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international federation of industrial energy consumers

# The outlook for hydrogen in the EU.

**Q1: In your opinion, what are the challenges/opportunities for the hydrogen market between now and 2030?**
**A1:** The hydrogen market presents both challenges and opportunities.

## Challenges

Harmonization hydrogen purity level and contaminants

The consistent production and transport of hydrogen at high purity levels is a challenge. Variations in hydrogen quality can significantly impact the efficiency and lifespan of industrial applications. Desynchronized hydrogen standards could necessitate additional purification at borders, driving up costs and tariffs for the hydrogen infrastructure. High hydrogen network tariffs could, in turn, slow the development of the hydrogen market and lead to inefficiencies in EU hydrogen markets. To further the energy transition and prevent high tariffs, harmonization of hydrogen purity and contaminant levels is essential to establish a European-wide hydrogen market which will cater to efficiency, eventually leading to the lowest possible costs for the hydrogen user.

RED-III

In the Renewable Energy Directive III, Article 22a, Member States have to ensure that the contribution of renewable fuels of non-biological origin (RFNBO) used for final energy and non-energy purposes shall be at least 42% of the hydrogen used for final energy and non-energy purposes in industry. In 2035 the obligation is 60%. Member States have the option to place the obligation on company-level. In such a case, it is important for Member States to take into account the impact that mandatory quotas can have on the competitiveness of industrial hydrogen consumers. As the European Commission Communication C(2024) 5042 notes, quotas that are not backed by adequate regulatory measures and support mechanisms to compensate for the cost difference between RFNBOs and fossil-based fuels could lead to carbon leakage and additional intra-EU or extra EU imports of products produced with fossil-based hydrogen. Moreover, desynchronized implementation of the obligation across Member States, whether at the company or national level, could disrupt the level playing field. Without adequate regulatory measures and public funding support, it is highly unlikely the RED III industry targets will be reached.[1]

[1]European Court of Auditors: Special report: The EU's industrial policy on renewable hydrogen Legal framework has been mostly adopted – time for a reality check

Low-carbon fuels and low-carbon hydrogen

With the RFNBO-obligation of Article 22a in RED III, the European Commission embarked on a path-dependent trajectory, sidelining other hydrogen production technologies and pathways. The European Commission has not yet published the Delegated Act on low-carbon fuels, including low-carbon hydrogen, from Article 9 Certification of renewable gas and low-carbon fuels of the Directive (EU) 2024/1788 on common rules for the internal markets for renewable gas, natural gas and hydrogen. Low-carbon hydrogen (regardless of production technology) is closer to competing with the commodity cost of grey (fossil) hydrogen than RFNBO-hydrogen. Scaling up the production of low-carbon hydrogen is potentially faster and more cost-efficient than RFNBO-hydrogen. To facilitate investments in its production, we recommend designing the regulatory framework in such a way that avoids cannibalization between low-carbon and renewable hydrogen.

CC(U)S

The lack of CC(U)S in the EU is another major challenge for the development of the hydrogen market. $CO_2$-transport infrastructure, $CO_2$-storage possibilities and a functioning $CO_2$-market is missing. Production of hydrogen using SMR/ATR technology generates $CO_2$-emissions. When the $CO_2$-emissions are captured and subsequently stored or used, the produced hydrogen is considered low-carbon (blue) hydrogen. Therefore, the development of $CO_2$-transport infrastructure, $CO_2$-storage possibilities and a functioning $CO_2$-market is crucial. While Europe has significant potential for CCS, the number of large-scale CCS projects with adequate storage capacity is limited.

The $CO_2$ market is still in its early stages; the slow development of regulation on CC(U)S is another factor hindering its growth. Currently, there are some CC(U)S projects under construction, but most of these projects operate in a largely unregulated market, which allows CC(U)S service providers to set tariffs without oversight from a regulatory authority. Consequently, fair, transparent, and non-discriminatory tariffs are not guaranteed. Additionally, in the case of the Netherlands, the lack of coordination between different stakeholders that are part of the CCS chain, such as storage operators, transport operators, and $CO_2$-emitters further complicates the development of a functional and efficient CCS market.

National Regulatory Authority (NRA) and the Transmission Service Operator (TSO)

The future roles of Hydrogen Network Operators (HNO) across the EU present significant challenges. The Hydrogen and Decarbonized Gas Market Package mandates the unbundling of asset bases for hydrogen, natural gas, and electricity to i.a. prevent cross-subsidization. Hydrogen network operators are restricted from engaging in market activities such as hydrogen production, operation of hydrogen terminals, and hydrogen storage; their primary responsibility is to manage the transmission system. IFIEC fully supports this unbundling of the TSOs. Starting in 2026, the Netherlands will implement negotiated Third Party Access (nTPA) to hydrogen infrastructure. The future Dutch hydrogen TSO, HynetworkServices (HNS), along with the regulatory authority, the Autoriteit Consument en Markt (ACM), will have until 2033 to adapt and gather insights before transitioning to regulated Third Party Access (rTPA). Consequently, following the adoption of the Gas Package, regulatory authorities will only gradually acquire mandate to oversee HNO activities. Until the regulatory authority acquires full mandate to oversee HNO-activities, access to public hydrogen infrastructure is governed by the HNO's contractual terms. This may delay the uptake of the foreseen new hydrogen market, due to considerable uncertainties (even on the most basic level of timely availability of transport) that remain in absence of regulated TPA.

Taxes hydrogen

The European Commission published the revision of the 2003 Energy Taxation Directive (ETD) in June 2021. As of August 2024, the European council has not agreed on the ETD. Therefore, the revision is still ongoing. Uncertainty around taxes for hydrogen, including low-carbon and RFNBO-hydrogen is another major challenge for the development of the hydrogen market.

Permitting

The length of permitting procedures presents a significant challenge to the development of the European hydrogen market. Users seeking access to hydrogen infrastructure or intending to offtake hydrogen must undergo a permitting process, which can be time-consuming and hinder market progress. Furthermore, modifying existing installations to make them hydrogen-ready, such as for combustion applications, requires additional permits, including those related to PFAS usage or nitrogen emissions. Over time, permitting procedures have become longer and increasingly complex, adding another layer of difficulty to the development and integration of hydrogen technologies and the hydrogen market.

Electricity (transport) cost

High electricity commodity prices pose a challenge to the hydrogen production business case in the EU, favoring imported ammonia over domestically produced green hydrogen. Additionally, in certain Members States, the increasing electricity grid tariffs (due to investments to alleviate grid congestion and connection of offshore wind parks) poses an additional challenge to the hydrogen production business case and disturbs the level-playing field.

**Opportunities**

Decarbonization

Opportunities include the potential for hydrogen to become a critical component in decarbonizing sectors such as the chemical industry, glass production, ceramics production (tiles, porcelain, e.g.), steel production, refineries, etc. These sectors are expected to be major consumers of hydrogen in the future. With two distinct usage applications: as a feedstock and high temperature heat generation (combustion purposes). Whether demand for hydrogen in these sectors is established by 2030 is uncertain (depends on positive business cases for the hydrogen route).

To decarbonize, companies are increasingly electrifying their operations. This surge in demand for connections to the electricity grid is causing significant challenges. Grid congestion is already slowing decarbonization efforts in countries such as the Netherlands and others. Herein lies an opportunity for electrolysers. Strategically placed electrolysers can help alleviate grid bottlenecks and reduce input congestion by providing flexible demand while supporting the grid, while increasing hydrogen production.

**Q2: What hydrogen production technologies (gasification, import of ammonia, electrolysis e.g.) do you expect to be dominant in the EU market?**
**A2:** Accurately forecasting the dominant future hydrogen technology is difficult. In the short term (5 – 10 years) hydrogen production with Steam Methane Reformers (SMR) (with and without CCS) will remain dominant. Autothermal Reforming (ATR) is also a relevant technology, for example to decarbonize refinery offgases. The ATR-process is more energy efficient and allows for more efficient CCS implementation due to the concentrated $CO_2$-stream. At the same time, hydrogen production through electrolysis is expected to ramp up in the coming years, especially in the Nordics, Spain, and Portugal. Imports are also expected to come in the next years.

In the longer term (over 10 years), we expect hydrogen production through electrolysis to mature and reach large volumes. However, imports are expected to play an increasingly significant role. We expect to develop infrastructure to import large quantities of hydrogen (carriers) and establish infrastructure to transport hydrogen to end consumers. A dominant hydrogen carrier for imports, such as ammonia, LOHC, or liquid hydrogen, will likely emerge. Imports may come from regions like the Americas, Asia, or North Africa (via the SoutH2 Corridor), while hydrogen produced in Southern Europe (e.g., Portugal, Spain) might reach northwestern Europe through maritime transport.

**Q3: Which end-users of hydrogen (fuel cells for mobility, heating for homes, feedstock e.g.) do you expect to dominate the EU market?**
**A3:** IFIEC expects industry to be the dominant end-user of hydrogen consuming the largest volumes, provided its costs are competitive. The main current application of hydrogen is as feedstock in refineries, the chemical industry, and ammonia production (fertilizers). Demand for hydrogen as feedstock will remain and grow as industries adopt other production methods employing hydrogen as feedstock. The steel industry can replace their coal-based production process with Direct Reduced Iron (DRI). For the DRI-process, high purity levels (99.5% mol) are essential for efficiency. It is unclear whether even higher purity (>99.9% mol or >99.99% mol) improves the efficiency of the process. For some industries, high hydrogen purity (cleaned by PSA) would be the only feasible option. High temperature applications will further increase hydrogen demand in the future. So-called hard-to-abate industries such as (petro)chemical industry, glass production, ceramics production (tiles, porcelain, e.g.), steel production, and refineries are expected to be major end-users.

**Q4: Do you expect a relatively low standard for hydrogen quality (<98% purity) or a relatively high one (>98%) to be in place in 2030? Why?**
**A4:** IFIEC expects the purity standard to be set based on system efficiency. Therefore, a very high hydrogen purity standard will (99.99% mol) be in place in 2030. Arguments for such a high purity level come from supply and demand.

Demand

Current demand for hydrogen is almost exclusively as feedstock, requiring high levels of purity (>99.5% – >99.99% mol purity). Future processes like DRI work optimal with high purity hydrogen. Potential future demand from mobility requires at least 99.97% mol purity. Demand for hydrogen for combustion purposes generally requires lower purity levels but will most likely not constitute the bulk of demand for hydrogen in 2030.

Supply

Most hydrogen supply, especially in the long term, will consist of high-grade, high-purity hydrogen. Using a lower standard could lead to mixing high-purity hydrogen with lower-purity hydrogen, reducing its value. Current hydrogen producers need to cater to the demand for high purity. Hydrogen producers use SMRs to produce hydrogen which, depending on the natural gas composition, contains several impurities and contaminants. For the hydrogen to be useful for the – industrial – consumer, it must be purified. Hydrogen producers use Pressure Swing Adsorption (PSA) to purify the hydrogen and remove contaminants. Therefore, current hydrogen suppliers already supply their customers with high purity (99.5% - 99.99% mol) hydrogen.

The addition of CCS to hydrogen production using SMR's results in low-carbon hydrogen. Production of hydrogen through SMR's with CCS is likely to remain for a long period. Carbon offtake contracts for large scale CCS likely run for a long period of time (15 – 20 years) to be financially feasible, extending the production of low carbon hydrogen through SMR technology.

Additionally, as electrolytic hydrogen production ramps up the supply of high purity hydrogen will increase. Electrolysis of water generally results in high purity hydrogen but does add the possibility for new contaminants generally not observed in SMR hydrogen with a PSA. Lastly, hydrogen imported using a carrier (ammonia, LOHC) is cracked or dehydrogenated and consequently purified with PSA (or other processes). Imported hydrogen will therefore further increase the amount of high purity (99.99% mol) in the European market.

**1.1.2 The quality of hydrogen.**

**Q5: What would be an ideal percentage (mol%) of hydrogen purity in the transport network from your perspective (as the association)? Why?**
**A5:** An ideal percentage of hydrogen purity in the transport network should be based on system costs and avoid the necessity for double purification as much as possible. System costs should be leading whether the eventual percentage comes out to >99.5% mol, >99.9% mol, or >99.99% mol. Given our answer regarding supply and demand from the previous question, we expect this ideal percentage to be very high. The high purity level caters to current demand for hydrogen. Transporting hydrogen in lower purity levels (98%, 99%) requires the use of PSA at the demand side (end user). A PSA at every end user, or group of end users, increases the total costs for the system, especially since the waste of the purification process can usually not be dealt with (recycled) locally. With the purification of hydrogen by a PSA unit, residual gasses (tailgas) remain after the purification step has taken place. Tailgas contains a variety of components, mainly byproducts and inert gases. These gases are typically treated, or recycled, depending on their composition and the specific process. Moreover, decentralized purification will seriously hamper the rollout of the hydrogen system, since it will require a lot of time to (get

permits to) develop PSAs, if even possible at end user sites. Furthermore, the costs of purification do not increase significantly with the purity level. It is equally expensive to purify up to 98% mol or up to 99.5% mol or even higher. The marginal costs of purification are minimal. The costs of purification, regardless of purity level, is made up primarily of the disposal or recycling of tailgas and the PSA cleaning process.

There are however economies of scale in the size of the PSA. Purification using a large PSA is cheaper than multiple smaller PSA's. From a total welfare point of view, centralized purification, ex ante injection is preferred. Additionally, a lower hydrogen purity standard for the transport network would be illogical with the future production methods in mind. Electrolytic hydrogen will, after purification (drying), net high purity hydrogen (99.99% mol). Contaminating the high purity hydrogen with lower purity levels is inefficient.

**Q6: What would be your organization's main concerns with respect to the harmonization of the hydrogen quality standard?**
**A6:** Unlike the natural gas buildout, where existing infrastructure was a significant factor, the absence of public hydrogen infrastructure places us in a green meadow situation. This presents an opportunity to make informed decisions now, enabling the creation of a highly efficient system. It offers a unique opportunity to shape the development of hydrogen infrastructure and support the harmonization of the EU hydrogen market by establishing a unified quality standard – one that considers the broader welfare of society, rather than prioritizing the interests of hydrogen network operators (HNOs) or owners of specific gas fields.

As mentioned above, we believe the ideal hydrogen purity level in the transport network is the one that minimizes system costs while considering both demand and supply, likely falling between >99.5% mol and >99.99% mol. Although it is difficult to determine the current and near-future balance between high and low purity standards, especially in the long term, "blue hydrogen" (low-carbon hydrogen) will likely be less relevant than green hydrogen (RFNBO) in the EU, given the REDII Transport Target and the REDIII Industry Targets for RFNBO. Ultimately, this balance will dictate whether overall societal costs are lower with a low standard and ex post purification or a high standard with ex ante or centralized purification.

In our view, as stated under questions 4 and 5, a high standard (e.g., 99.5 – 99.99 mol%) offers the lowest societal costs, if not immediately, then certainly over time. This is due to the challenges with ex post purification, the economies of scale from centralized purification, the elimination of marginal purification costs, and the avoidance of value loss from expensive green RFNBO hydrogen.

**Q7: From your perspective, which contaminants are of concern? What limits would you put on these contaminants (ppm)?**
**A7:** Contaminants of concern include nitrogen, MEA, DEA, MDEA, oils, sulfur, halogens, $H_2O$, and the concentration of oxygen molecules. Other contaminants which cannot be ignored and arise from electrolytic hydrogen are possible traces of KOH (Potassium Hydroxide) and NaOH (Sodium Hydroxide).

The members IFIEC will use hydrogen for different applications with varying specifications for quality. Chemical processes generally require strict quality specifications due to toxicity to catalyzers, while combustion processes generally allow for a more lenient bandwidth but are at risk of nitrogen emissions.

For the capture of $CO_2$-emissions adsorption materials like MEA, DEA and MDEA are used. These contaminants are problematic in chemical processes. Hydrogen is compressed using oil-lubricated compressors which use oil to reduce friction and wear between moving parts. The lubrication can contaminate the hydrogen with oils. Oils are problematic contaminants in chemical processes. Also, sulfur and halogen levels in the hydrogen must be untraceable. These contaminants are problematic in chemical processes. When producing electrolytic hydrogen, $H_2O$ can contaminate the hydrogen. Inadequate drying or purification can leave traces of water vapor in the hydrogen gas. Regarding oxygen, the concentration of oxygen molecules ($CO_2$, $O_2$, CO) must be limited. Higher levels of oxygen lead to efficiency losses and higher costs.

**Q8: Would your members desire a single European hydrogen quality standard?**
**A8:** Yes, a single European hydrogen quality standard is preferable. For hydrogen producers, uncertainty is a major challenge for investments. A single European hydrogen quality standard would ensure a stable hydrogen market across Europe by reducing inefficiencies and enabling the seamless trade and transport of hydrogen without requiring additional purification at borders. Harmonization is essential, and the acceptable quality/purity on the European hydrogen backbone should have minimum purity level to minimize variations and maintain consistency. Predictable European and national policy is essential for the development of the hydrogen market. However, space for derogations for local deviations from the standard **must** be guaranteed. The market will start with bilateral contracts for the offtake of hydrogen. Moreover, a single standard is less cumbersome when RFNBO hydrogen needs to remain mass balanced (REDIII art 31) between production/import and supply, even when the Union Database is (to be) applied. When the level (purity and contaminants) is to be considered, that level should be based on the lowest overall cost to society. A standard based on the maximization of total welfare among producers as well as end users is the superior standard from an EU community perspective. Multiple standards or too many opt out options would hinder trade and thereby the overall welfare creation.

**Q9: In your opinion, what are the current gaps in European standards regarding hydrogen transmission, distribution, end-use, production, purifying and storage?**
**A9:** There are gaps in the depth of analysis regarding the cost and placement of purification systems (e.g., PSAs) and in understanding the specific needs of different end-users regarding hydrogen purity. It is essential to map out different requirements for hydrogen and to acknowledge the differences in specifications to understand the hydrogen landscape. Additionally, there is a lack of standardization in measuring contaminants and setting consistent quality standards across the EU, which could lead to inefficiencies and increased costs.

**Additional Thoughts/Comments:**
It is crucial to conduct a more detailed analysis of where purification should occur in the hydrogen supply chain to minimize costs and hydrogen losses. Moreover, a flexible yet harmonized approach to hydrogen quality standards could support a more inclusive and efficient market.