2021-IP21

IEA Global Hydrogen Review 2021

The global pathway to net zero by 2050 will require nothing short of a holistic transformation of the global energy system. Thus, a growing number of governments are announcing a hydrogen strategy as part their net zero emissions (NZE) commitments. On the backdrop of this renewed momentum on hydrogen as a key decarbonisation energy vector, the International Energy Agency (IEA) published in October 2021, its Global Hydrogen Review. This report is an output of the Clean Energy Ministerial Hydrogen Initiative (CEM H2I) which is designed to inform decision makers on the status and future prospects of hydrogen by tracking the progress of hydrogen production and demand as well as other important areas such as the techno-economic, environment, infrastructural development, innovation, investment, regulation and policy.

The Global Hydrogen Review 2021 consists of seven chapters. The first chapter, policy trends described progress made by governments in adopting hydrogen-related policy frameworks identified in the 2019 The Future of Hydrogen report. Following this, are two chapters covering hydrogen demand and supply which present an exhaustive evaluation of the global hydrogen market dynamics, the global storage facilities and the emerging hydrogen technologies. A chapter on infrastructure and hydrogen trade underscores the prominence of large-scale hydrogen deployment which is underpinned by an effective and cost-efficient system for storage and transport and strategically designed to connect supply sources to demand hubs, subsequently creating an effective liquid market. Investments and Innovations jointly constitute chapter 5 and presents the global and regional financial mechanisms in hydrogen production and the investment outlook for the announced pledges and net zero emissions scenarios. Innovation has been described as vital to ensure that the entire value chain of hydrogen production is fully developed to avoid bottlenecks in the decarbonisation endeavours. The chapter on regional insights presents an in-depth exploration of regional hydrogen markets, potentials and opportunities. The final chapter presents policy recommendations to facilitate the massive deployment of hydrogen technologies and accelerated development of innovative and emerging technologies while ensuring its techno-economic viability and social acceptability.

This Global Hydrogen Review relies on three indicators to track progress on hydrogen production and use:

- On-the-ground progress in hydrogen technology deployment
- Government ambitions to integrate hydrogen into long-term energy strategies
- Gaps between on-the-ground progress, government ambitions and projected energy transition requirements.

So far, the sixteen governments with adopted national hydrogen strategies; announced targets; priorities for hydrogen and use; and committed funding are: Australia, Canada, Chile, Czech Republic, European Union (EU), France, Germany, Hungary, Japan, Korea, Netherlands, Norway, Portugal, Russia, Spain and the United Kingdom. The EU has the highest deployment targets of low carbon hydrogen at 40 GW in 2030 and followed by Chile at 25 GW.

Hydrogen demand stood at 90 Mt in 2020 produced almost exclusively from fossil fuel with resulting emissions at close to 900 Mt of CO_2. More than 8 Mt of global hydrogen from electrolysers is projected to be produced by 2030. While noteworthy, it falls short of the 80 Mt required by that year in the net zero pathway by 2050 set out in the IEA Roadmap for Global Energy Sector.

Hydrogen and hydrogen-based fuels are projected to provide energy where electricity cannot easily or economically replace fossil fuels and where limited sustainable bioenergy supplies cannot cope with demand. A fundamental drawback for low carbon hydrogen is the cost gap with unabated-fossil fuel hydrogen. The levelized cost of hydrogen (LCOH) from natural gas is from US$ 0.5 to US$ 1.7 per kg. The LCOH of hydrogen with CCUS and hydrogen from renewables increases to about US$ 1 to 2 US$ and US$ 3 to US$ 8 per kg respectively. As both renewable electricity and electrolyser costs decrease, the price gap between production techniques is expected to quickly diminish. Higher carbon prices could further narrow the gap by increasing the cost of hydrogen produced from fossil fuels e.g., a carbon price of US$ 100/t CO_2 corresponds to a cost increase of US$ 0.90/kg of unabated natural gas-based hydrogen or US$ 2.00/kg of hydrogen for coal gasification without CCS. At higher capture rates (90-95%), the impact of CO_2 prices on hydrogen production costs from fossil fuels with CCS can significantly be reduced. Figure 1 shows the projection of cost of unabated and abated-fossil fuel hydrogen production and the influence of renewables on cost of hydrogen production in the coming decades.

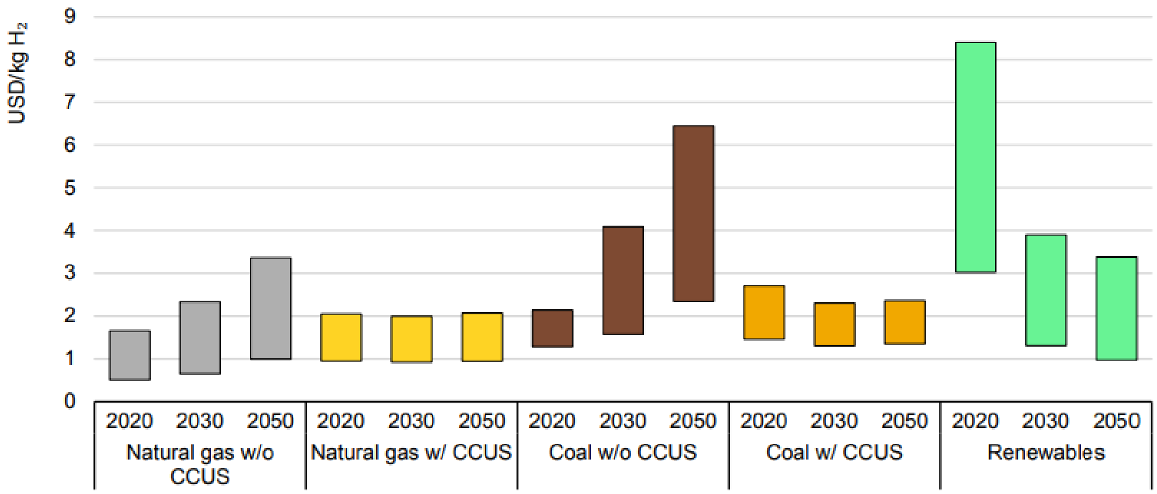

Figure 1. Levelized cost of hydrogen production by technology in 2020, and in the Net zero Emissions Scenario, 2030 and 2050

The potential for hydrogen production cost through technology innovation and increased deployment is significant and is reflected in the IEA's Net Zero Emissions by 2050 Scenario where hydrogen from renewables falls to as low as US$ 1.3 per kg by 2030 and US$ 1 per kg in the longer term (in regions with excellent renewable resources), which is comparable to the cost of CCUS-abated hydrogen.

The adoption of hydrogen as a clean fuel is accelerating but still lags behind that required to support net zero by 2050 even if all announced industrial plans are achieved, by 2030.

- Total hydrogen demand could increase to as high as 105 Mt, compared with more than 200 Mt in the NZE Scenario
- Low-carbon hydrogen production could reach more than 17 Mt i.e., 12.5 % of the production level required in the NZE Scenario
- Electrolysis capacity could increase to 90 GW but well below the nearly 850 GW in the NZE Scenario

- Up to 6 million fuel cell electric vehicles (FCEVs) could be deployed, though this is but 40% of the level of deployment in the NZE Scenario at 15 million FCEVs.

Integrating hydrogen as a new vector into energy systems is a complex endeavour. Thus, government intervention and working with diverse stakeholders is critical to develop policies that can facilitate the transition to a low carbon economy. National strategies published to date reveal that almost all countries with hydrogen policies have similar views regarding the role of hydrogen in their economies, which entails the adoption of a three-phased approach to integrate hydrogen into the energy system as follows:

- Early 2020s: Institutionalising of policy framework and scaling up
- Late 2020s: Extensive adoption and market maturity
- Post 2030s: Full implementation of hydrogen as a clean energy vector

By 2050, global hydrogen production reaches 250 Mt in the [Announced Pledges Scenario](), with 51% provided by electrolysis, 15% by fossil fuels with CCUS and the remainder by fossil fuels without CCUS. This corresponds to global electrolyser capacity of 1,350 GW and the capture of 0.4 Gt CO_2/yr as presented in Figure 1. Further, in the NZE Scenario, global production doubles compared to the Announced Pledges Scenario, with shares of 60% from electrolysis and 36% from fossil fuels with CCUS as installed electrolyser capacity reaches 3,600 GW and the capture rate climbs to 1.5 Gt CO_2/yr. Notably, this corresponds to electricity consumption of almost 15,000 TWh (20% of global generation) and 50% of global natural gas demand.

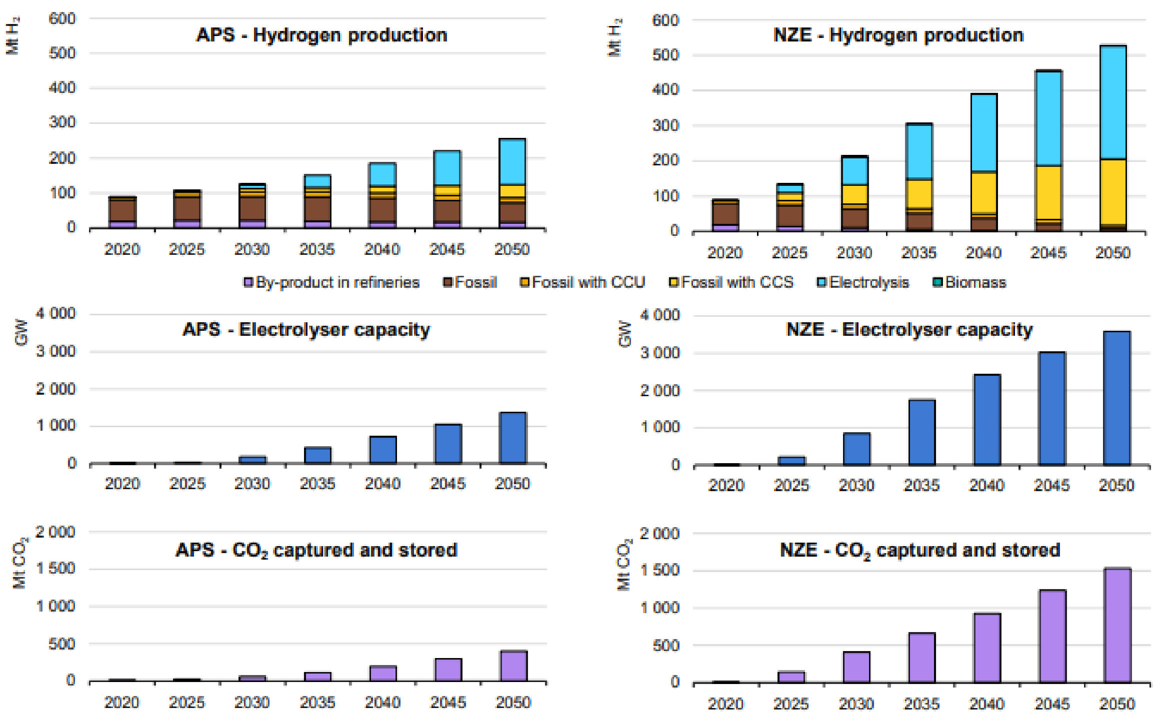

Figure 2. Global hydrogen production, installed electrolysis capacity and CO_2 captured and stored in the Announced Pledges and Net zero Emissions scenarios

Notes: APS = Announced Pledges Scenario. NZE = Net zero Emissions Scenario. CCS = carbon capture and storage; CCU = carbon capture and use. Hydrogen production from fossil fuels with CCU refers to ammonia production in which captured CO2 is used to produce urea fertiliser. When urea fertiliser is applied to soil, it breaks down again into ammonia and CO2, with the latter released into the atmosphere.

The IEA's 'Net Zero by 2050' roadmap reports that achieving NZE will necessitate immediate action to make the 2020s the decade of sustainable energy deployment via extensive employment of accessible low-carbon technologies and accelerated innovation of those still under development. Having recognised hydrogen as a key energy vector to meet the climate goals, the three overarching objectives to institute the hydrogen economy are as follows:

- Sizeable expansion of hydrogen usage through provision of enabling policy framework and embracing novel technologies onto the market
- Make hydrogen production low carbon; innovation and demonstration are important to validate the low carbon emission potential of hydrogen technologies
- Implementation of cost reduction mechanisms of low carbon hydrogen production processes across the full chain production portfolio

To inform decision-making, the IEA Global Hydrogen Review 2021 presents a series of key milestones that must be reached by 2030 to unlock hydrogen's contribution to a zero-emission economy. These milestones encompass the whole hydrogen value chain, including its production, infrastructure requirements, transformation into other fuels and end uses. Government-led policy frameworks have been developed through an all-inclusive stakeholder collaboration to support the implementation of hydrogen projects and this is expected to help build confidence in the industry, as a result prompting a prosperous hydrogen economy.

To underscore the importance of government's role as a driver for hydrogen to meet its potential in a NZE scenario, the IEA estimates that about US$ 90 billion of public funds is required to finance global clean energy innovation as fast as possible with about 50% designated for hydrogen-related technologies. This finding underscores the statement by the IEA Executive Director, Fatih Birol who stated that "*Governments need to take rapid actions to lower the barriers that are holding low-carbon hydrogen back from faster growth, which will be important if the world is to have a chance of reaching net zero emissions by 2050*."

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