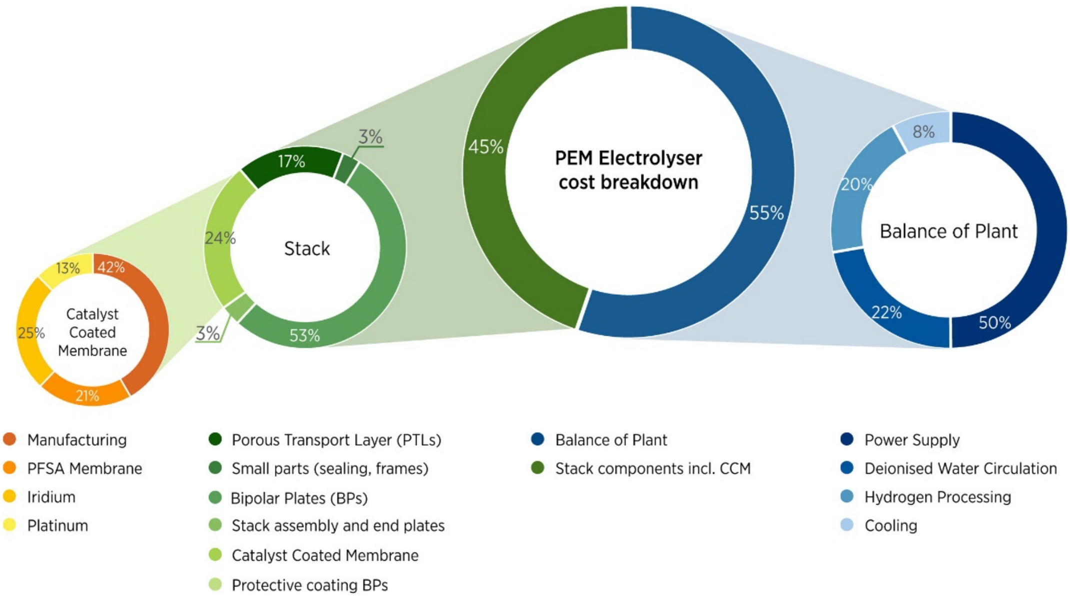

Figure 2 Cost breakdown of a 1MW PEM electrolyster system based on analysis by IRENA[9]. Whilst the cost of interconnects in SOEC systems are 20% lower than in PEMWE[10], these costs can be reduced further.

In order to provide momentum for decarbonizing hard-to-abate sectors using green hydrogen as an energy carrier, it is necessary to drive forward on facilitating the technological advantages in flexibility, efficiency, and power density of SOEC and PEMWE technologies.

A new project funded through the Nordic Energy Research Programme seeks to do just that by increasing the durability of electrolyser stacks and reducing costs. The **MoreH2** project will focus on the development of inexpensive and durable electrolyser components. It will also prioritise key stakeholder involvement to ensure effective implementation in the future.

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[8] Hydrogen Europe (2022), Hydrogen: Enabling a Zero-Emission Society

[9] Green hydrogen cost reduction: Scaling up electrolysers to meet the 1.5C climate goal (irena.org)

[10] James B.D. et al: https://www.energy.gov/sites/default /files/2022-03/HTW&20&Workshop-Strategic%20Analysis.pdf

The project will increase stack durability by developing low-cost coatings to protect bipolar plates (and interconnects) from degradation, thereby increasing the feasibility of upscaling. The low-temperature fuel cell and electrolyser lab operated by SINTEF Industry offers testing capabilities from research and development to kW scale short stack testing. From there, it is a small step to achieving a significant push forward in the green energy transition.

More about MoreH2

The MoreH2 Project (Unlocking the Full Potential of Green Hydrogen: Towards Cost-Effective, Durable, Efficient and Flexible Electrolysis) is coordinated by Chalmers University of Technology (research organisation, Sweden). In addition to SINTEF AS, the project will collaborate with industry partners Outokumpu (Finland), Alleima (Sweden), Topsoe (Denmark), and Hystar (Norway). The Norwegian Hydrogen Forum (non-profit member organisation) and Icelandic New Energy (industry partner, Iceland) will hold responsibilities for communication and dissemination between the project consortium and stakeholders.

The primary objective of MoreH2 is to develop low-cost coatings to protect bipolar plates in PEM electrolyser stacks and interconnects in SOEC systems, thereby enabling upscaling of green hydrogen production by improving on current stainless steel technologies. For PEMWE, the project aims to do this by replacing the expensive Platinum coated Titanium plates with low cost, carbon coated stainless steel which can withstand harsh operating environments. For SOEC, the project will develop dedicated coatings for the stainless steel interconnects as well as develop new and improved steels.

These coatings will then be tested to evaluate their durability in both single cell and stack tests. The latter, using real life operating conditions, will also be used to demonstrate the feasibility of the newly developed coatings. Post test characterisation of samples from both the laboratory and field tests will allow further understanding of degradation mechanisms.

The project began in January 2024 and will run for 3 years. The total budget for the project is 1.33 million Euros.