Assessing the Scalability of Green Hydrogen Innovation for Net Zero

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Project Description

Global warming, driven by greenhouse gas emissions, is leading to accelerated sea-level rise and higher mortality rates in vulnerable regions. Achieving net-zero emissions—balancing anthropogenic carbon dioxide emissions with their removal—has become an urgent global priority.
This study evaluates current green hydrogen production and estimates future demand by 2050, revealing a significant gap due to high costs and inadequate infrastructure. With around 14% of green hydrogen costs stemming from electrolyser capital expenditure, advancing electrolysis technology is key to closing this gap.
Innovations such as mass production of electrolyser stacks, cheaper materials, and standardized installations offer pathways to lower costs and boost scalability.
These advancements, highlighting their role in speeding up the transition to sustainable energy systems are explored here.

Types of Hydrogen

Gray Hydrogen: Hydrogen produced from natural gas by using steam-methane, releasing carbon emissions.

Blue Hydrogen: Hydrogen produced form fossil fuels where CO2 is captured.

Pink Hydrogen: Hydrogen produced by electrolysis of water using nuclear power.

Green Hydrogen: Hydrogen Produced by electrolysis of water using renewable electricity.

Electrolysers

AEM: A type of alkaline electrolysers, using alkaline polymer as electrolyte. Its key technology is anion exchange membrane.

PEM: A type of acidic electrolysers, using acid polymer as electrolyte. Its key technology is proton exchange membrane.

Solid Oxide: A type of electrolysers that use solid oxide as electrolyte and its key technology is protonic ceramic electrochemical cell

Result

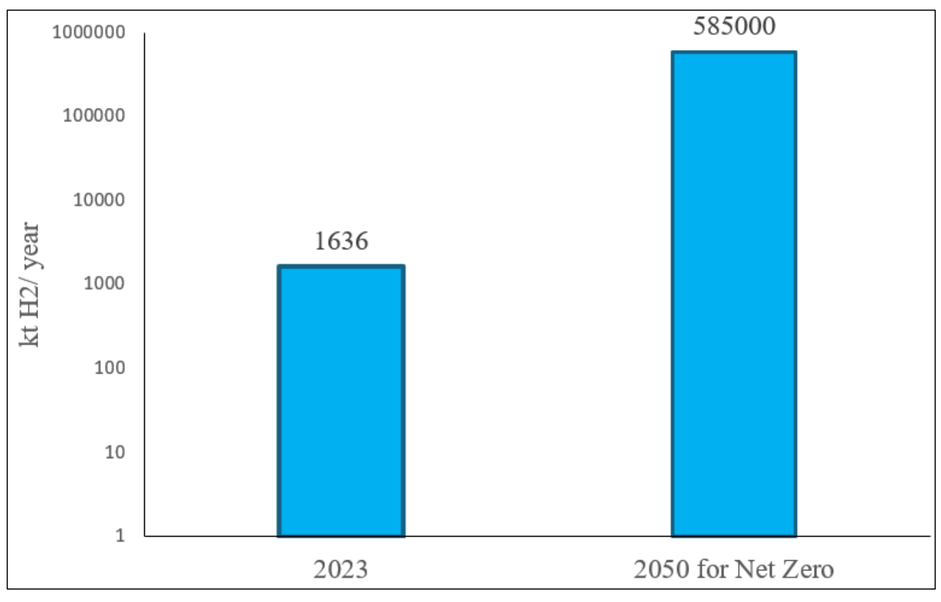

Figure 1. Current Green Hydrogen Production VS Demand in 2050 for Net Zero

The current annual production for green hydrogen is much less than the requirement to achieve Net Zero target in 2050. From the data published by International Energy Agency, the total Green Hydrogen production amount in operational projects in 2023 is around 1636 kilo tonnes per year, which is almost 500 times less than the 585 million tonnes per year objective; in another word, current production does **not reach 0.5%** of the future goal.

Engineering Innovations to Capital Expenditure Reduction

- Cheaper Material and Catalyst: transition metal can be used to replace expensive noble metal
- Mass-production of Modular Stacks/Cores of electrolysers: size increases and the average cost decreases
- Increasing Learning Rate

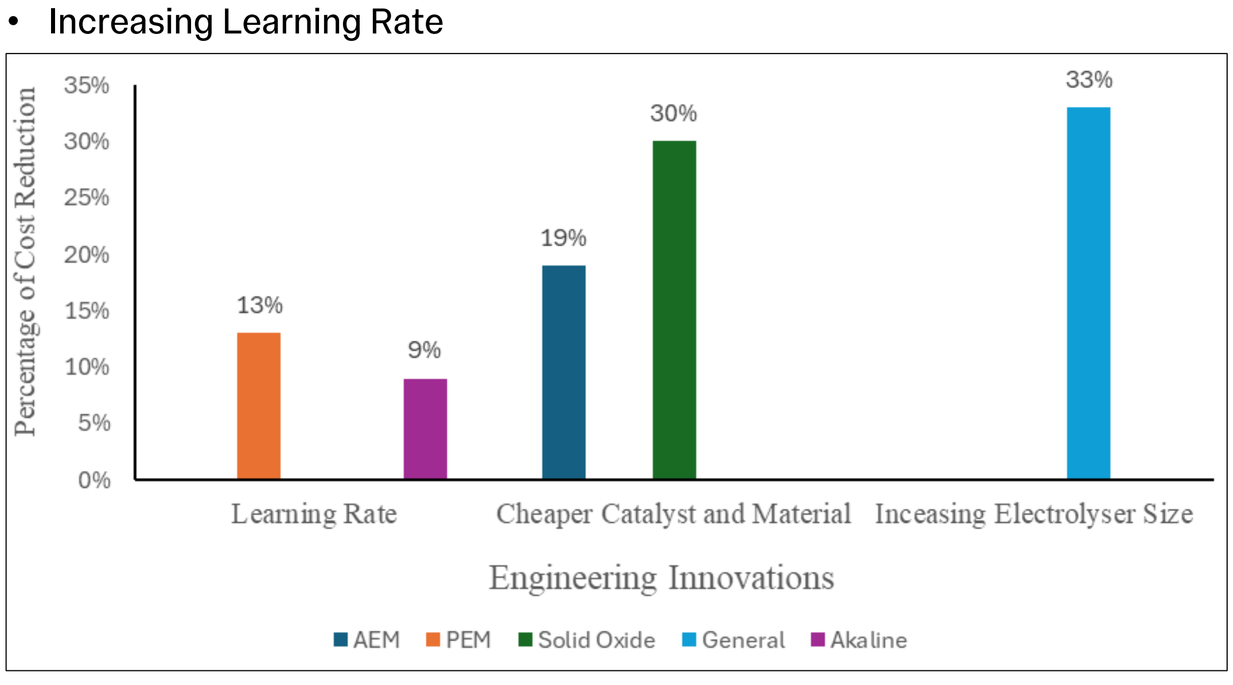

Figure 3. Percentage of Reduction with Engineering Innovations

Learning rate refers to the percentage by which the cost decreases when the production is doubled by means of standardising the electrolyser technologies, specialising production of specific parts of electrolysers in certain companies and simplifying the production process and instalment

Green Hydrogen Cost Breakdown

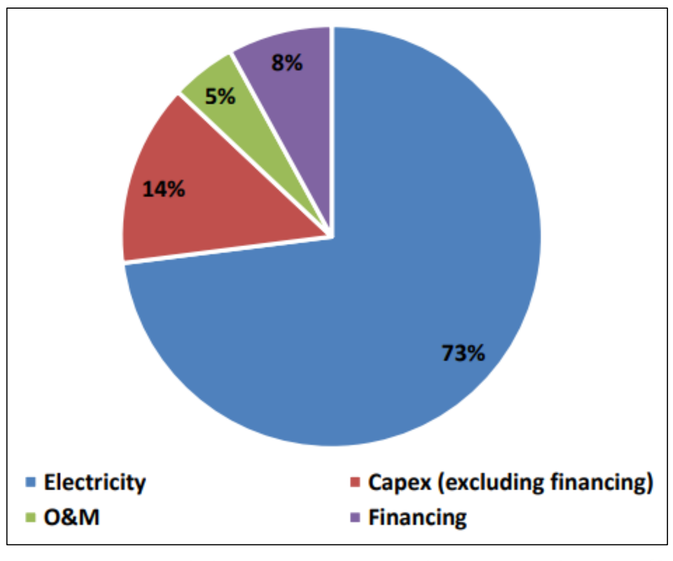

Figure 2. Cost Breakdown of Green Hydrogen Production (from The Oxford Institute for Energy Studies, 2022)

The **uncompetitive price** of green hydrogen is one of the main challenges that prevents its scaling-up.

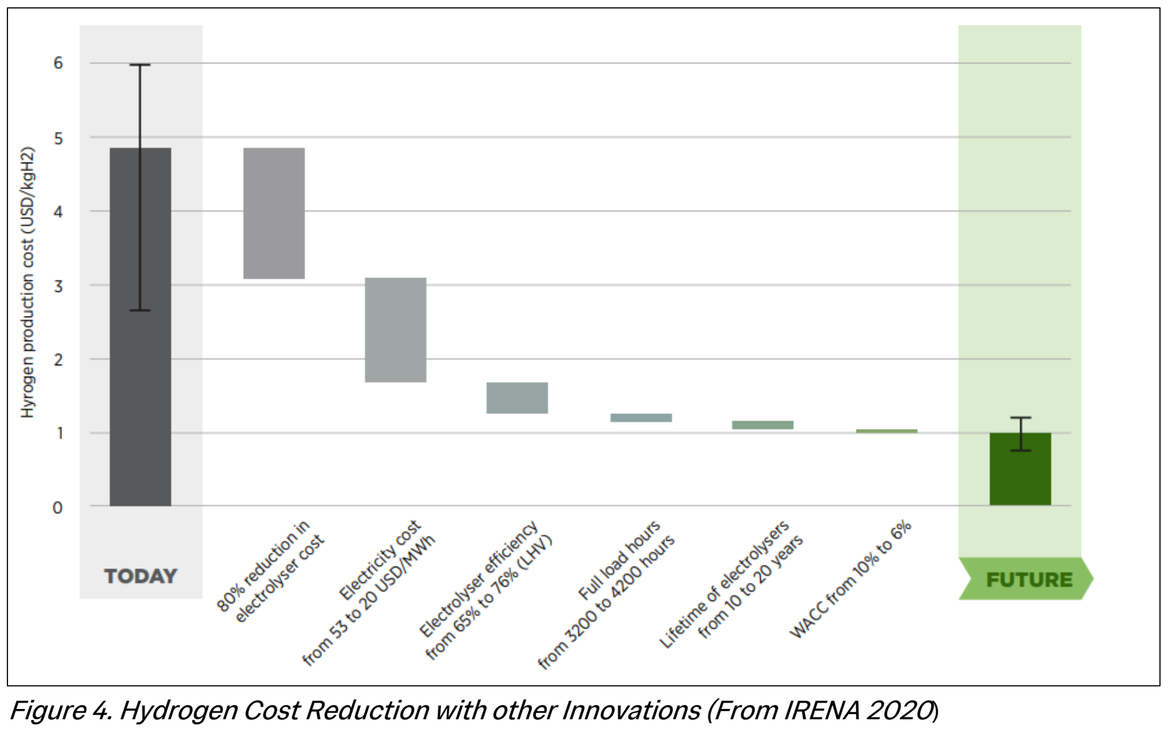

Figure 4. Hydrogen Cost Reduction with other Innovations (From IRENA 2020)

80% of cost reduction can be achieved with combined reductions in electrolysers and electricity's fee and increase in operating time and lifetime of electrolysers.