# The potential of hydrogen

To get ahead in the energy transition, energy players should take advantage of the growing momentum for hydrogen.

*This article is a collaborative effort by Suzane de Sá, Thomas Geissmann, Jesse Noffsinger, Rim Rezgui, and Jesús Rodríguez González, representing views from McKinsey's Electric Power & Natural Gas Practice.*

Renewable energy sources (RES) play a critical role in meeting global climate targets, and hydrogen is emerging as another key solution in the energy transition. Although hydrogen is used in just a few applications today, it can help enable a decarbonized electric grid and provide substitution for fossil fuels in several parts of the industry, transportation, and buildings sectors.

## Hydrogen of the future

**Hydrogen now**

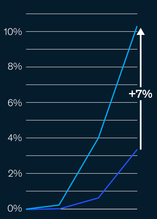
- Ammonia and methanol production
- Steel production

- Transportation
- Building heat
- Thermal power generation
- Fuel cells

## In the years to come, an increasing share of RES will be dedicated to green hydrogen production, enabling a large value pool

**Energy demand for hydrogen production in main continental EU markets[1]**

Energy demand for hydrogen production as a percentage of planned RES production, %




**Scenario 1: Accelerated energy transition**

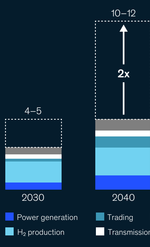
Increased regulations around faster uptake of hydrogen and revised production routes

**Scenario 2: Delayed energy transition**

Consensus view on adoption of hydrogen-based solutions, especially in road transport and aviation

**Future hydrogen value**

Hydrogen EBIT value pools across the value chain, € billions




**2x**

A strong push for hydrogen could double the value pool in 2040 from $5 billion to $10 billion or more

Across the hydrogen value chain, the main drivers of growth are expected to be power generation for green hydrogen and hydrogen production itself, making up the bulk of the value pools in the next two decades.

## The increasing role of hydrogen poses several questions for governments, utilities, and potential producers or off-takers

**Resource quality and production costs**

- What are the most attractive locations for hydrogen production, given renewable resource quality?
- What will be the optimal production costs in different countries?

**System configuration and sizing**

- What is the optimal mix of solar and wind?
- What is the optimal configuration among RES, electrolyzer, and storage sizes to minimize waste and reduce costs?

**Carrier choice and distribution costs**

- What are the best energy carriers and transport modes (such as truck versus pipe versus wire) depending on end use and location?
- What shipping distribution costs will be associated with different hydrogen carriers?

## Players should consider several factors when answering these questions—and advanced modeling capabilities can help inform and provide insights

The potential of RES, along with electrolyzer costs, will play a critical role in determining production costs for green hydrogen

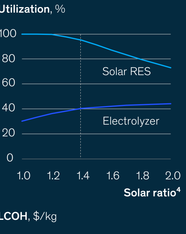
**Levelized cost of hydrogen (LCOH) in select countries in 2030,[3] $/kg**


**Other cost factors to consider:**

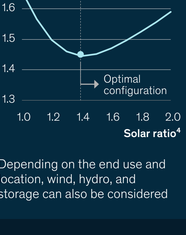
- local weighted average cost of capital
- presence of off-takers or demand market
- access to water and qualified labor
- permitting for infrastructure building
- sentiment of local populations

An optimal, least-cost configuration will likely require RES to be built at higher capacity than the electrolyzer

**Utilization**, %




**LCOH**, $/kg




Depending on the end use and location, wind, hydro, and storage can also be considered

Distribution costs will depend on the carrier of choice as well as the existing infrastructure[5] to support it[6]

**$LiqH_2$ and LOHC**

**Liquid hydrogen and Liquid Organic Hydrogen Carrier**

for all hydrogen consuming end applications[7] including high purity applications like transport

**$NH_3$**

**Ammonia**

for direct use,[8] for applications with lower purity requirement[9] or high purity applications (requires additional purification)

**As we move toward building a hydrogen economy, it is crucial to select optimal production locations, plant configurations, and carrier options. These choices are important from the project level to a country's energy strategy level.**

**Want to learn more about how hydrogen can be optimally harnessed? Contact us here.**

**Suzane de Sá** is a solution manager in McKinsey's Southern California office, **Thomas Geissmann** is an alumnus of the Zurich office, **Jesse Noffsinger** is an associate partner in the Seattle office, **Rim Rezgui** is a solution analyst in the Düsseldorf office, and **Jesús Rodriguez González** is a partner in the Madrid office.

[1]Austria, Belgium, Bulgaria, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Italy, the Netherlands, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden.
[2]High hydrogen consumption scenario, in which hydrogen uptake is driven by government pushes. For more, see "Global Energy Perspective 2021," McKinsey, January 2021.
[3]Illustrative example based on simulations for the year 2030, considering alkaline electrolyzers.
[4]Ratio of solar to electrolyzer capacity.
[5]"Hydrogen insights: A perspective on hydrogen investment, market development and cost competitiveness," Hydrogen Council and McKinsey, February 2021.
[6]Synthetic methane produced from biogenic or air-captured $CO_2$ is a possible fourth candidate, which will be further studied.
[7]Depends on selected carrier.
[8]Eg, chemical feedstock, shipping fuel, power plant fuel.
[9]Eg, industrial heating.

Source: McKinsey analysis

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