We are *not on track* to meet the Paris Agreement's objectives. What should we do?

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07

Focus *hydrogen* on hard to abate industries

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Key Points

1. The Hydrogen Recalibration: A strategic shift from a universal decarbonization tool to a niche player, primarily focusing on sectors like heavy industry (representing 42% of the targeted low-carbon hydrogen use by 2030 under the EU's RED III) and heavy-duty transportation (5.5% of fuels used in transport shall be biofuels or RFNBO by 2030, with a minimum 1% RFNBO), where electrification faces significant challenges.
2. Deployment Challenges and Varying Willingness to Pay: An in-depth look at the obstacles hindering hydrogen deployment, including securing cost-competitive low-carbon electricity and addressing infrastructure limitations. We also examine the disparity in willingness to pay across sectors, with aviation and shipping potentially leading due to limited alternatives and rising carbon costs.
3. The Role of Regulation: An analysis of how regulatory schemes, particularly in the EU, are shaping the hydrogen market through incorporation targets and incentives like the French TIRUERT, driving the adoption of greener solutions

Introduction

The hydrogen landscape is undergoing a profound transformation, marked by a significant recalibration of expectations. Once envisioned as a panacea for decarbonization across all sectors, hydrogen is now finding its strategic niche in hard-to-abate industries. It's a « realistic » moment for the Hydrogen sector.

In this note, we delve into the complexities of the hydrogen market, examining the factors that have led to a 50% reduction in the International Energy Agency's (IEA) projected low-carbon hydrogen demand for 2030. From escalating production costs and competition with electrification to regulatory frameworks and the varying willingness to pay across sectors, we provide a comprehensive overview of the hydrogen landscape.

Hard-to-abate sectors: Betting on hydrogen's unproven promises

1. The great hydrogen recalibration: From a universal decarbonizer vector to strategic niche player

A. This situation is explained by the increasing costs of low-carbon hydrogen production, competition

- **Hydrogen produced by electrolysis will not decarbonize all uses**

  When hydrogen strategies emerged across developed countries about four years ago (the French hydrogen strategy was launched in September 2020 and now more than 50 national strategies are deployed worldwide), low-carbon hydrogen was seen as a vector for decarbonizing numerous sectors. Indeed, the role of hydrogen as a means of decarbonization was very broad, including mobility, industry, stationary storage, heating, etc., with very ambitious goals.

- **To meet these decarbonization needs, the goals are far too ambitious. Only certain uses have strong potential: heavy industry and air/maritime mobility.**

  Whatever the source, 90 million tons of low-carbon hydrogen by 2030 would be enough to sustain claims that the world is on track to limit warming to 1.5°C above pre-industrial levels.

But is this realistic? After all, 150 million tons in 2030 would be a 50% increase over the current 95 million tons of annual demand in seven years. This would only require a 6% compound annual growth rate. The International Energy Agency's (IEA) October 2021 net zero by 2050 roadmap showed a figure of 212 million tons of hydrogen by 2030 (150 million must be low-carbon).

The 2023 update of this roadmap saw the IEA reduce the total figure to 150 million tons in 2030 and drop the low-carbon figure to 70 million.

Projection	2021 Roadmap net zero by 2050	2023 Roadmap Update
Total hydrogen demand by 2030 (million tons)	212	150
Low-carbon hydrogen demand by 2030 (million tons)	150	70

The evolving landscape has led to a strategic refocusing of hydrogen's role. It's no longer about replacing every fossil fuels molecule but about identifying sectors where its unique properties align with decarbonization challenges. This includes sectors with high-temperature processes that are difficult to electrify directly (e.g., steelmaking, chemical industry) and sectors that rely on liquid fuels for long-distance transportation (e.g., aviation, shipping).

In Europe, the steel and refinery sectors are leading the way, with first projects under construction. In France, the 200 MW Normand'HY project, initiated by H2V and acquired by Air Liquide, has entered the construction phase. It will supply 15 kta to TotalEnergies' oil complex in Normandy. In Portugal, Galp invested in a 100 MW production capacity for its Sines refinery; and in Rotterdam, Shell's Hydrogen Holland project is also under construction to supply 25 kta to the Shell Energy and Chemicals Park. In Germany, RWE plans to commission 300 MW of electrolysis capacity in three stages by 2027. The aim of the project, GET H2 Nukleus, is to initiate the development of a regional hydrogen infrastructure together with partners.

"After a period of adjustment to the reality of green hydrogen prices, industrial offtakers are now ready to enter into long-term agreements with producers. The example is the massive tenders launched by German steelmakers (SHS, Thyssenkrupp and Salzgitter AG) or by TotalEnergies to supply six of its European refineries. This means almost one million tons a year of low-carbon or renewable hydrogen by 2030."

B. This situation is explained by the increasing costs of low-carbon hydrogen production, competition between uses, and regulations, particularly in the European Union.

- **Production cost**

  According to a recent Capgemini study[1], Hydrogen market players generally agree today that the price for low-carbon hydrogen production will decrease below €7/kg by 2030. However, there is no real consensus here, which is leading to a lot of uncertainty overall. (As of today, the actual price range of carbon hydrogen production is estimated to be between €1-3 per kilogram).

  This figure is far from the previous prediction, with production prices expected below €2-3/kg by 2030. In its 2023 Global Hydrogen Review, the IEA maintains that low-carbon hydrogen could be produced in Europe for €1.60/kg by 2030. Meanwhile the market has seen hydrogen production costs increase by 30-65% between 2021 and 2023, according to the World Hydrogen Council.

  Currently, there is no common vision and a lot of real uncertainty, with estimates far away from previous predictions made just a few years ago—a time when the consensus was that renewable hydrogen production costs would dip below €3/kg.

- **Competition of hydrogen with other decarbonization technologies, especially for electrification**

  In some cases, hydrogen as an energy vector is in competition with other decarbonization technologies, particularly when it comes to electrification. This is especially the case for road mobility. The electrification of land transport, such as heavy goods vehicles or buses, is carried out via batteries or via a fuel cell powered by hydrogen.

  Given technological advances, electric batteries are becoming more efficient. Therefore, in increasingly frequent cases, hydrogen is not competitive compared to batteries for electrifying uses, particularly in heavy mobility.

  "Public authorities have stopped investing in hydrogen-powered buses, which are too expensive and complicated to operate. Truck manufacturers are focusing their efforts on battery-powered vehicles. The hydrogen-powered engine could still restore H_2 to its rightful place and put European OEMs back in the international game thanks to their expertise in internal combustion engines."

  Similarly, the use of hydrogen as a means of storage does not appear competitive compared to other means of flexibility (notably batteries), except in rare cases in island areas not connected to the grid.

- **Regulation, particularly in the European Union, encourages the use of hydrogen in heavy industry and air/aviation mobility sectors**

  EU regulation schemes have the merit of being exhaustive and serve as a model for the rest of the world, particularly regarding the definition of renewable hydrogen.

  Indeed, the revised Renewable Energy Directive (RED III) introduces renewable fuels of non-biological origin (RFNBO) into targets for developing the use of low-carbon hydrogen in the sectors most difficult to decarbonize.

  The objectives vary significantly according to sector. RED III targets 42% low-carbon hydrogen in the industrial sector by 2030 and 60% by 2035.

  "Current consumers of grey hydrogen, including ammonia producers, are concerned that overly restrictive regulatory targets for the incorporation of green hydrogen into their processes would undermine their competitiveness in a global market. That's why a recital has been added to the European RED III regulation, aimed at excluding some usages from the hydrogen greening objectives."

[1] https://www.capgemini.com/wp-content/uploads/2024/02/Capgemini-PoV_Hydrogen-Position.pdf

For the transport sector, 5.5% of fuels used in transport shall be biofuels or RFNBO by 2030, with a minimum 1% RFNBO.

Member states with ports should also aim to ensure that RFNBO occupies 1.2% of the total amount of energy supplied to the maritime transport sector by 2030.

"Ultimately, the transport sector is most regulated by Europe. The Refuel EU Aviation and Fuel EU Maritime regulations provide for dissuasive penalty mechanisms for the maritime and aviation sectors, which have no choice but to move rapidly towards hydrogen-based fuels (methanol for maritime and eSAF for aviation)."

2. While deployment challenges remain numerous, the level of penetration of low-carbon hydrogen will not be the same across sectors, and the willingness to pay among industrialists and consumers will vary

A. Deployment challenges remain numerous, differing between sectors

Deploying low-carbon hydrogen faces several challenges, including securing competitively priced low-carbon electricity, rising interest rates, finding suitable partners—especially EPC partners—and addressing transportation issues such as costs and insufficient infrastructure.

This situation differs between sectors. It is indeed easier to obtain low-carbon hydrogen in a gaseous state, particularly in industry, compared to the mobility sector. In the maritime and aviation sectors, it is necessary to convert the hydrogen molecule into e-fuel (e-methanol/ammonia) to be used as fuel.

B. The willingness to pay is not the same across sectors

The economic viability of hydrogen projects depends heavily on the willingness of industries and consumers to pay a premium for low-carbon solutions (see table below). Sectors like aviation and shipping, where alternatives are limited and the cost of carbon emissions is increasingly factored in, may be more willing to adopt hydrogen-based fuels despite their higher price. Conversely, sectors with readily available and cheaper alternatives may be less inclined to switch to hydrogen.

Low-carbon hydrogen is not sufficiently competitive with fossil fuels or fossil-based hydrogen, particularly for industrial uses or road transportation.

Competitiveness is achieved when the price of low-carbon hydrogen reaches the opportunity cost (i.e., the price of fossil-based hydrogen or equivalent energy, including carbon taxes and the TIRUERT[2] within road transportation.)

2 TIRUERT stands for Taxe Incitative Relative à l'Utilisation d'Energie Renouvelable dans les Transports, which translates to Incentive Tax Relating to the Use of Renewable Energy in Transport. It's a French mechanism introduced by the 2022 Finance Law to promote the use of renewable energy in the transportation sector. How it works:

- **Certificate Generation:** Operators of electric vehicle charging stations can generate and sell certificates of renewable electricity (called "certificats TIRUERT").
- **Certificate Purchase:** Fuel distributors are obligated to incorporate a certain percentage of renewable energy into their fuel mix. They can meet this obligation by either:
  - Blending biofuels into their products
  - Purchasing TIRUERT certificates
- **Incentive:** If fuel distributors don't meet their renewable energy obligations, they have to pay a tax. By purchasing TIRUERT certificates, they avoid this tax, hence the "incentive" aspect.

Final use of hydrogen	Market price (willingness to pay)(2024 conditions)	Regulatory /market deadline to switch to green H_2	Typical gap between market price and production cost	Analysis of underlying drivers
Refineries	€7-8/kg H_2 (RFNBO)	Immediately	<€0.50/kg H_2	The national transposition of the RED directive imposes a share of renewables in fuels, on penalty of a tax (in France, the TIRUERT). The renewable hydrogen used in refineries meets this obligation. The market price is therefore calculated based on the price of grey hydrogen, CO_2 quotas and the tax avoided thanks to the renewable hydrogen.
Aviation fuel (e-SAF)	[€5.2-6.6] k/t_{eSAF}	Starting in 2030 Turning point in 2035	<€0.50/kg H_2	The Refuel EU Aviation regulation requires the use of an increasing proportion of e-SAF from 2030, under penalty of heavy fines. This extra-budgetary mechanism limits the need for public support, despite fuel costs being five times higher than kerosene.
Maritime fuel (e-Methanol)	[€1200-1600]/t_{MeOH}	Starting in 2030 Turning point in 2035	<€1/kg H_2	The FuelEU Maritime regulation requires shipping companies to progressively reduce CO_2 emissions, which will involve a change of fuel. Methanol offers an effective alternative for achieving these objectives, with a global market price determined by the competitiveness of different solutions (bioLNG, biofuel, e-Methanol).
Steel production (DRI)	[€2-3]/kg H_2	Immediately	~€4/kg H_2	The use of hydrogen in steelmaking through the direct reduction process reduces the sector's CO_2 emissions by over 90%. As a result, subsidies allocated to offset the price differential with natural gas offer unrivalled efficiency (€subsidy/tCO_2 avoided).
Road transportation (fuel cell vehicle)	[€4-5]/kg H_2 (RFNBO)	Between 2035 and 2040	~€5/kg H_2	In the short term, the total cost of ownership (TCO) of a hydrogen truck should be balanced with that of a diesel, i.e. €4-5/kg H_2 at fuel station. After 2040, the end of fossil fuels engines will naturally increase the size of the market, making hydrogen indispensable as a complement to electric power.
Ammonia production	[€2-3]/kg H_2	2030 to 2035, according to RED III national transposition	~€4/kg H_2	In the short term, existing ammonia plants cannot accept more than 15% green hydrogen, limiting the size of the market. A major process change will be required for full decarbonization. Without specific penalty from RED III transposition, market price is based only on grey hydrogen, adjusted for the price of CO_2 quotas.
Chemical industry	[€2-3]/kg H_2	2030 to 2035, according to RED III national transposition	~€4/kg H_2	Without specific penalty from RED III transposition, market price is based only on grey hydrogen, adjusted for the price of CO_2 quotas.
Industrial heating	[€2-2.5]/kg H_2	No dedicated regulatory framework	NC	Green hydrogen could eventually replace natural gas. In the short term, the market is limited by the compatibility of existing installations, and by the absence of eligible subsidies for this segment.

A subsidy of €4.58/kg H_2 would be necessary to make low-carbon hydrogen competitive for industrial use in France; and a subsidy of up to €5.53/kg H_2 for road transportation would be required to offset the opportunity cost.

In comparison, low-carbon hydrogen is more competitive with the production of e-methanol and e-ammonia. Its production cost is 37% lower and it therefore requires a much lower subsidy of €1.34/kg H_2.

The “hydrogen recalibration" is underway, shifting hydrogen's role from a universal decarbonization tool to a strategic niche player. While initial ambitions were high, the reality of production costs, competition with other decarbonization/ electrification technologies, transportation challenges and regulatory frameworks has led to a more focused approach.

Hydrogen's potential now lies primarily in hard-to-abate sectors like heavy industry and heavy transportation sectors (maritime and aviation), where electrification faces challenges. This strategic refocusing is prompting organizations to:

- Mobilize the necessary investments to create new low-carbon hydrogen assets
- Finance the gap between prices and production costs of low-carbon hydrogen

Regulatory schemes, particularly in the EU, play a crucial role in driving this transition. By setting incorporation targets and requirements for low-carbon hydrogen adoption and providing incentives like TIRUERT in France, they create market pull for greener solutions.

However, deployment challenges remain. The availability of competitive low-carbon electricity, rising interest rates, and infrastructure limitations pose significant hurdles. Moreover, the willingness to pay for low-carbon hydrogen varies across sectors, influencing adoption rates.

Ultimately, the successful integration of low-carbon hydrogen hinges on striking a balance between technological advancements, cost reductions, supportive policies, market demand and the willingness of consumers to pay. As we navigate this complex landscape, it is crucial to focus on sectors where hydrogen's unique technical, economic, and environmental properties can make a tangible difference in the fight against climate change.

The road to a hydrogen-powered future might be longer and more nuanced than initially envisioned, but with strategic planning and collaborative effort, it remains a vital pathway towards a decarbonized economy.

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