IEA EGRD Webinar, Hydrogen in the Energy System Decarbonization

Contributions of hydrogen energy system analysis on finding clues for R&D prioritization

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Contents

Introduction: Generic description of hydrogen Energy systems analysis

General definition

- To understand the interactions between elements in the energy system to be analyzed, especially using mathematical tools.

Wide variety of outputs depending on objectives

- Technical (energy efficiency), Environmental (GHG, other aspects), Economic (levelized cost of hydrogen) performances

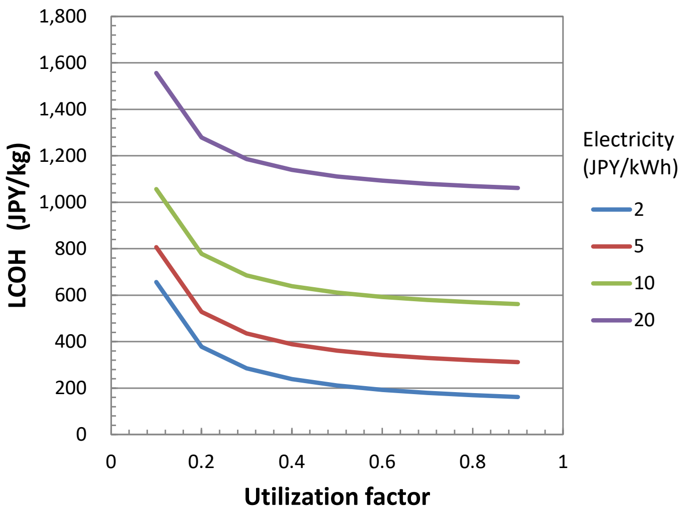
Can provide many clues for improvement

- Energy intensive, high CO_2 emission and/or most costly part(s)
- Sensitivity analysis of above also helps our understanding
- Note: we must use “correct” assumptions and methodologies to get good implications
  - The results totally depend on them and objective settings. Anything not considered in the model does not change the results.

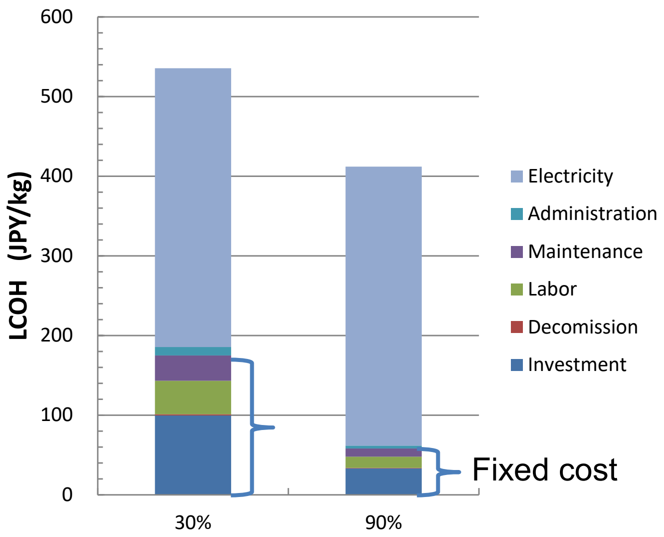
Example 1 Hydrogen production: water electrolysis

- With a low utilization factors, hydrogen cost is relatively high. Especially with low electricity prices, this becomes significant.
- Variable cost does not largely change with a lower utilization factor. The total amount of annual fixed cost (investment, labor and maintenance) does not change, and this is allocated to a smaller amount of hydrogen.
- This is the reason why investment cost reduction of electrolyzers is considered in both relatively small PtG systems and large scale green hydrogen production.

Utilization factor dependence of hydrogen cost



Differences in cost breakdown with utilization factors of 30% and 90%

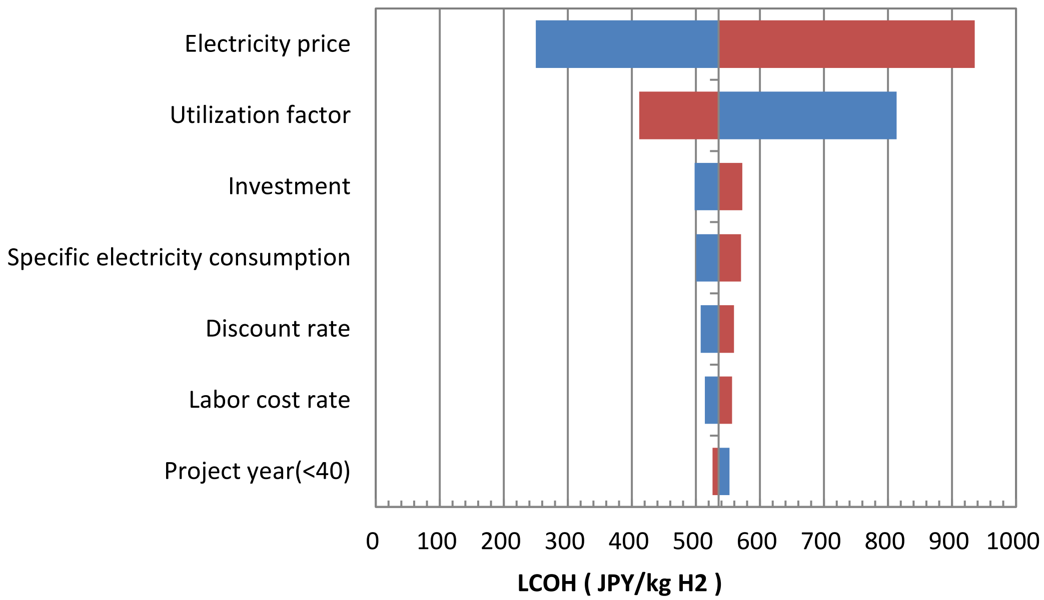


1 USD = 115 JPY

Example 1 Hydrogen production: water electrolysis

- Assumptions that have high sensitivity to hydrogen costs are electricity price and utilization factor.
- Other assumptions changed here have small effect on the results.

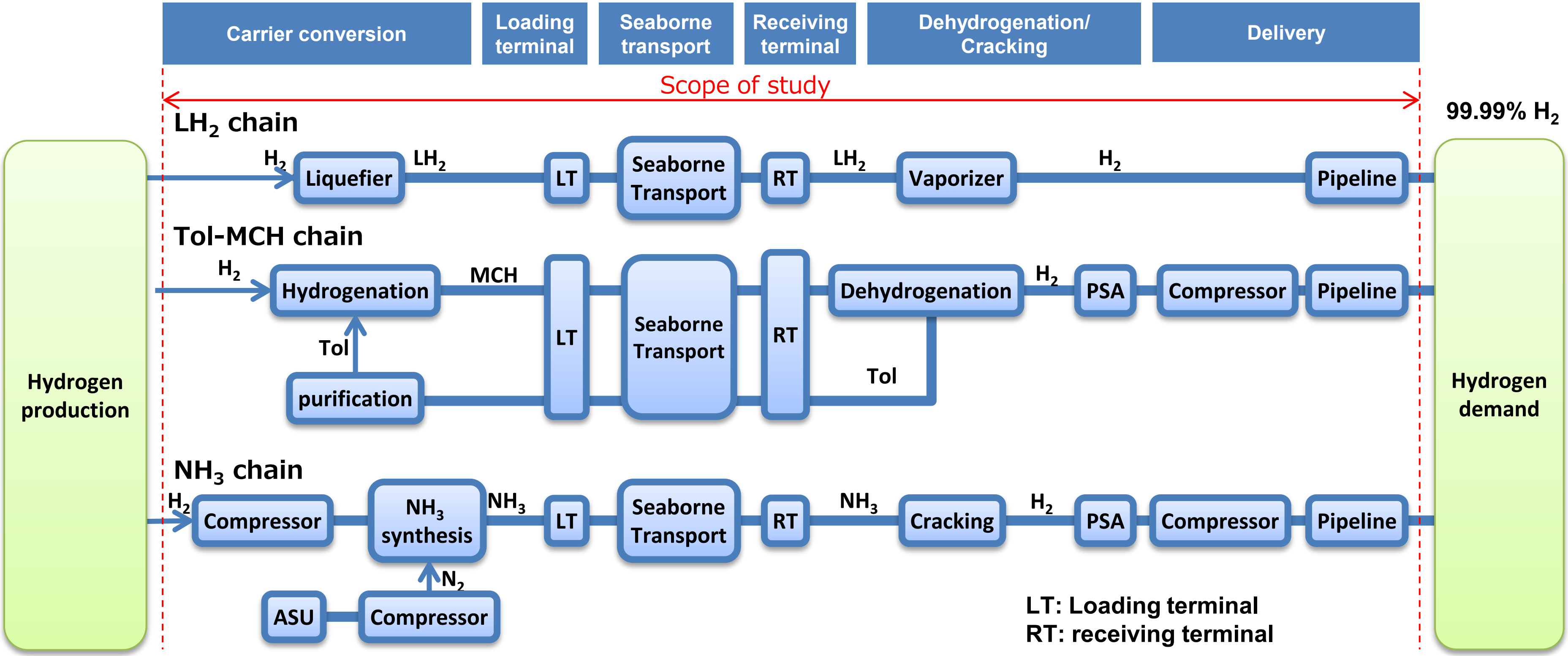
Sensitivity analysis of hydrogen cost by water electrolysis (Utilization factor = 90%)



Cost breakdown and its sensitivity on assumptions tell us clues for improvement.

Example 2: hydrogen long distance transport

- System consists of Large scale carrier conversion, long distance transport, delivery(pipeline, road, train and ship)
- The scope is from hydrogen to hydrogen.
  - Input hydrogen is considered as feedstock.



Y. Ishimoto et al, Techno-economic study of hydrogen carrier chains for long distance transport in a deployment phase, World Hydrogen Technology Convention 2019 (WHTC2019), 2019, Tokyo.

Common assumptions

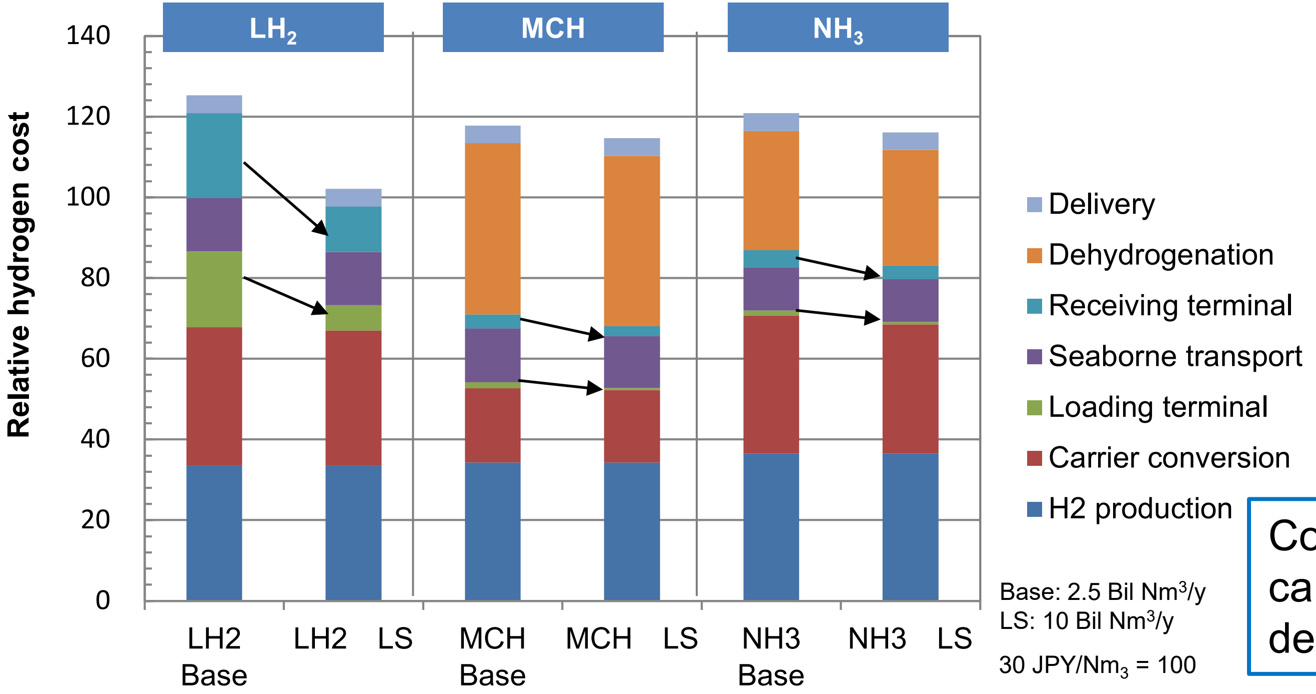
Case	Delivered hydrogen	Note
Base	2.5 billion Nm^3/(y chain) (225 kt/y chain)	Baseline
Large scale (LS)	10 billion Nm^3/(y chain) (900 kt/y chain)	Assumed the same technology level as baseline case

- Static and block flow diagram based analysis
- Energy carrier system
  - Utilization factor: 90%
  - Electricity for utility: supplied from the grid
  - Plant life time: 30 years
  - Transport distance :10,000 km

Y. Ishimoto et al, Techno-economic study of hydrogen carrier chains for long distance transport in a deployment phase, World Hydrogen Technology Convention 2019 (WHTC2019), 2019, Tokyo.

Large scale chain can improve economic efficiency

- LH_2
  - Increase of turnover in the loading terminal storage reduces the cost .
  - Increased storage in the receiving terminal also reduces CAPEX per unit storage
- MCH and NH_3
  - The same effects are expected but cost contribution from terminals are not large.
  - Heat integration with adjacent industry plants, demand without purification, direct use (only NH_3) can reduce the hydrogen cost.



Base: 2.5 Bil Nm^3/y
LS: 10 Bil Nm^3/y

30 JPY/Nm_3 = 100

- Major cost drivers
- LH_2 (CAPEX)
  - LH_2 related technologies (liquefier and storage technologies)
- MCH (OPEX)
  - Dehydrogenation, especially reaction heat
- NH_3 (OPEX)
  - NH_3 synthesis and cracking

Competitiveness of hydrogen carriers also depends on demand technologies

Y. Ishimoto et al, Techno-economic study of hydrogen carrier chains for long distance transport in a deployment phase, World Hydrogen Technology Convention 2019 (WHTC2019), 2019, Tokyo.

Summary

- Energy systems analysis of hydrogen can provide a lot of useful clues for R&D prioritization.
  - Cost breakdown tells us which part should/can be cut
- Large scale chain can improve economic efficiency
  - Levelized cost of hydrogen using energy carrier are in similar range.
  - Competitiveness of hydrogen carriers also depends on demand technologies
- There are multiple directions of R&D for hydrogen deployment
  - Efficiency, large-scale facility, learning effect etc.