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On Point

Modelling levelised cost of hydrogen under scenario based circumstances for India for Alkaline Water Electrolysis

Part -7 (Scaling policy, support infrastructure and trade opportunities for hydrogen in India with technology and policy comprehensive roadmap)

RAEninrac

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Pricing of hydrogen in India Scenario based estimation using “Data to Information” (D2I) Model

Building a hydrogen economy will require substantial investment. Production technologies alone will need to attract between $4.68 billion and $15.24 billion by 2035. Minimizing the hydrogen conversion, storage and transport costs by using localized applications could significantly improve hydrogen’s commercial competitiveness.

This section sets out the findings of the eninrac’s “Data to Information” (D2I) model to analyze LCOH. The aim of the model is to show the impact of each segment of the hydrogen value chain.

LCOH figures help to understand the cost of hydrogen per unit – in our model it is USD per kg.

The LCOH can be one of the metrics to assess the economics and commercial viability of a project or to understand its cost competitiveness compared with other energy sources or projects located elsewhere. LCOH is calculated as the discounted total costs incurred during the lifetime of an asset or project over the total discounted hydrogen volumes generated. Total costs in our model include capital costs (total upfront costs to bring the asset to commission) and operating costs (fixed and variable – these vary depending on the segment and hydrogen production technology, but typically include stack replacement, electricity cost, water for electrolysis, grid, maintenance and other costs).

Assumptions about several factors (including useful life of plants, stack lifetimes and replacements, load factors and conversion energy losses) have been made based primary research and direct industry feed through multiple F2F interactions with the technology providers, OEMs and other stakeholders.

> The LCOH can be one of the metrices to assess the commercial viability & economics of a project or to understand the cost competitiveness compared with other sources of energy or projects located globally

Eninrac's D2I model analyses LCOH under following **three scenarios** till 2050:

- **Base Case Scenario (BS):** For this case we assume (basis current trends & channel checks) the project developers shall prefer price over efficiency in India and in a decade's, time later shall take over for > 10 MW size
- **Lower Case Scenario (LS)**: For this case we have assumed a lower variance of 7-12% from base case values based upon the feed from channel checks for an electrolyser size in excess of 10 MW size
- **High Case Scenario (HS):** For this case we have assumed a variance of 35-50% higher from base case values based upon the feed from channel checks for an electrolyser size in excess of 10 MW size, purely driven by the improvements in efficiency and technology factors

The model has been analysed on the following types of energy sources:

- **Grid Fed Electricity;**
- **Electricity Fed through Solar Power Projects;**
- **Electricity Fed through Wind Power Projects;**

Eninrac's D2I model analyses LCOH under following **three technologies of electrolyser** till 2050:

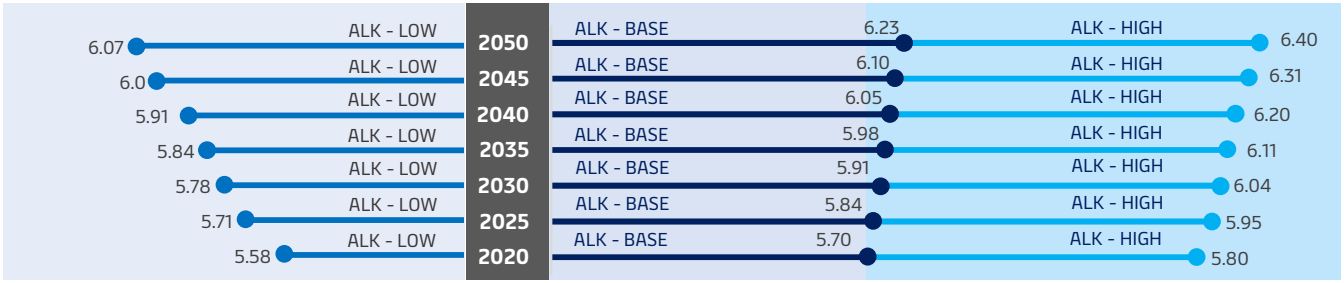
- **PEM Electrolyser:** Hydrogen electrolysis with PEM (Proton Exchange Membrane) offers rapid dispatchability and turn down to follow the energy output from renewables and is therefore ideal for pairing with wind farms for low-carbon hydrogen production or the provision of rapid response to the grid. Eninrac has leveraged the PEM efficiency data through multiple studies conducted by FCH JU (Fuel Cell Hydrogen Joint Undertaking) coupled with subsequent channel checks with the OEMs.
- **Alkaline Water Electrolysis**: Alkaline water electrolysis is a key technology for large-scale hydrogen production powered by renewable energy. As conventional electrolyser are designed for operation at fixed process conditions, the implementation of fluctuating and highly intermittent renewable energy is challenging.
- **Solid Oxide Electrolyser:** SOECs can be used to produce hydrogen (H2), Syngas Fuel (CO+H2) from the mixture of water and carbon dioxide and oxygen from carbon dioxide. They operate a high temperature, typically 600°C to 1000°C to allow electrolysis of water. The high temperature operation reduces the need of electrical energy required for the electrolysis and instead uses heat energy to split water & carbon dioxide.

Levelised Cost of Hydrogen – Alkaline Water Electrolysis

While using ALK technology the LCOH is projected to be USD 6.23/kWh by 2050 under Base Case Scenario while electricity is being fed through grid. Further, the LCOH is expected to be USD 6.40/kWh & USD 6.07/kWh under High Case Scenario & Low Case Scenario respectively by 2050.

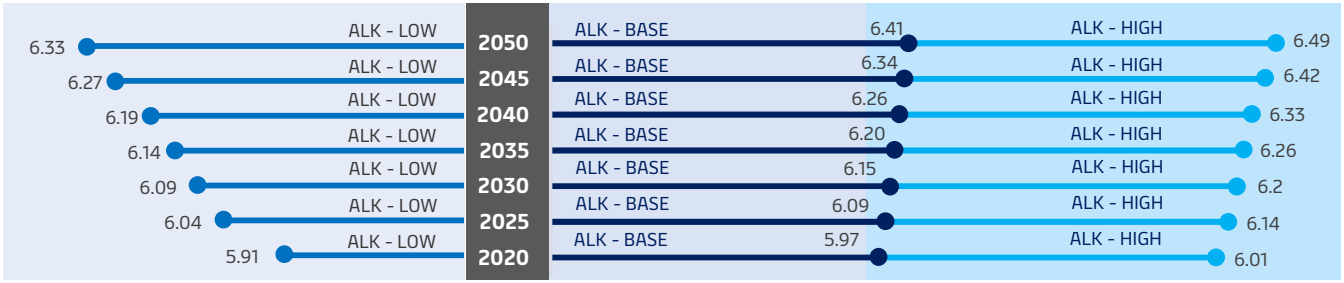
Under base scenario the LCOH comes out to be USD 5.70/kWh in 2020 while using power through grid. Further, LCOH comes out to be USD 5.97/kWh while feeding power through solar & USD 5.78/kWh while feeding power through wind under in 2020.

Source: eninrac's exclusive D2I model



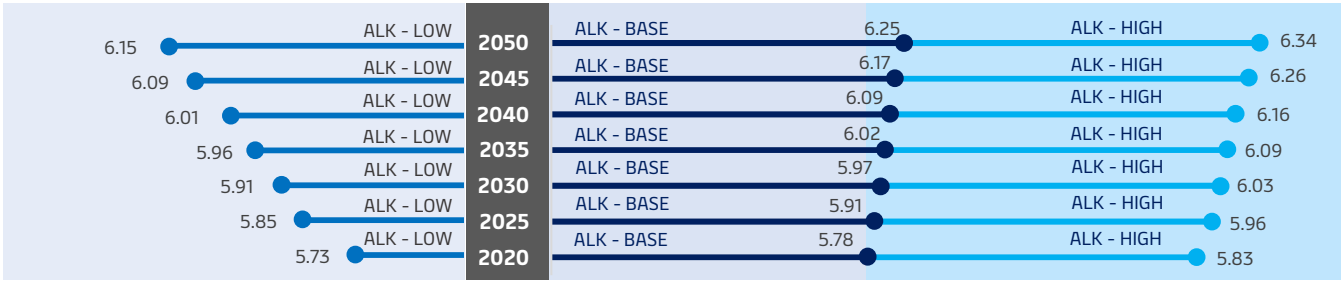
Grid connected H_2 production cases (LCOH in USD/kWh)

Grid connected H_2 production cases (LCOH in USD/kWh)



Solar connected H_2 production cases (LCOH in USD/kWh)

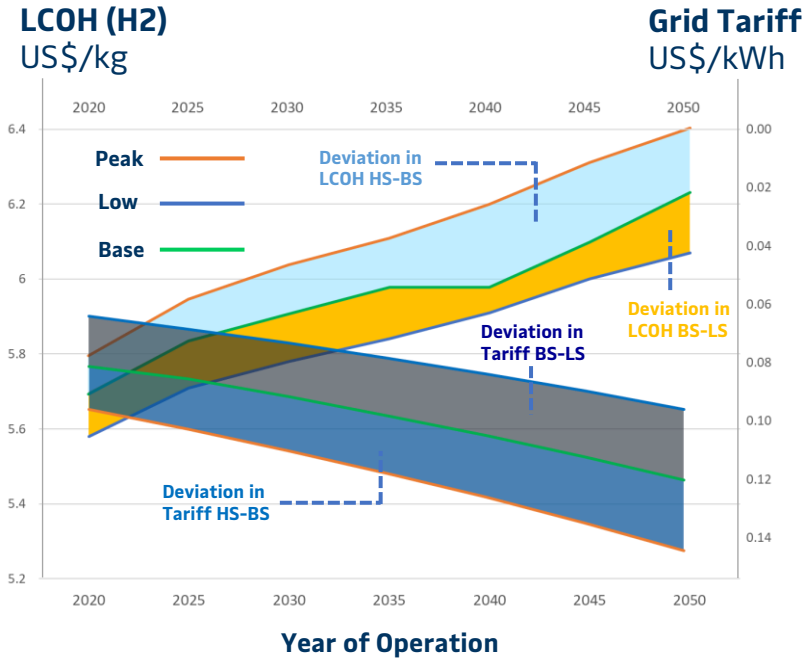
Solar connected H_2 production cases (LCOH in USD/kWh)

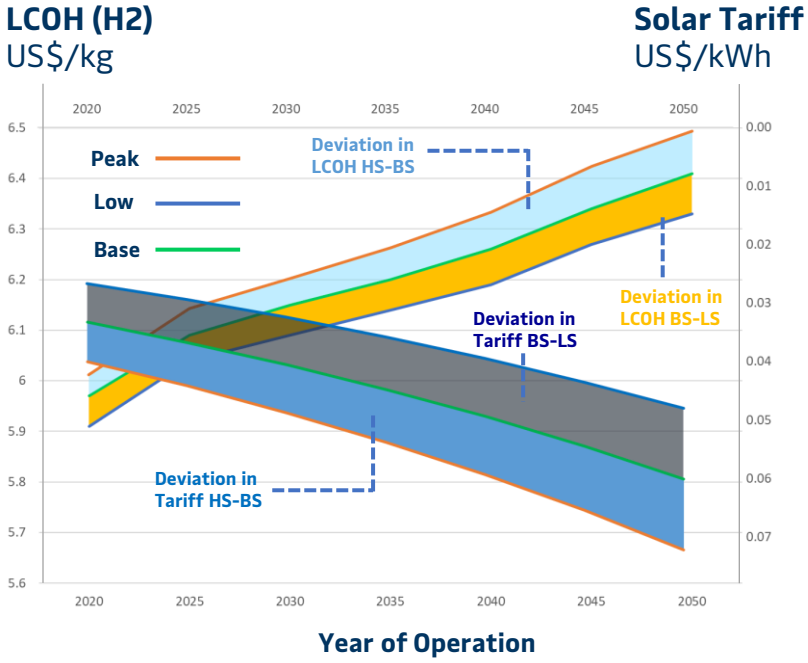


Wind connected H_2 production cases (LCOH in USD/kWh)

Wind connected H_2 production cases (LCOH in USD/kWh)

Sensitivity Analysis – Alkaline Water Electrolysis



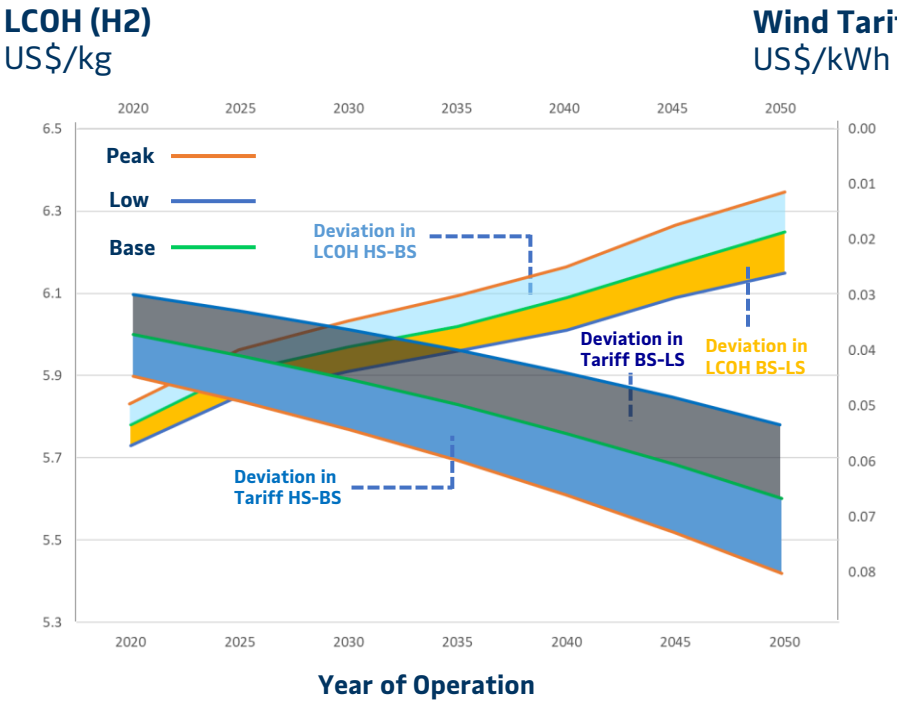


Grid Fed: Under base case scenario the LCOH for year 2020 & 2050 comes out to be USD 5.70/kWh & USD 6.23/kWh respectively. Under lower case scenario the LCOH for year 2020 & 2050 comes out to be USD 5.58/kWh & USD 6.07/kWh respectively. Under high case scenario the LCOH for year 2020 & 2050 comes out to be USD 5.80/kWh & USD 6.40/kWh respectively.

Solar Fed: Under base case scenario the LCOH for year 2020 & 2050 comes out to be USD 5.97/kWh & USD 6.41/kWh respectively. Under lower case scenario the LCOH for year 2020 & 2050 comes out to be USD 5.91/kWh & USD 6.33/kWh respectively. Under high case scenario the LCOH for year 2020 & 2050 comes out to be USD 6.01/kWh & USD 6.49/kWh respectively.

Source: eninrac's exclusive D2I model

Sensitivity Analysis – Alkaline Water Electrolysis



Wind Fed: Under base case scenario the LCOH for year 2020 & 2050 comes out to be USD 5.78/kWh & USD 6.25/kWh respectively. Under lower case scenario the LCOH for year 2020 & 2050 comes out to be USD 5.73/kWh & USD 6.15/kWh respectively. Under high case scenario the LCOH for year 2020 & 2050 comes out to be USD 5.83/kWh & USD 6.34/kWh respectively.

Source: eninrac's exclusive D2I model

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