Current status and anticipated developments in hydrogen

"Clean hydrogen proves that we can reconcile our economy with the health of our planet"
Ursula von der Leyen[32]

Current production and consumption situation

This section provides a quantitative analysis both of hydrogen production, specifying which countries are at the forefront in the production of this resource, and of hydrogen demand, reviewing what hydrogen percentages are requested by each sector.

Hydrogen production

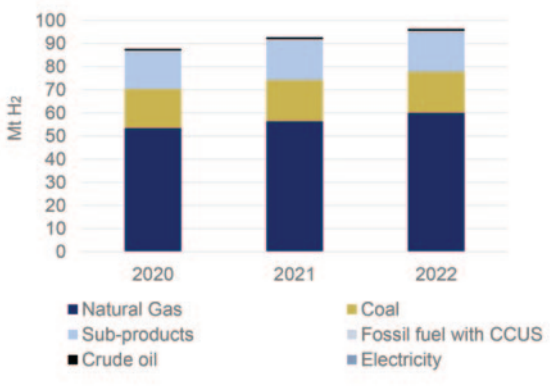
In 2022, global hydrogen production experienced a 3% increase compared to the previous year. In line with the 2021 trend, hydrogen production continued to be dominated by the use of fossil resources. Specifically, 62% of global production came from natural gas without carbon capture, utilization and storage (CCUS), while coal contributed 21% of global production. In addition, 16% of global hydrogen production was a by-product generated mainly in refineries and petrochemical industries during the naphtha reforming process.

In 2022, only 0.1% of the world's hydrogen production was carried out by electrolysis[33]. However, in recent years there has been strong growth in production capacity by this method, with approximately 600 projects announced with a combined capacity of more than 160 GW from 2022. By the end of 2022, the global installed capacity of water electrolyzers for hydrogen production reached almost 700 MW, an increase of 20% compared to the previous year (see Figure 14). Alkaline electrolyzers (ALK) accounted for 60% of installed capacity by the end of 2022, followed closely by proton exchange membrane (PEM) electrolyzers, which accounted for approximately 30%.

Finally, global installed capacity could increase more than threefold by 2023, reaching 2 GW by the end of 2023 (equivalent to approximately 0.2 million tons of hydrogen production), assuming all projects are realized as planned.

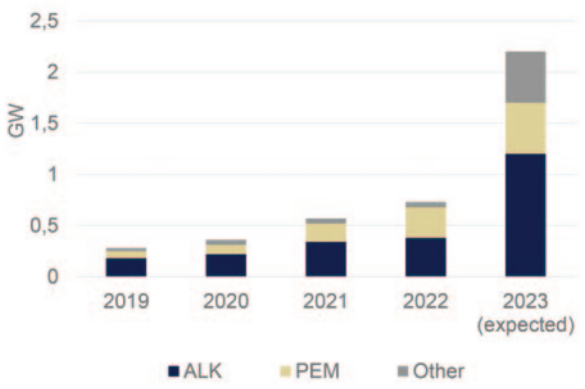
[32]Ursula von der Leyen, Presidenta de la Comisión Europea.
[33]IEA, "Global Hydrogen review" 2023.
[34]Data based on projects that have reached at least the final investment decision (FID), or are under construction.

Figure 13. Hydrogen production from its various sources.



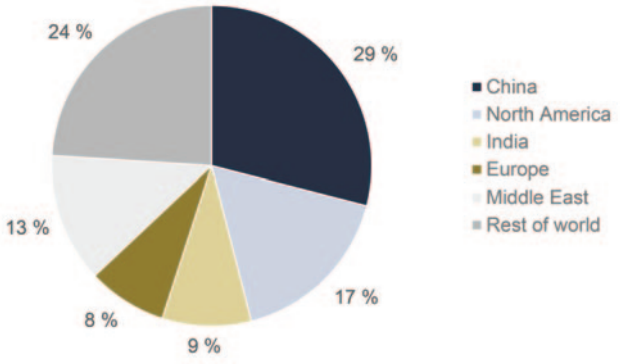
Source: IEA "Global Hydrogen Review 2023".

Figure 14. Current hydrogen production capacity by electrolysis in GW of existing plants worldwide[34].



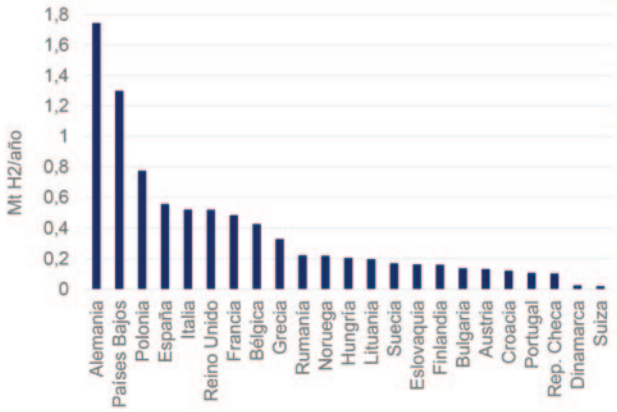
Source: IEA "Global Hydrogen Review 2023".

Figure 15. Global hydrogen demand by region in 2022.



Source: IEA "Global Hydrogen Review 2023".

Figure 16. Hydrogen consumption in Europe by country.



Source: Fuel Cells and Hydrogen Observatory (FCHO) "Demanda de Hidrógeno de Europa", mayo 2022.

Hydrogen consumption

Global hydrogen demand for 2022 reached 95 Mt (million tons), an increase of almost 3% over the previous year[35]. Hydrogen use grew significantly in all major consuming regions except Europe, due to reduced activity as a result of sharply rising natural gas prices[36].

In contrast, North America and the Middle East significantly increased hydrogen use (about 7% in both cases). In China, hydrogen use grew more modestly, but it remains by far the largest consumer of hydrogen, accounting for almost 30% of world consumption.

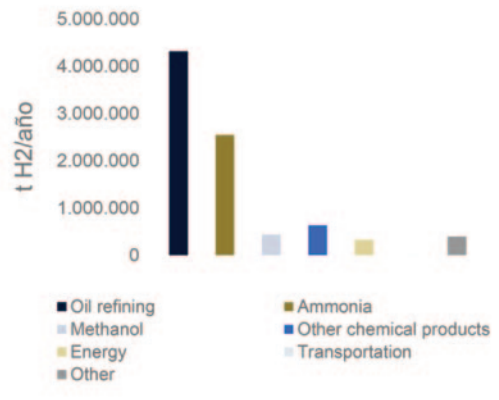
As in previous years, the growth in global hydrogen use is not the result of specific incentive policies, but rather of global energy trends. Virtually all of the increase has occurred in traditional applications, mainly in refining and chemical processes, and has been aligned with the increase in fossil fuel-based production.

Within the European Union, Germany is the country with the highest demand for hydrogen, followed by the Netherlands, Poland and Spain (see Figure 16).

By type of activity, oil refining, ammonia production, and methanol production are the main users. However, it is oil refining that consumes most of the hydrogen produced worldwide. In Europe, for example, hydrogen demand for oil refining makes up almost 50% of all hydrogen needs in this continent.

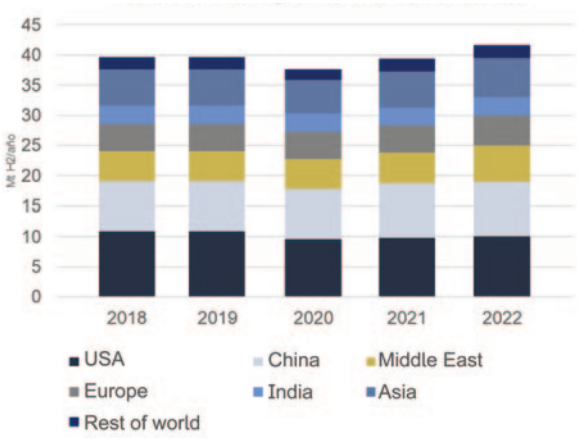
[35] IEA, "Global Hydrogen Review 2023" (2023).
[36] The chemical industry reduced its production, bringing down H2 use in Europe by almost 6%.

Figure 17. Hydrogen consumption in Europe.



Source: Fuel Cells and Hydrogen Observatory (FCHO) "Demanda de Hidrógeno de Europa", mayo 2022.

Figure 18. Hydrogen consumption in the refining industry by country.



Source: IEA "Global Hydrogen Review 2023".

I. Hydrogen consumption in industry

a) Refining industry

Hydrogen use in oil refining reached more than 41 Mt in 2022. Refineries use it mainly to remove impurities and transform oil fractions into lighter products. Over the last six years, demand has remained at around 40 Mt H2/year, with most of the production being met by gray hydrogen and only 1% by low-emission technologies.

b) Chemical and metallurgical industry

Ammonia and methanol production and steel reduction are the main uses in which hydrogen plays an important role. Of the 53 Mt of hydrogen used in 2022, about 60% was for ammonia production, 30% for methanol and 10% for direct reduction iron[37] in the iron and steel subsector.

II. Hydrogen consumption in transportation

Although transportation is not currently one of the largest hydrogen users, this sector has seen very significant growth. In 2022, hydrogen use for road transport increased by 45% compared to 2021 (see Figure 20).

Although cars represent a lower demand for hydrogen for transportation compared to buses, it is worth noting that the production of Fuel Cell Electric Vehicles (FCEVs), which are powered by hydrogen, has increased considerably over the last 2 years. A total of 58,000 FCEVs had been registered by the end of 2022, representing a growth of more than 40% over the previous year, and 63,000 more were registered during the first half of 2023 alone. Some companies already have fuel cell electric vehicle models available on the market and continue to invest in the development of such technology. Against this backdrop, the market for hydrogen electric vehicles is expected to continue to expand over the next decade in all road segments.

The stock of fuel cell buses grew similarly to that of private vehicles, with an increase of about 40% in 2022 compared to the previous year. In June 2023, there were around 7,000 fuel cell buses worldwide, approximately 85% of which are located in China.

Globally, there were around 1,100 hydrogen refueling stations in operation as of June 2023, and hundreds more are planned. As an example, the EU Alternative Fuels Infrastructure Regulation requires hydrogen refueling stations every 200 km along major road networks and at all urban nodes from 2030.

As far as the railway sector is concerned, there are many projects in different European countries, such as Italy, Canada, Spain and Japan; for example, in Germany, there are fleets of hydrogen fuel cell trains.

As for shipping, the Getting to Zero initiative, which aims to reduce greenhouse gas emissions in the maritime sector to zero by 2050, has published numerous ongoing pilot projects and demonstrations in 2022, of which about 45 focus on the use of hydrogen, 25 on the use of ammonia and 10 on the use of methanol in shipping[38].

III. Hydrogen consumption in the energy sector

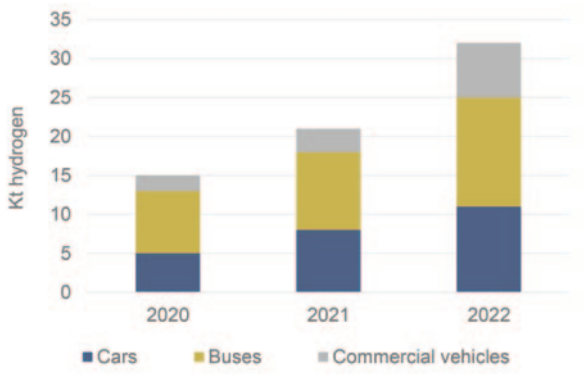
Hydrogen as a fuel in the energy sector is virtually non-existent today, with a share of less than 0.2% of the global electricity generation mix[39] (and largely not from pure hydrogen, but from hydrogen-containing mixed gases from steel production, refineries or petrochemical plants).

[37] DRI - Direct Reduced Iron.
[38] Getting to Zero Coalition. "Mapping of Zero Emission Pilots and Demostration Projects" (2022).
[39] Considering electric power produced with hydrogen in internal combustion engines (ICE) and gas turbines.

Figure 19. Hydrogen demand in the chemical industry worldwide.

Source: IEA "Global Hydrogen Review 2023".

Figure 20. Hydrogen demand in the transport sector worldwide.



Source: IEA "Global Hydrogen Review 2023." Commercial vehicles include light commercial vehicles,as well as medium and heavy-duty trucks.

IV. Hydrogen consumption in the construction sector

The contribution of hydrogen to meeting energy demand in the building sector remains negligible and, there is no significant progress in 2022. As part of efforts to meet climate targets, there is a need to shift the use of fossil fuels in buildings towards low-carbon alternatives, but options such as electrification through heat pumps, district heating and distributed renewables appear to be far ahead of hydrogen technologies.

Green hydrogen development

The level of global green hydrogen development can be measured by the installed electrolysis capacity. By the end of 2022, the global installed capacity reached almost 0.7 GW[40]. However, the great potential of green hydrogen has led to a global alignment for its promotion and use as a lever for decarbonization. The world's major economies are promoting new projects and are expected to reach capacities of between 100 and 300 GW in 2030[41], which implies a remarkable increase considering the 2GW expected to be reached by the end of 2023 with ongoing projects.

I. Worldwide electrolysis targets

As mentioned, the commitment to energy transition needs a boost in green hydrogen production. Currently, around 600 projects with a combined capacity of more than 160 GW have been announced worldwide. If all the announced projects for hydrogen produced from water electrolysis and fossil fuels with CCUS are realized, the annual production of low-emission hydrogen could reach more than 38 Mt by 2030 (17Mt being from projects currently still at an early stage). .

Half of all hydrogen to be produced by the projects announced for completion by 2030 comes from projects that are currently in feasibility stage, followed by projects that are in their very early stages of development. The world's first priority is to shift the existing demand for hydrogen in industry and refining from fossil-based hydrogen to low-emission hydrogen. If these projects go ahead, global electrolyzer capacity could reach 175 GW by the end of 2030 and even up to 300 GW (420 GW if very early-stage projects are considered).

The European Union is close to reaching the 44 GW target set in the Fit for 55 package[42] in 2021 thanks to a projected installed capacity of 39 GW by 2030 based on announced projects. However, there is still a long way to go to reach the 65 GW target set in 2022 as part of the more ambitious REPowerEU Plan. To achieve this, further progress in adding electrolyzer capacity would be necessary.

More specifically, Spain, Denmark, Germany and the Netherlands lead the way in electrolytic hydrogen production, together accounting for almost 55% of European production. In 2022, the European Commission focused on projects that promote renewable and low-carbon hydrogen supply during the second round of funding approvals for Important Projects of Common European Interest (IPCEI). The first European Hydrogen Bank auctions scheduled for late 2023 were also announced.

Australia, taking advantage of its abundant solar and wind renewable energy sources, aims to produce around 6 Mt of low-emission hydrogen through water electrolysis by 2030, with many of these projects targeting export markets.

In Latin America, hydrogen production through electrolysis is expected to reach approximately 6 Mt by 2030, according to announced projects. Chile leads the region, accounting for 45% of planned electrolytic hydrogen production from announced projects, followed by Brazil and Argentina, which together account for 30% of expected production.

In the United States, electrolyzer projects with a total capacity of 9 GW were announced in the last 12 months. In addition, China experienced significant development in electrolyzer technology and is expected to reach 1.2 GW by the end of 2023 (representing half of global installed capacity).

II. Hydrogen demand projections: climate scenarios

The European Union's main objective is to achieve climate neutrality by 2050. To this end, different scenarios have been developed to simulate how the energy system could evolve over time. The Net Zero Emissions scenario (NZE) is designed to achieve specific decarbonization outcomes, i.e. it reflects an emissions trajectory consistent with keeping the temperature

[40] IEA, "Global hydrogen review 2023" (2023).
[41] IRENA, "Green Hydrogen Cost Reduction" (2020).
[42] A set of legislative proposals and measures presented by the European Commission in 2021 to combat climate change. Its main objective is to reduce greenhouse gas emissions in the EU by 55% by 2030.

increase below 1.5 °C. The Announced Pledges scenario (APS) and the Stated Policies scenario (STEPS) are exploratory, as they define a set of initial conditions, such as policies and targets, and analyze where they lead based on different market dynamics and technological developments.

Total final energy consumption worldwide today is 442 EJ. This consumption is projected according to each different scenario. Under NZE, energy consumption would be reduced by an annual average of 0.9% from today until 2050. Under APS, it would increase until 2025 and then begin to decrease gradually. Finally, under STEPS, consumption would increase by 1.1% per year until 2030 and then continue to increase at a slower rate until 2050.

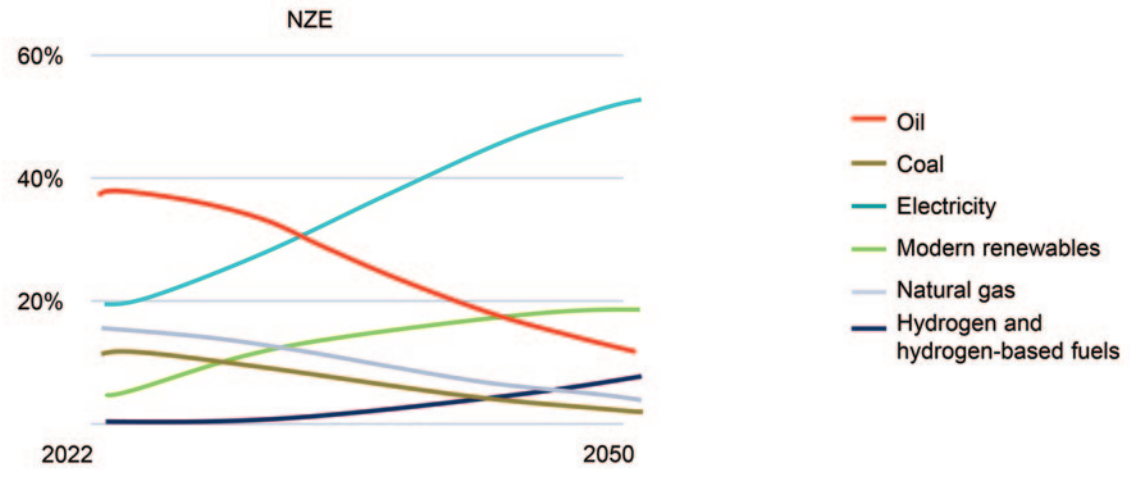
The NZE scenario states that, although the world population may increase significantly by 2030 following the trends of recent years, global energy consumption would decrease by 7% by 2030[44]. To achieve this, this scenario relies mainly on increasing energy efficiency, i.e. requiring less energy for end uses. The European Commission is aligned with this objective and considers it crucial to increase energy efficiency in order to reduce final consumption and thus achieve the EU's climate ambition[45]. Another of the fundamental pillars on which this scenario is based is the adoption and promotion of new technologies, mainly batteries, electrolysers and CCUS technologies.

The share of total world final consumption by fuel type in the NZE scenario is largely based on electricity and the increase in renewable energies, as 90% of electricity production would come from these sources. This would require a large increase in electricity system flexibility, such as batteries, hydrogen-based fuels or hydropower, to ensure reliable supplies. Moreover, as carbon neutrality implies a large decrease in fossil fuel use, fossil fuels would go from accounting for almost four-fifths of total energy supply today to just over one-fifth by 2050.

As for clean hydrogen, according to the NZE, by 2030, there would be an installed capacity of 850 GW of electrolysers and a production of 150 Mt (compared to the currently announced projects, which are expected to produce 38 Mt and could reach an installed capacity of 420 GW by 2030). By 2050, clean hydrogen production would reach 520 Mt. This shows a strong need to further boost hydrogen production in order to achieve emission neutrality targets.

[43]IEA, "World Energy Outlook", (2023).
[44]IEA. "Net Zero by 2050" (2021).
[45]European Commission. "Energy Efficiency Directive". (2023).

Figure 21. NZE scenario: Energy consumption by fuel.



Source: IEA, "World Energy Outlook" (2023).