Questions and answers: A Hydrogen Strategy for a climate neutral Europe

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Hydrogen can be used as a feedstock, a fuel or an energy carrier and storage, and has many possible applications across industry, transport, power and buildings sectors. Most importantly, it does not emit CO2 and does not pollute the air when used. It is therefore an important part of the solution to meet the 2050 climate neutrality goal of the European Green Deal.

It can help to decarbonise industrial processes and economic sectors where reducing carbon emissions is both urgent and hard to achieve. Today, the amount of hydrogen used in the EU remains limited, and it is largely produced from fossil fuels. The aim of the strategy is to decarbonise hydrogen production - made possible by the rapid decline in the cost of renewable energy and acceleration of technology developments - and to expand its use in sectors where it can replace fossil fuels.

How is hydrogen produced and what is its impact on the climate?

Hydrogen may be produced through a variety of processes. These production pathways are associated with a wide range of emissions, depending on the technology and energy source used and have different costs implications and material requirements. In this Communication:

- 'Electricity-based hydrogen' refers to hydrogen produced through the electrolysis of water (in an electrolyser, powered by electricity), regardless of the electricity source. The full life-cycle greenhouse gas emissions of the production of electricity-based hydrogen depends on how the electricity is produced.
- 'Renewable hydrogen' is hydrogen produced through the electrolysis of water (in an electrolyser, powered by electricity), and with the electricity stemming from renewable sources. The full life-cycle greenhouse gas emissions of the production of renewable hydrogen are close to zero[1]. Renewable hydrogen may also be produced through the reforming of biogas (instead of natural gas) or biochemical conversion of biomass, if in compliance with sustainability requirements.
- Clean hydrogen refers to renewable hydrogen
- 'Fossil-based hydrogen' refers to hydrogen produced through a variety of processes using fossil fuels as feedstock, mainly the reforming of natural gas or the gasification of coal. This represents the bulk of hydrogen produced today. The life-cycle greenhouse gas emissions of the production of fossil-based hydrogen are high.
- 'Fossil-based hydrogen with carbon capture' is a subpart of fossil-based hydrogen, but where greenhouse gases emitted as part of the hydrogen production process are captured. The greenhouse gas emissions of the production of fossil-based hydrogen with carbon capture or pyrolysis are lower than for fossil-fuel based hydrogen, but the variable effectiveness of greenhouse gas capture (maximum 90%) needs to be taken into account.
- 'Low-carbon hydrogen' encompasses fossil-based hydrogen with carbon capture and electricity-based hydrogen, with significantly reduced full life-cycle greenhouse gas emissions compared to existing hydrogen production.
- Hydrogen-derived synthetic fuels refer to a variety of gaseous and liquid fuels on the basis of hydrogen and carbon. For synthetic fuels to be considered renewable, the hydrogen part of the syngas should be renewable. Synthetic fuels include for instance synthetic kerosene in aviation, synthetic diesel for cars, and various molecules used in the production of chemicals and fertilisers. Synthetic fuels can be associated with very different levels of greenhouse gas emissions depending on the feedstock and process used. In terms of air pollution, burning synthetic fuels produces similar levels of air pollutant emissions than fossil fuels.

What kind of hydrogen will the strategy support?

Renewable hydrogen is the focus of the strategy, as it has the biggest decarbonisation potential and is therefore the most compatible option with the EU's climate neutrality goal.

The strategy also recognises the role of other low-carbon hydrogen production processes in a transition phase, for example through the use of carbon capture and storage or other forms of low-carbon electricity, to clean existing hydrogen production, reduce emissions in the short term and scale up the market.

The differentiation between types of hydrogen will allow to tailor supportive policy frameworks in function of the carbon emissions reduction benefits of hydrogen based on benchmarks and certification.

How quickly can we roll out this promising technology?

The strategy foresees a gradual trajectory, with three phases of development of the clean hydrogen economy, at different speed across different industry sectors:

- In In the first phase (2020-24) the objective is to decarbonise existing hydrogen production for current uses such as the chemical sector, and promote it for new applications. This phase relies on the installation of at least 6 Gigawatt of renewable hydrogen electrolysers in the EU by 2024 and aims at producing up to one million tonne of renewable hydrogen. In comparison to the current situation, approximately 1 Gigawatt of electrolysers are installed in the EU today.
- In the second phase (2024-30) hydrogen needs to become an intrinsic part of an integrated energy system with a strategic objective to install at least 40 Gigawatt of renewable hydrogen electrolysers by 2030 and the production of up to ten million tonnes of renewable hydrogen in the EU. Hydrogen use will gradually be expanded to new sectors including steel-making, trucks, rail and some maritime transport applications. It will still mainly be produced close to the user or close the renewable energy sources, in local ecosystems.
- In a third phase, from 2030 onwards and towards 2050, renewable hydrogen technologies should reach maturity and be deployed at large scale to reach all hard-to-decarbonise sectors where other alternatives might not be feasible or have higher costs.

How does hydrogen support the European Green Deal?

Alongside renewable electrification and a more efficient and circular use of resources – as set out in the Energy Sector Integration Strategy - large-scale deployment of clean hydrogen at a fast pace is key for the EU to achieve its high climate ambitions. It is the missing part in the puzzle to a fully decarbonised economy.

Hydrogen can support the transition towards an energy system relying on renewable energy by balancing variable renewable energy. It offers a solution to decarbonise heavily-emitting industry sectors relying on fossil fuels, where conversion to electricity is not an option. And it emits no CO2 and almost no air pollution.

How can hydrogen support the recovery, growth and jobs?

Investment in hydrogen will be a growth engine which will be critical in the context of recovery from the COVID-19 crisis. The Commission's recovery plan highlights the need to unlock investment in key clean technologies and value chains, to foster sustainable growth and jobs. It stresses clean hydrogen as one of the essential areas to address in the context of the energy transition, and mentions a number of possible avenues to support it.

Moreover, Europe is highly competitive in clean hydrogen technologies manufacturing and is well positioned to benefit from a global development of clean hydrogen as an energy carrier. Cumulative investments in renewable hydrogen in Europe could be up to €180-470 billion by 2050, and in the range of €3-18 billion for low-carbon fossil-based hydrogen. Combined with EU's leadership in renewables technologies, the emergence of a hydrogen value chain serving a multitude of industrial sectors and other end uses could employ up to 1 million people, directly and indirectly. Analysts estimate that clean hydrogen could meet 24% of world energy demand by 2050, with annual sales in the range of €630 billion.

Is renewable hydrogen cost-competitive?

Today, neither renewable hydrogen nor fossil-based hydrogen with carbon capture are cost-competitive against fossil-based hydrogen. Current estimated costs for fossil-based hydrogen are around 1.5 €/kg for the EU, highly dependent on natural gas prices, and disregarding the cost of CO2. Estimated costs for fossil-based hydrogen with carbon capture and storage are around 2 €/kg, and renewable hydrogen 2.5-5.5 €/kg.

That said, costs for renewable hydrogen are going down quickly. Electrolyser costs have already been reduced by 60% in the last ten years, and are expected to halve in 2030 compared to today with economies of scale. In regions where renewable electricity is cheap, electrolysers are expected to be able to compete with fossil-based hydrogen in 2030. These elements will be key drivers of the progressive development of hydrogen across the EU economy.

How will the strategy support investments in the hydrogen economy?

The strategy outlines a comprehensive investment agenda, including investments for electrolysers, but also for the renewable power production capacity required to produce the clean hydrogen, transport and storage, retrofitting of existing gas infrastructure, and carbon capture and storage.

To support these investments and the emergence of a whole hydrogen eco-system, the Commission launches the European Clean Hydrogen Alliance – as announced in the Commission's New Industrial Strategy. The Alliance will play a crucial role in delivering on this Strategy and supporting investments to scale up production and demand. It will bring together the industry, national, regional and local public authorities and the civil society. Through interlinked, sector-based CEO round tables and a policy-makers' platform, the Alliance will provide a broad forum to coordinate investment by all stakeholders and engage civil society. The key deliverable of the European Clean Hydrogen Alliance will be to identify and build up a clear pipeline of viable investment projects.

What EU financial instruments can be used for investing in hydrogen?

The Commission will also follow up on the recommendations identified in a report by the Strategic Forum for Important Projects of Common European Interest (IPCEI) to promote well-coordinated or joint investments and actions across several Member States aimed at supporting a hydrogen supply chain.

Additionally, as part of the new recovery instrument Next Generation EU, the InvestEU programme will see its capacities more than doubled. It will support the deployment of hydrogen by incentivising private investment, with a strong leverage effect.

A number of Member States have identified renewable and low-carbon hydrogen as a strategic element of their National Energy and Climate Plans. These plans will have to be taken into account when designing the national recovery and resilience plans in the context of new Recovery and Resilience Facility.

Furthermore, the European Regional Development Fund and the Cohesion Fund, which will benefit from a top-up in the context of the new initiative REACT-EU, will continue to be available to support the green transition. The possibilities offered to carbon intensive regions under the Just Transition Mechanism should also be fully explored.

Synergies between the Connecting Europe Facility for Energy and the Connecting Europe Facility for Transport will be harnessed to fund dedicated infrastructure for hydrogen, repurposing of gas networks, carbon capture projects, and hydrogen refuelling stations.

In addition, the EU ETS ETS Innovation Fund, which will pool together around €10 billion to support low-carbon technologies over the period 2020-2030, has the potential to facilitate first-of-a-kind demonstration of innovative hydrogen-based technologies. A first call for proposals under the Fund was launched on 3 July 2020.

The Commission will also provide targeted support to build the necessary capacity for preparation of financially sound and viable hydrogen projects, where this is identified as a priority in the relevant national and regional programmes, through dedicated instruments (e.g. InnovFin Energy Demonstration Projects, InvestEU) possibly in combination with advisory and technical assistance from the Cohesion Policy, from the European Investment Bank Advisory Hubs or under Horizon Europe.

Can the EU be a global leader in clean hydrogen technologies?

The international dimension is an integral part of the EU approach. Clean hydrogen offers new opportunities for re-designing Europe's energy partnerships with both neighbouring countries and regions and its international, regional and bilateral partners, advancing supply diversification and helping design stable and secure supply chains.

The EU has supported research and innovation on hydrogen for many years, giving it a head start on the development of technologies and high profile projects, and establishing EU leadership for technologies such as electrolysers, hydrogen refuelling stations and large fuel cells. The strategy aims to consolidate EU leadership by ensuring a full supply chain that serves the European economy, but also by developing its international hydrogen agenda.

This includes in particular working closely with partners in the Eastern and Southern Neighbourhood. In this context, the EU should actively promote new opportunities for cooperation on clean hydrogen with neighbouring countries and regions, as a way to contribute to their clean energy transition and foster sustainable growth and development.

The interest in clean hydrogen is growing globally with several other countries developing dedicated research programmes and an international hydrogen market is likely to develop. The EU will globally promote sound common standards and methodologies to ensure that a global hydrogen market contributes to sustainability and achievement of climate goals.

What uses does the Commission foresee for hydrogen?

Hydrogen is a key solution to cut greenhouse gas emissions in sectors that are hard to decarbonise and where electrification is difficult or impossible. This is the case of industrial sectors such as steel production, or heavy-duty transport for example. As a carbon-free energy carrier, hydrogen would also allow for transport of renewable energy over long distances and for storage of large energy volumes.

An immediate application in industry is to reduce and replace the use of carbon-intensive hydrogen in refineries, the production of ammonia, and for new forms of methanol production, or to partially replace fossil fuels in steel making. Hydrogen holds the potential to form the basis for zero-carbon steel making processes in the EU, envisioned under the Commission's New Industrial Strategy.

In transport, hydrogen is also a promising option where electrification is more difficult. For example in local city buses, commercial fleets or specific parts of the rail network. Heavy-duty vehicles including coaches, special purpose vehicles, and long-haul road freight could also be decarbonised by using hydrogen as a fuel. Hydrogen fuel-cell trains could be extended and hydrogen could be used as a fuel for maritime transport on inland waterways and short-sea shipping.

In the long term, hydrogen can also become an option to decarbonise the aviation and maritime sector, through the production of liquid synthetic kerosene or other synthetic fuels.

Is hydrogen safe?

Hydrogen is a highly flammable gas and care must be taken that hydrogen is produced, stored, transported and utilised in a safe manner. Standards are already in place, and the European industry has built up significant experience with already more than 1500 km of dedicated hydrogen pipelines in place.

With hydrogen consumption expanding to other markets and end-use applications, the strategy points out that the need for safety standards from production, transport and storage to use is critical, include a system to monitor and verify.

What does the strategy foresee in terms of infrastructure development?

Appropriate infrastructure is a condition for the EU-wide development of hydrogen, but the specific infrastructure needs will depend on the patterns of development both in terms of production and use.

Hydrogen demand will largely be met by localised production in an initial phase, for example in industrial clusters or for hydrogen production for refuelling stations. However, local networks and more extensive transport options will be required for further development. Different options will have

to be considered, including the repurposing of existing gas infrastructure.

For more information

Q&A - An EU Strategy for Energy System Integration

IP – Powering a Climate-Neutral Economy

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