Hydrogen Tech 2.0:

Breakthrough Technologies Reshaping the Market

Cansu Doganay
Analyst

Agenda

01 | The EU’s hydrogen strategy, progress, & challenges

02 | Next-generation hydrogen production technologies

03 | Conclusions & takeaways

The EU’s energy transition started in 2019…

DECEMBER 2019

EU Green Deal

...and is gaining steam with multiple policy measures

DECEMBER 2019

EU Green Deal

JULY 2020

EU Hydrogen Strategy

JULY 2021

Fit For 55

OCTOBER 2023

RED III

APRIL 2024

1ST EHB AUCTION

DECEMBER 2024

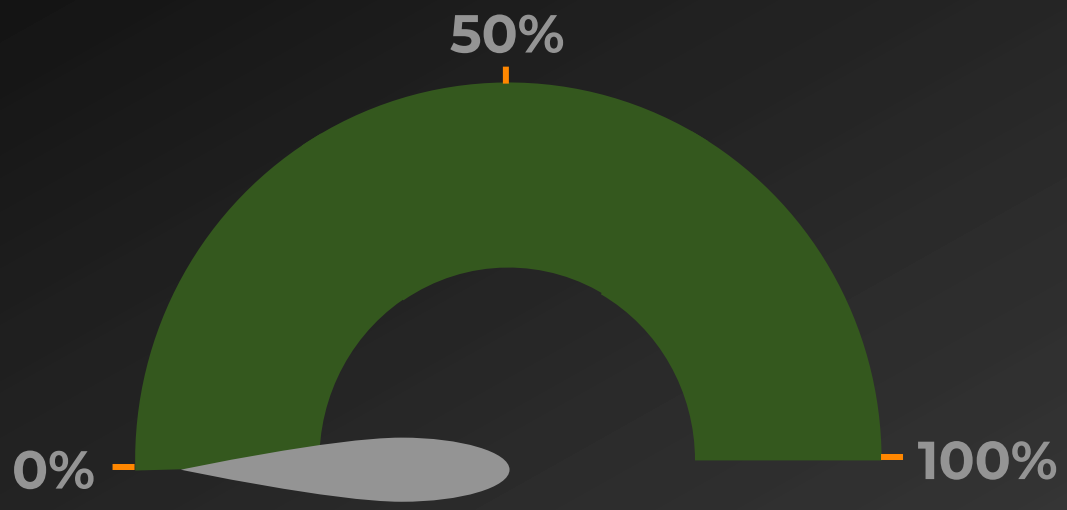
2ND EHB AUCTION

Low-carbon Hydrogen

GOAL

10 Mtonne of hydrogen production + 10 Mtonne of hydrogen imports by 2030

Progress toward 2030 target



Low-carbon Hydrogen

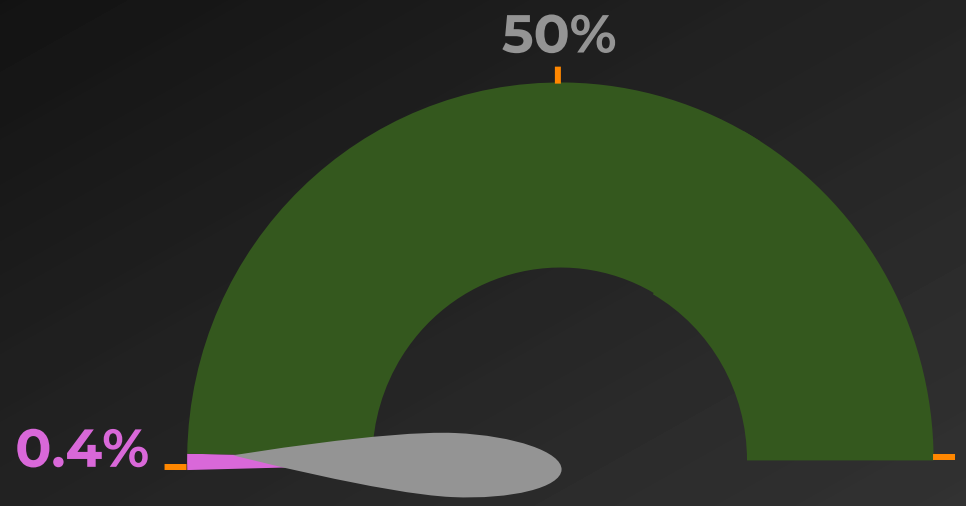
GOAL

10 Mtonne of hydrogen production + 10 Mtonne of hydrogen imports by 2030

PROGRESS

The EU has capacity to produce 37,000 tonne of green hydrogen in 2024.

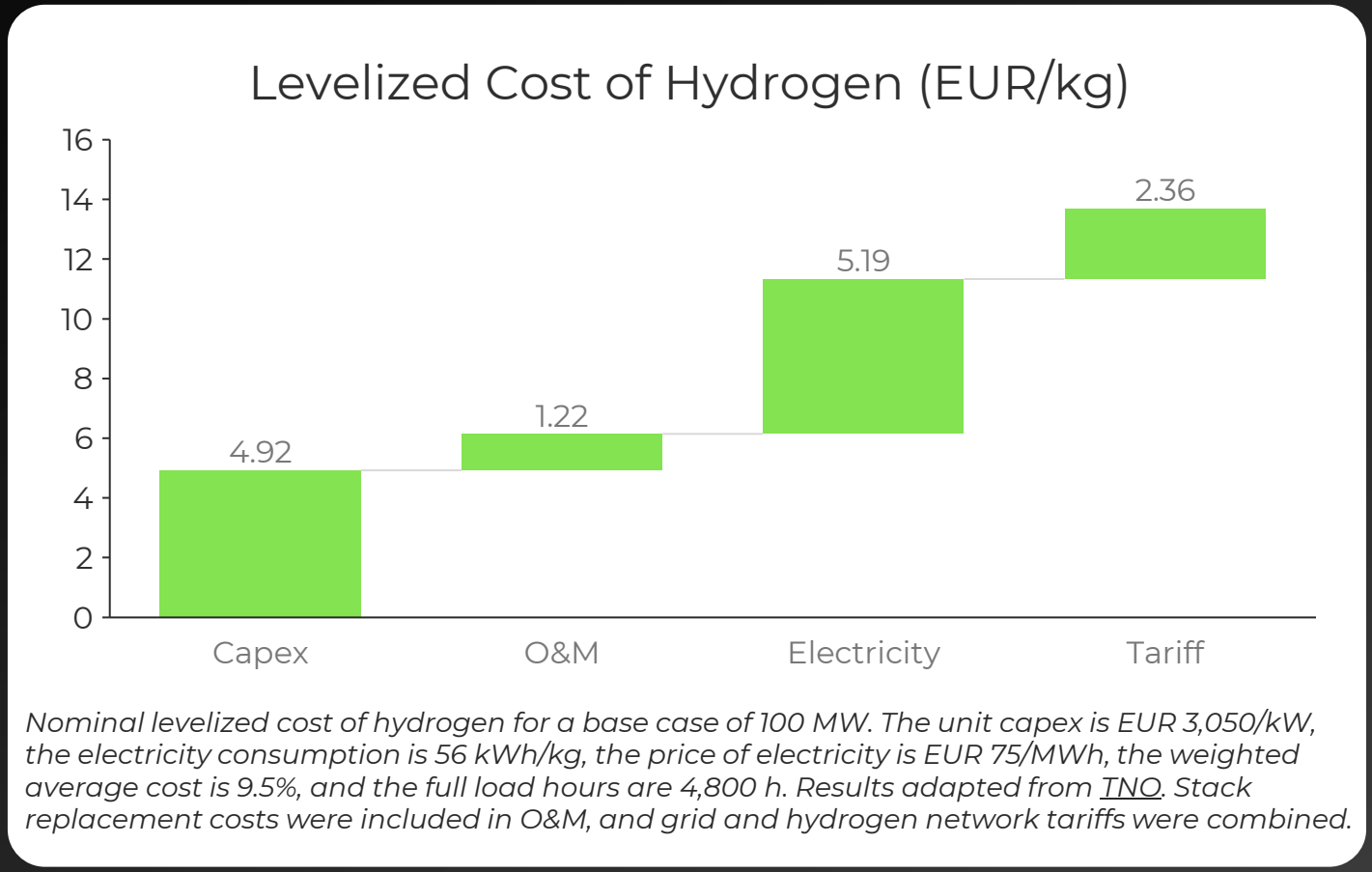
Progress toward 2030 target



Despite its best efforts, the EU is not on track to meet its net-zero targets.

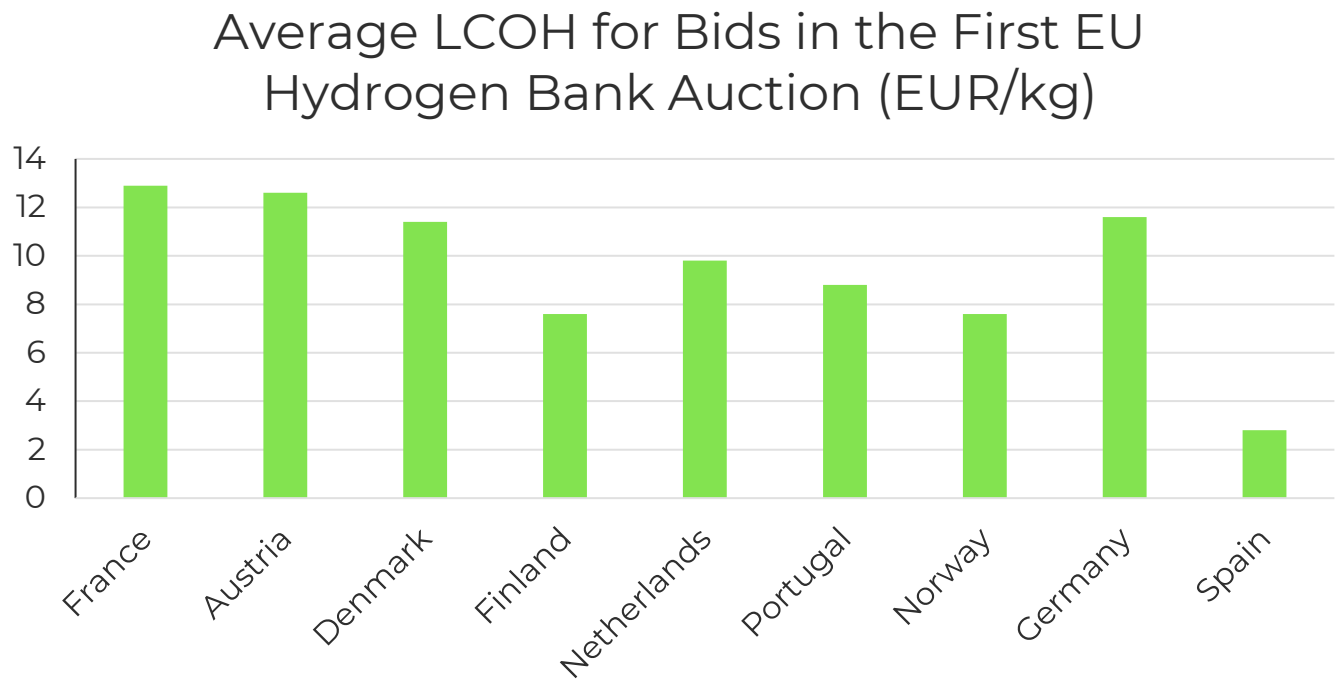
Green H_2 at EUR 14/kg in NL

Electricity is the largest contributor to LCOH, followed by capex.



Nominal levelized cost of hydrogen for a base case of 100 MW. The unit capex is EUR 3,050/kW, the electricity consumption is 56 kWh/kg, the price of electricity is EUR 75/MWh, the weighted average cost is 9.5%, and the full load hours are 4,800 h. Results adapted from TNO. Stack replacement costs were included in O&M, and grid and hydrogen network tariffs were combined.

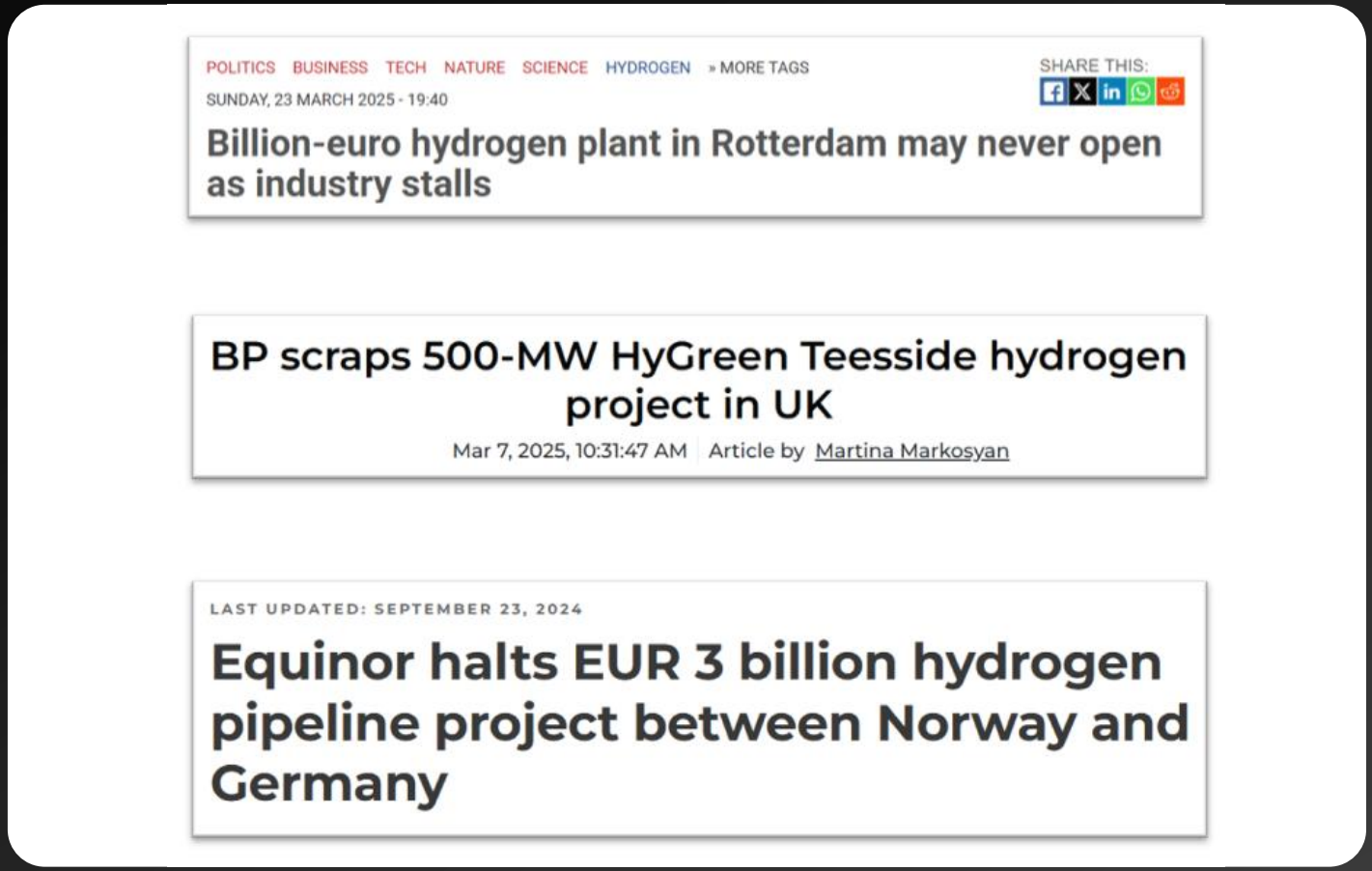
Similar Situations Across EU



Average levelized cost of hydrogen (LCOH) for countries with at least five bids in the first EU Hydrogen Bank Auction. Results adapted from the European Commission.

Project Cancelations in the EU

Multiple large-scale green hydrogen projects in the EU cancel as LCOH remains prohibitively expensive.



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SUNDAY, 23 MARCH 2025 - 19:40

Billion-euro hydrogen plant in Rotterdam may never open as industry stalls

BP scraps 500-MW HyGreen Teesside hydrogen project in UK

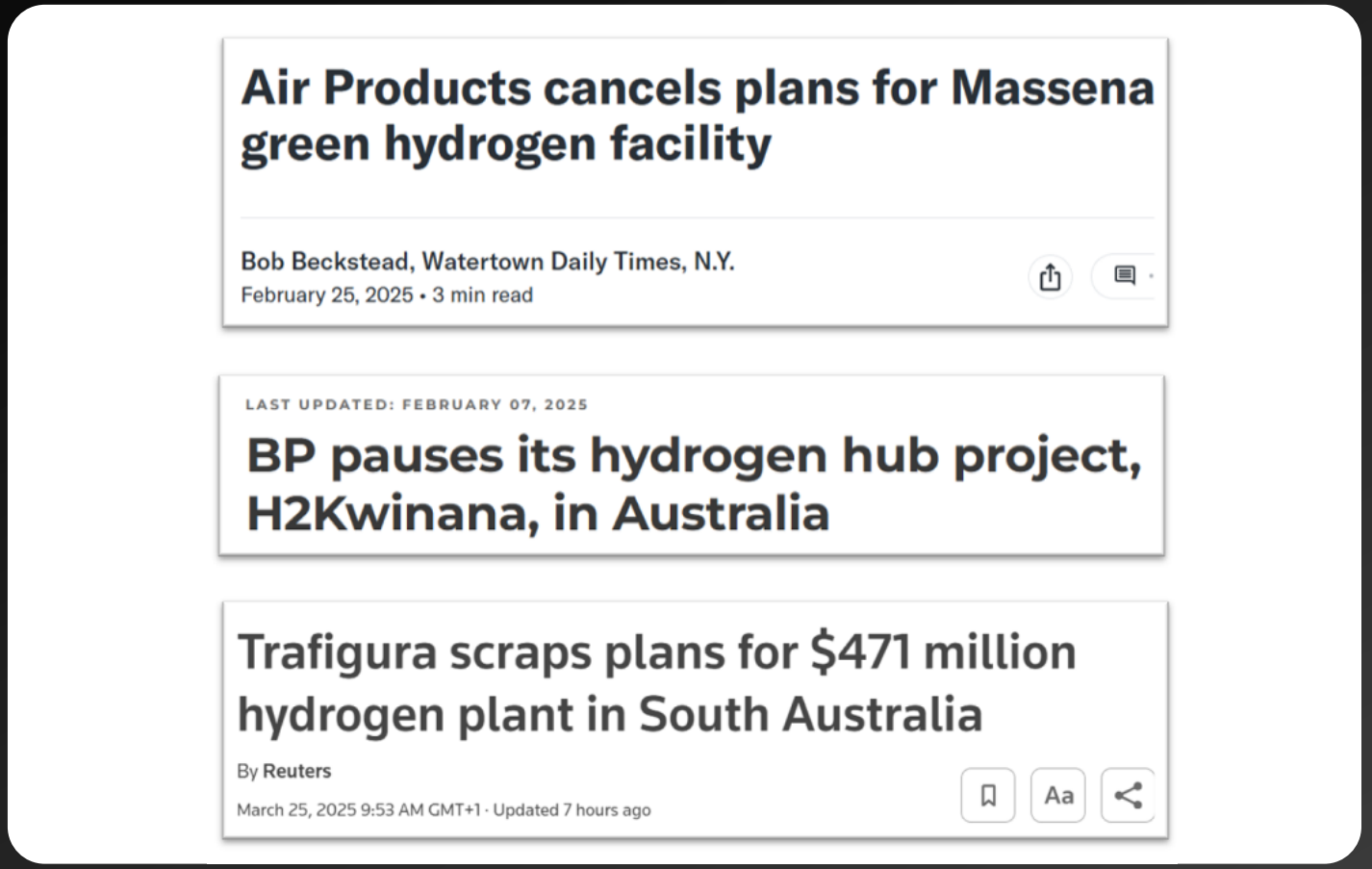
Mar 7, 2025, 10:31:47 AM | Article by Martina Markosyan

LAST UPDATED: SEPTEMBER 23, 2024

Equinor halts EUR 3 billion hydrogen pipeline project between Norway and Germany

Project Cancelations Outside EU

Cancellation of green hydrogen projects is a global trend.



Air Products cancels plans for Massena green hydrogen facility

Bob Beckstead, Watertown Daily Times, N.Y.
February 25, 2025 • 3 min read

LAST UPDATED: FEBRUARY 07, 2025

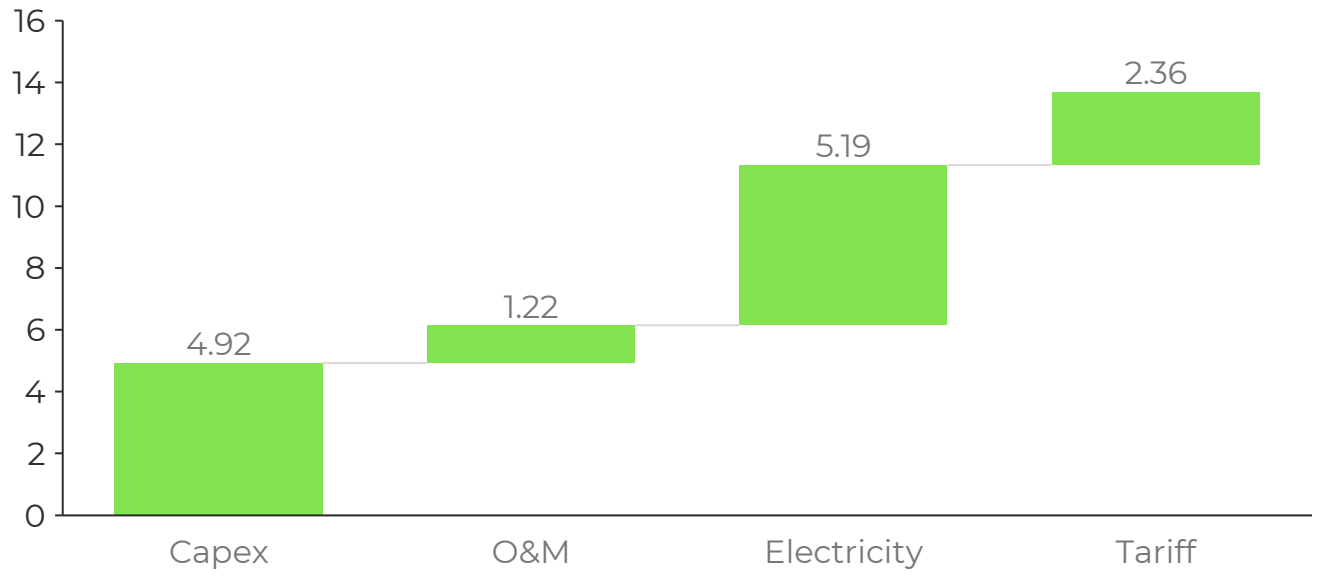
BP pauses its hydrogen hub project, H2Kwinana, in Australia

Trafigura scraps plans for $471 million hydrogen plant in South Australia

By **Reuters**
March 25, 2025 9:53 AM GMT+1 · Updated 7 hours ago

Green H_2 at EUR 14/kg in NL

Electricity is the largest contributor to LCOH, followed by capex.



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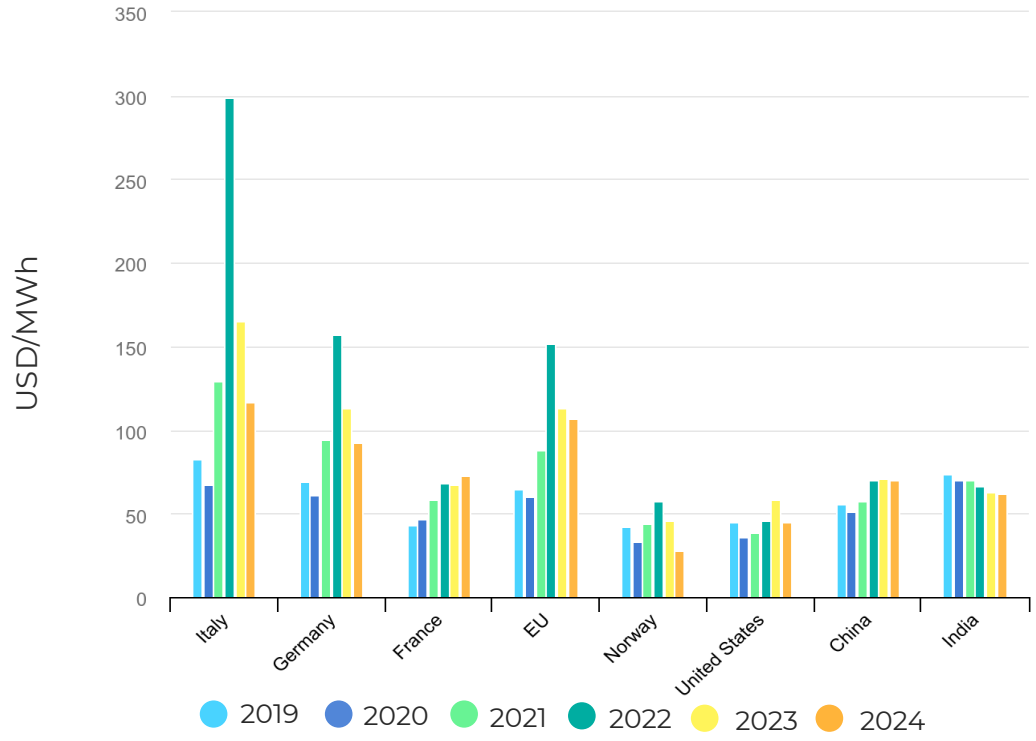
EU’s Electricity Price

While on the decline, the final price of electricity for large industrial customers was USD 100/MWh in 2024, which is much higher than in major countries outside the EU such as the U.S., China, and India.

Estimated Final Electricity Price for Large Industrial Customers in Energy-Intensive Industries, 2019–2024 (Source: IEA)



How can the EU ensure energy security and meet decarbonization goals?

Water Electrolysis is the Main Technology to Produce Green H_2

Hydrogen 2.0: Next-generation Technologies

Gen 1

Using only electricity for water splitting

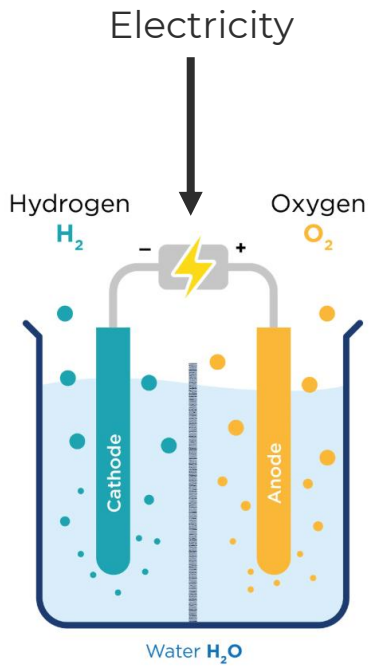


Image source: De Nora

Case Study

Thyssenkrupp focuses on zero-gap configuration

- Thyssenkrupp's technology is an alkaline electrolyzer with a zero-gap configuration. There is virtually no gap between the membrane and electrodes, resulting in a claimed efficiency of >82% (HHV – 4.3 kWh/Nm3 H2).
- Core IP is on the plastic spacer fabric, which is coated with a metallic layer or incorporated with woven-in metal wires, maintaining elasticity and electrical contact.

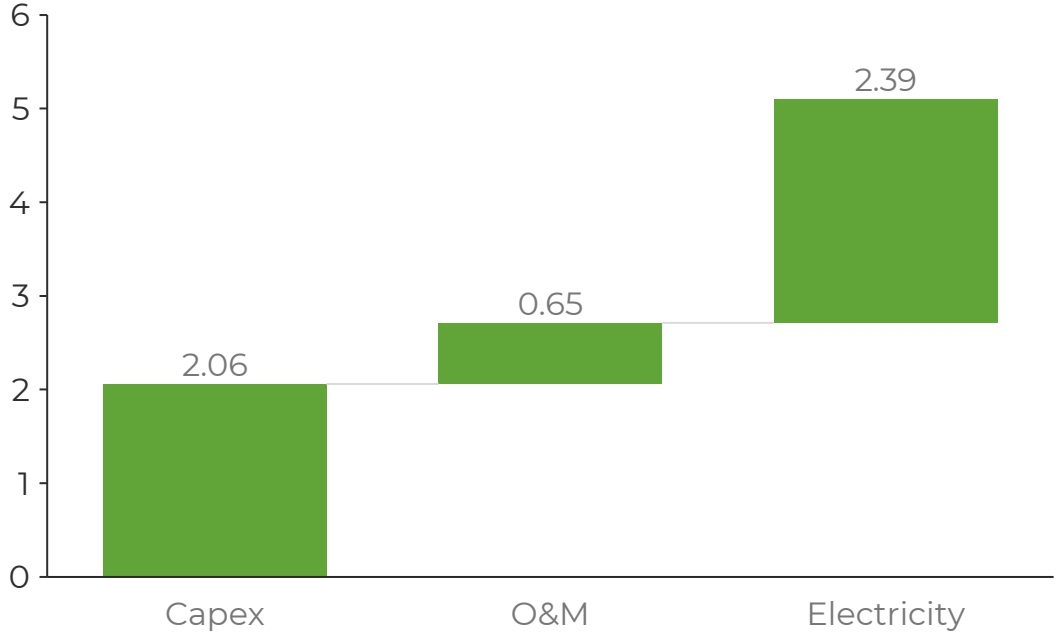
LUX TAKE

Zero-gap configuration is a significant advance to the efficiency of traditional alkaline electrolysis that typically exhibits 50%–60% efficiency. Thyssenkrupp is a key player in the space with proven technology that is ready for commercial deployment.

thyssenkrupp

Image source: Thyssenkrupp

Gen 1: Hydrogen at EUR 5.11/kg



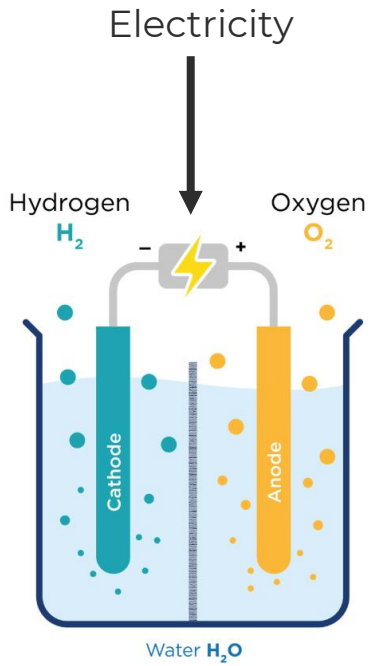
Assumptions: Capex: EUR 1,300/kW; electricity: EUR 50/MWh; system electricity consumption: 47.8 kWh/kg H_2

Thyssenkrupp has one of the most efficient Gen 1 electrolyzers.

Hydrogen 2.0: Next-generation Technologies

Gen 1

Using only electricity for water splitting



Gen 2

Partially replacing electricity with other energy sources

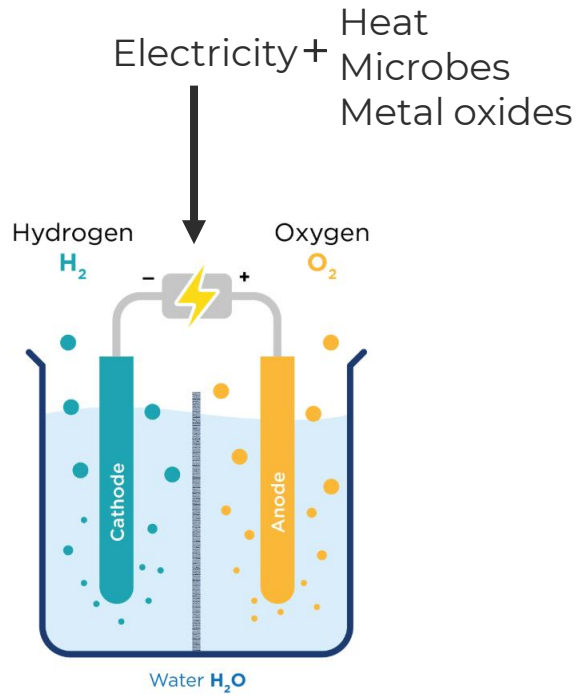
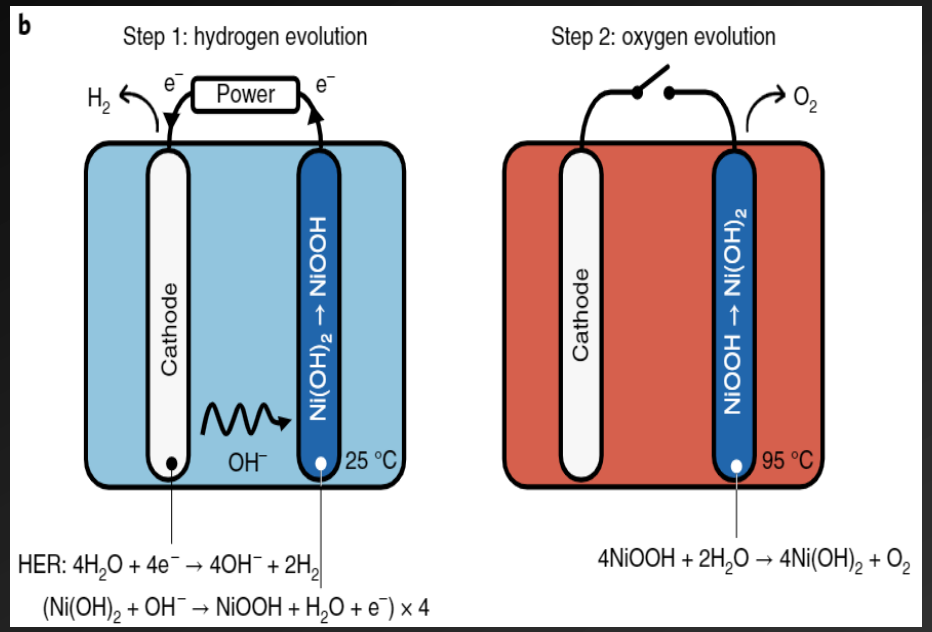


Image source: De Nora

Case Study

H_2Pro focuses on E-TAC-decoupled electrolysis

- Core to H_2Pro's technology is the electrochemically and thermally activated (E-TAC) anode, which is charged with OH- during hydrogen evolution at 25 °C. Power is cut during discharge and the E-TAC anode releases oxygen at 95 °C.
- The company claims a maximum electricity consumption of 44 kWh/kg of hydrogen (~90% HHV) for E-TAC. There is no membrane or precious metals in the stack.



LUX TAKE

H_2Pro is currently scaling the first-generation system to pilot scale; the second generation, which will incorporate E-TAC, can lead to much lower LCOH compared to conventional electrolysis.

H_2PRO

Image source: Utility

Case Study

Ki Hydrogen focuses on electrochemical looping to produce H_2 and CO_2 from biomass

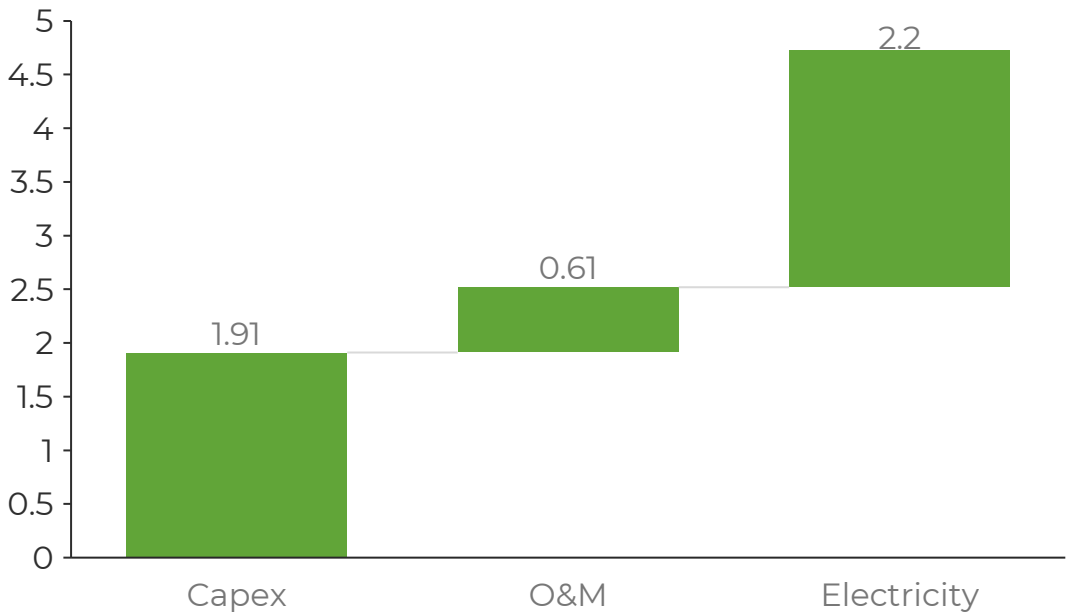
- Ki Hydrogen's electrochemical looping system does not use microbes to process biomass,. It uses liquid biomass to reduce an undisclosed catalyst, releasing biogenic CO_2. The reduced catalyst is oxidized in an electrochemical cell to produce H_2. H_2:CO_2 yield is 9:1.
- It claims to consume 25 kWh/kg H_2 and produce hydrogen at USD 2/kg and biogenic CO_2 at USD 100/tonne.

LUX TAKE

While the company has yet to reach pilot scale, the lack of microbes in the system makes Ki Hydrogen's technology easier to scale compared to competitors using microbes, as microbes are difficult to keep alive and monitor at scale.

Image source: Ki Hydrogen

Gen 2: Hydrogen at EUR 4.84/kg



Assumptions: Capex: EUR 1,300/kW; electricity: EUR 50/MWh; system electricity consumption: 44 kWh/kg H_2

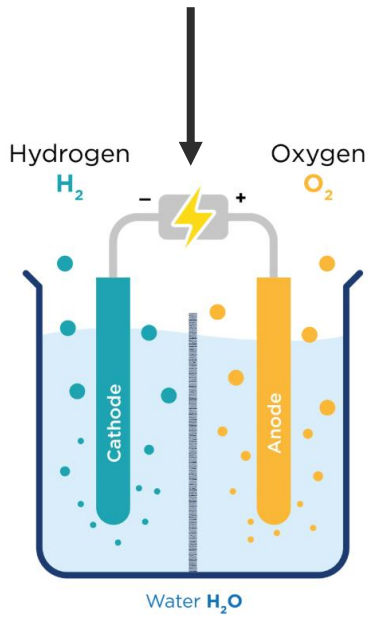
H_2Pro's decoupled electrolysis can match the lowest electricity consumption from Gen 1 while also lowering capex.

Hydrogen 2.0: Next-generation Technologies

Gen 1

Using only electricity for water splitting

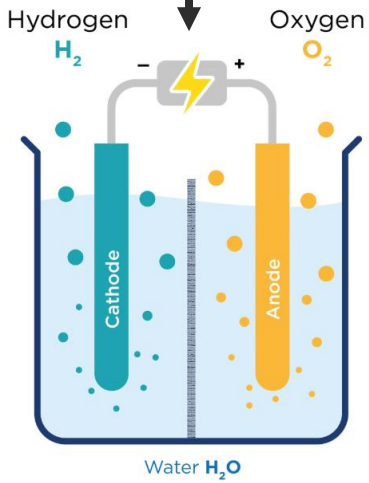
Electricity



Gen 2

Partially replacing electricity with other energy sources

Electricity + Heat, Microbes, Metal oxides



Gen 3

Eliminating electricity fully with other energy sources

Heat, Solar energy

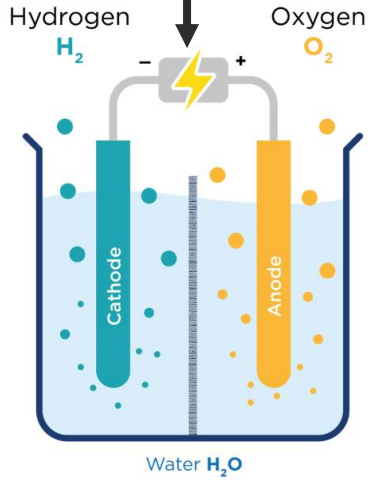
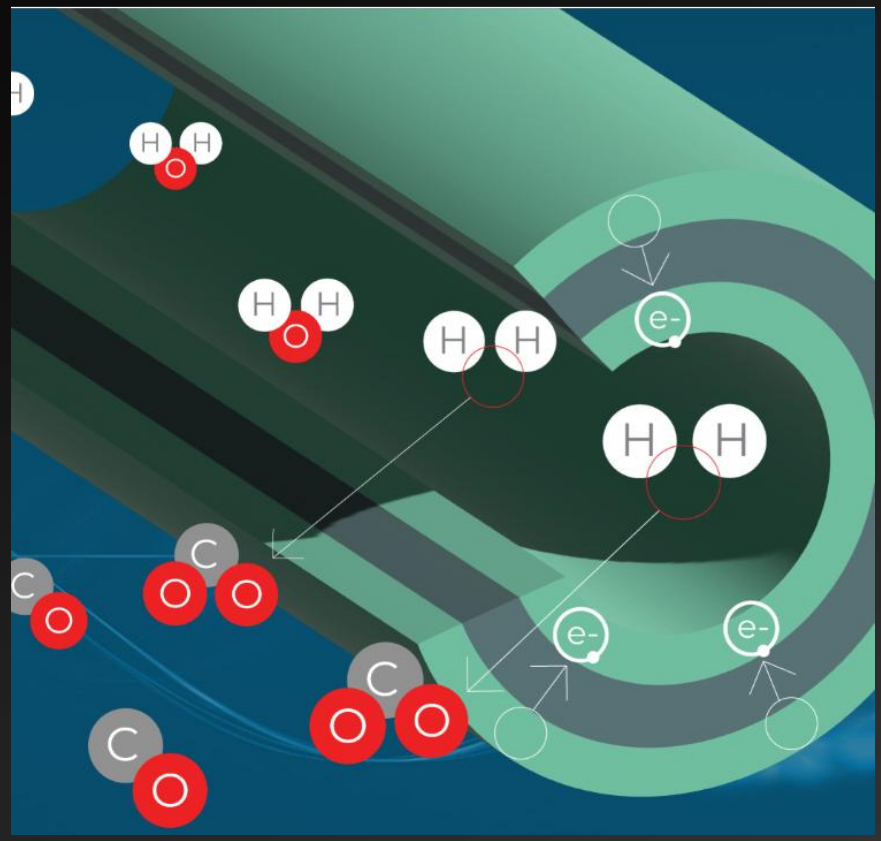


Image source: De Nora

Case Study

Utility focuses on electricity-free water splitting

- Utility's proprietary, tubular, solid oxide cells leverage the electrochemical reaction between steam and offgasses at the cathode and anode, respectively. Steam and industrial offgasses at 600 °C react with water to produce H_2 and CO_2.
- Utility completed piloting the H_2 generator that was directly coupled to a steel blast furnace in Ontario, Canada. The reactor ran for 3,000 hours and produced 10 kg H_2/day.



LUX TAKE

While the company will need to combine this approach with carbon capture for full decarbonization, it is a viable retrofit solution for hard-to-abate sectors, given its no electricity requirement and highly concentrated CO_2 output, which is cheaper to capture than capturing directly from the facility.

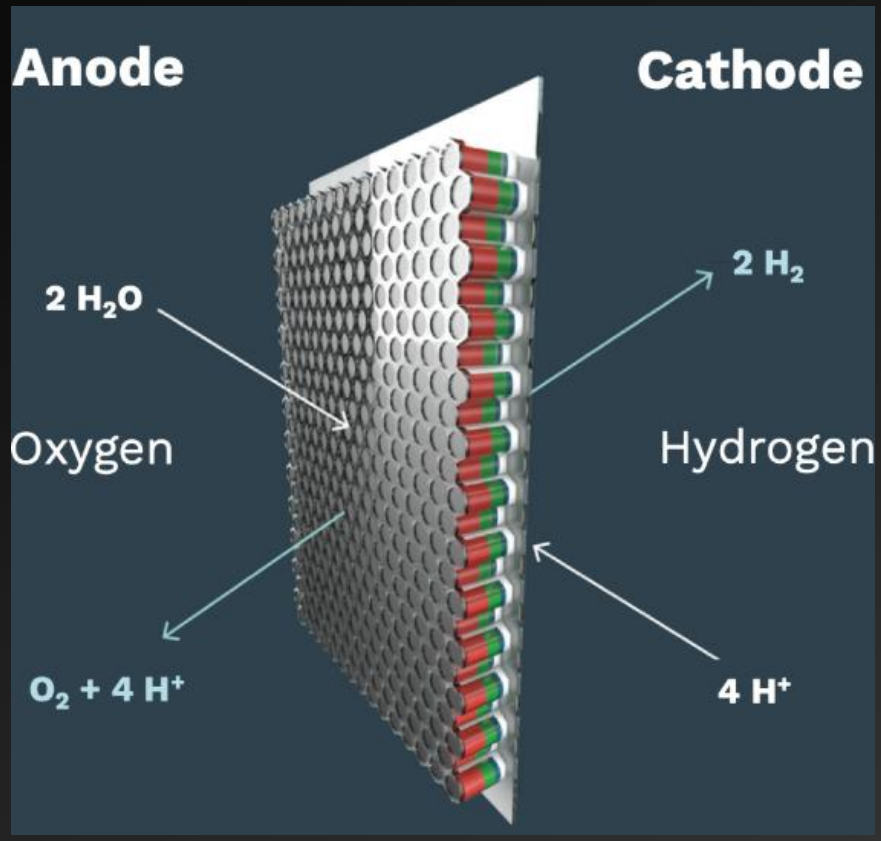
UTILITY

Image source: Utility

Case Study

SunHydrogen focuses on photocatalytic water splitting

- SunHydrogen develops photoelectrosynthetically active heterostructures (PAHs) that are composed of multiple layers of oxidation and reduction electrocatalysts. The company assembles PAHs in larger panels.
- It tested a 100-cm^2 panel at Honda's R&D facility in Japan demonstrating 10.8% STH* efficiency, while the most recently built 1200 cm^2 panel showed 9% STH efficiency.



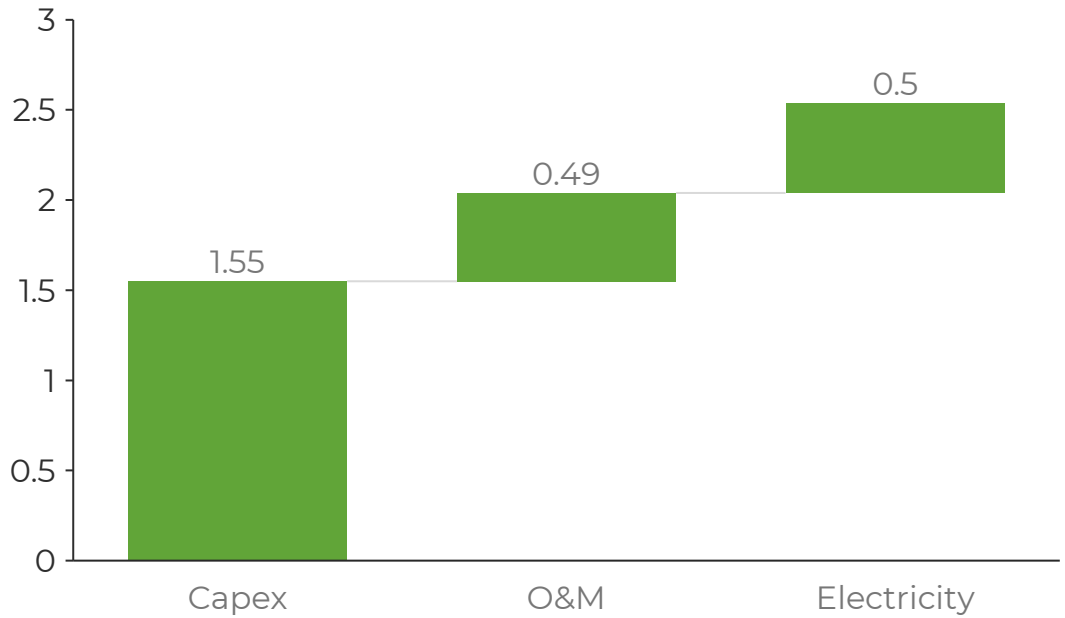
LUX TAKE

While SunHydrogen claimed 3× higher STH than the market range in 2021, it is not yet able to prove this claim as STH went down as the company scaled up. While this is an inherent challenge of photocatalysis, the company needs to attain higher STH for commercialization.

SunHydrogen

*STH: solar-to-hydrogen; Image source: SunHydrogen

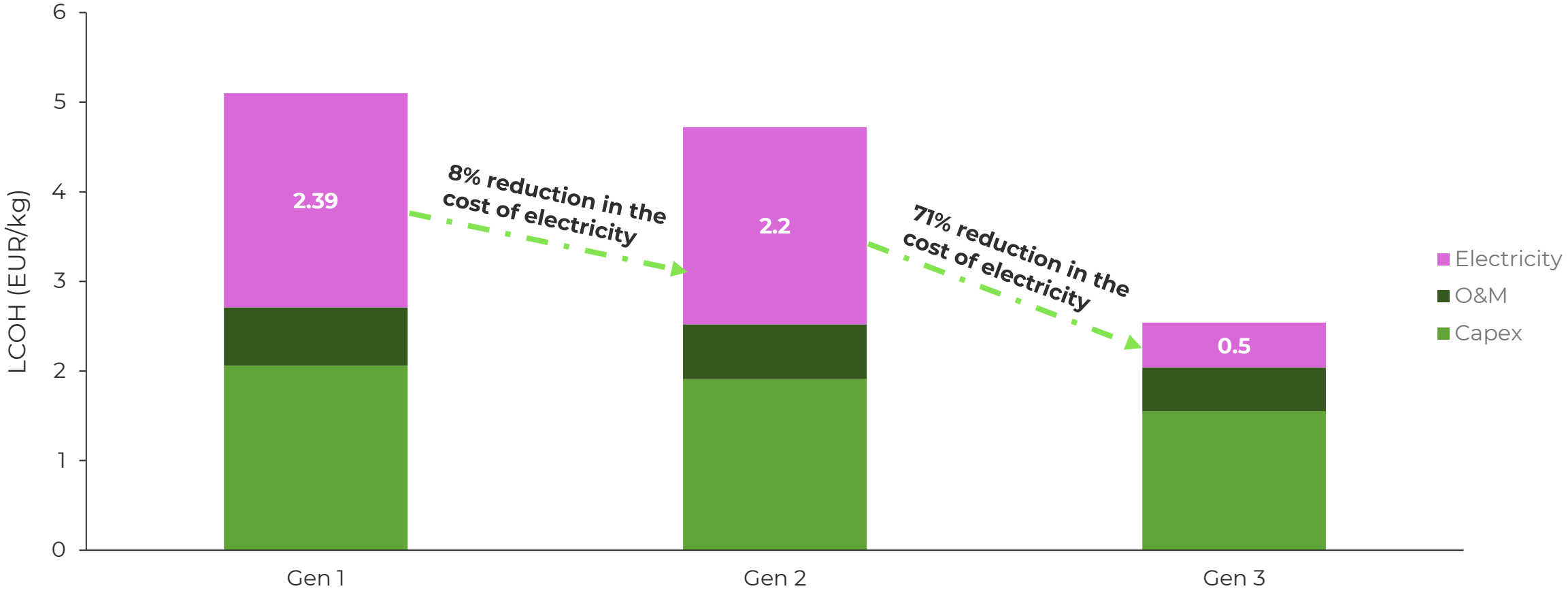
Gen 3: Hydrogen at EUR 2.66/kg



Assumptions: Capex: EUR 3,900/kW; electricity: EUR 50/MWh; system electricity consumption: 10 kWh/kg H_2

Utility's system requires electricity only for the balance of plant (pumps and compressors) to move the gases, leading to significant LCOH savings.

79% Of Electricity Saved From Gen 1 To Gen 3



Hydrogen 2.0: Next-generation Technologies

Gen 1

Using only electricity for water splitting

thyssenkrupp
Enapter
SIEMENS energy
sunfire
VERDAGY
TOPSOE
John Cockerill
nel
LONGi
ITM

Gen 2

Partially replacing electricity with other energy sources

H2PRO
Clyde Hydrogen
Integrated Dynamics
H2WIN
Hydrogen Worldwide Integration
HYDROPORE
surrey hydrogen
STOFF2

Gen 3

Eliminating electricity fully with other energy sources

UTILITY
NewHydrogen
SunHydrogen
SPARC HYDROGEN
hysun
Solhyd
SoHHytec
SOLAR FUEL. THE SMARTER WAY

Hydrogen Has Two Key Roles: Fuel And Feedstock

Hydrogen as a fuel

Heat and power production

Technology	Fuel type
Fuel cells	H_2
Boilers	H_2 or e-methane
Turbines	H_2 or e-methane

Mobility

Technology	Fuel type
Fuel cells	H_2
Jet engines	e-SAF

Hydrogen as feedstock

Methanol

Technology	Feedstock
CO_2 hydrogenation	H_2, CO_2

Refining

Technology	Feedstock
Hydrocracking	H_2
Hydrotreatment	H_2

Steel

Technology	Reducing agent
H_2-direct reduced Iron	H_2

Ammonia

Technology	Feedstock
Haber-Bosch	H_2, N_2

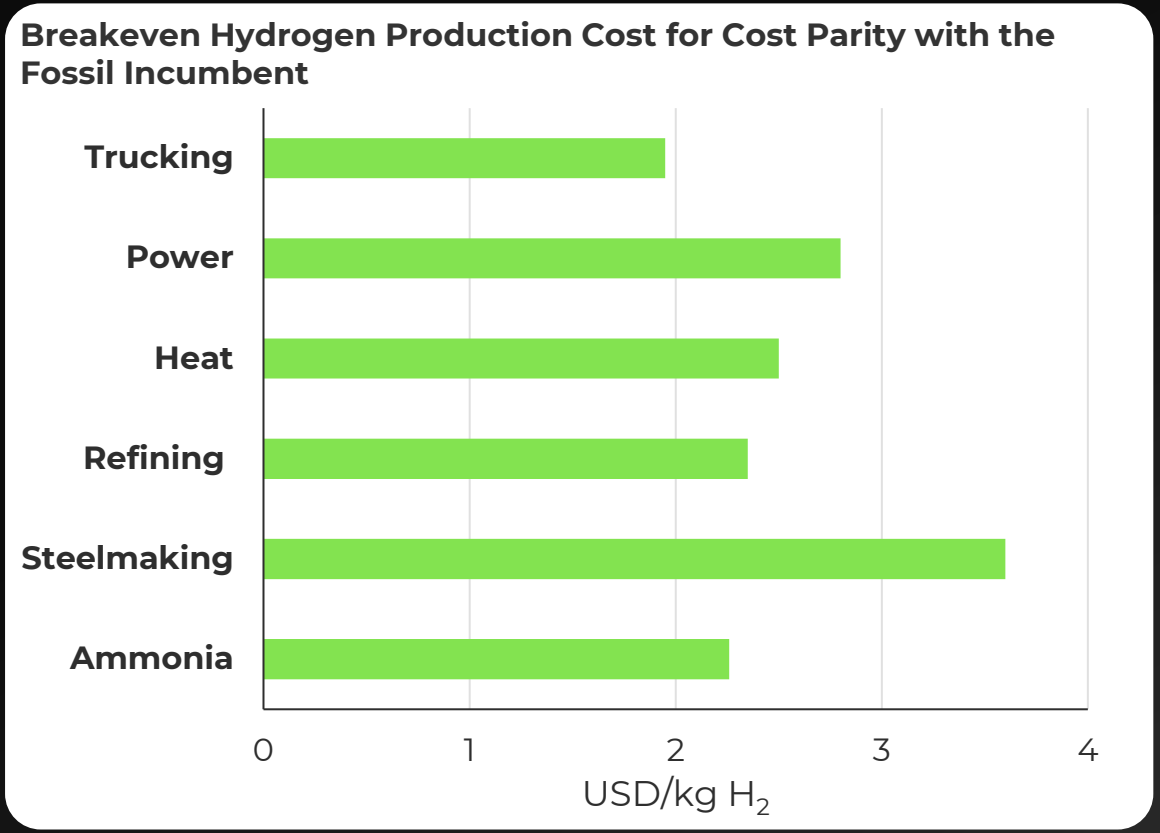
“ ”

Under the Renewable Energy Directive, at least 42% of hydrogen used in industry and 29% in transport must be renewable by 2030. These are binding targets we all agreed on.

Ursula von der Leyen
November 2024

Image and quote source: European Commission

Gen 3 is Needed For Industrial Adoption of Green Hydrogen



The breakeven hydrogen price to reach cost parity with the incumbent pathways used in the industrial sector ranges from USD 1.95–USD 3.6/kg H_2.

Key Takeaways

1

Traditional electrolysis is only option for near-term deployments.

Even though traditional electrolyzers exhibit poor performance, they are the only options for near-term commercial projects. Due to high production costs, deployments will be supported heavily by government grants.

2

Decoupled electrolysis and thermochemical water splitting should be considered for pilots.

Gen 2 & 3 technologies will play a key role in producing hydrogen by reducing the LCOH in the long term, while microbial electrolysis and photolysis are not ready for engagement.

3

Corporate activity needs to grow in the next-gen technology landscape.

Next-generation technology development is pursued only by startups, and scaling up these technologies will require collaboration between industrial hydrogen consumers and technology developers.

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