Response to EC Public Consultation:
Strategy for Energy System Integration

Hydrogen Europe welcomes the opportunity to respond to this public consultation on *Preparing a future EU strategy on energy sector integration* and fully supports the EU objective of reaching climate neutrality by 2050. Meeting the EU's long-term climate and energy goals and realising the promise of the Green Deal means carbon free power, increased energy efficiency and deep decarbonisation of industry, transport and buildings. Achieving all this will require both electrons and molecules, and more specifically: renewable and low-carbon hydrogen at large scale. Without it, the EU will not achieve its decarbonisation targets. As such, hydrogen and hydrogen-based fuels are set to play a systemic role in the transition to renewable sources by providing a mechanism to flexibly transfer energy across sectors, time and place, in order to meet demand. It can also be the bridge that unites the gas and electricity sectors, including their respective infrastructures while also acting as a link pin between the traditional energy sector and other demand sectors.

Both hydrogen and electricity grid infrastructures together with large scale seasonal hydrogen storage and small-scale day-night electricity storage, in mutual co-existence, will be essential to realise a sustainable, reliable, zero-emission and cost-effective energy system. Indeed, energy sector integration will improve the overall efficiency of the system and lead to cost reductions in the energy sector and across the economy.

Hydrogen is a versatile, clean and flexible energy vector that will play a crucial role in this process. It can be used as a feedstock for industry and as a carbon-neutral fuel for transport (land-use, maritime and aviation), an energy carrier in the power sector as well as for heating in buildings and heavy industry. Hydrogen and hydrogen technologies will drive decarbonisation through innovation, boosting the EU economy and competitiveness via EU industrial leadership and the creation of high skilled labour. By 2050, we expect 2,250 TWh of hydrogen in Europe, which represents roughly a quarter of the EU's total energy demand in 2050[1]. A scaled-up industry could deliver hydrogen for a benchmark cost of $2/kg in 2030 and $1/kg in 2050 in many parts of the world[2]. Our 2x40 GW initiative elaborates further on how to enable and realise the large-scale production of renewable hydrogen. [3]

Hydrogen supplies could come from a mix of sources. While the exact split of production methods could differ among applications depending on cost assumptions/developments of the different technologies, electrolysis, pyrolysis and steam methane reforming/autothermal reforming with carbon capture and storage (SMR/ATR with CCS) will most likely play key roles. Scenarios relying on only one of these three production pathways seem unrealistic and would fall short of the required deployment.

In addition, hydrogen carriers (eg. ammonia, synthetic methane, liquid organic hydrogen carriers (LOHC)) may be used to effectively transport and distribute renewable energy over large distances without having to handle large quantities of hydrogen. This is paramount because Europe will need to import renewable energy from the best wind and solar spots worldwide to meet its decarbonisation target. Their production requires a further conversion, but they potentially offer advantages such as much higher energy density, better compatibility with end use applications and lower cost.

[1] Hydrogen Roadmap Europe, FCH JU, 2019, P.50

[2] Bloomberg, 2019, P. 4 https://data.bloomberglp.com/professional/sites/24/BNEF-Hydrogen-Economy-Outlook-Key-Messages-30-Mar-2020.pdf

[3] 2x40 GW Green Hydrogen Initiative Paper, April 2020
https://hydrogeneurope.eu/news/2x40gw-green-hydrogen-initiative-paper

Benefits of Hydrogen for the EU[4]

Hydrogen use in various demand sectors

Below are a few examples of the contribution of hydrogen to enabling energy sector integration as well as broader examples of its potential to enable decarbonisation and harness wider benefits of sector integration across the EU economy:

Industry

With the long-term cost of renewables expected to further decline, and by harnessing the best wind and solar spots worldwide, clean hydrogen will come closer to parity with fossil alternatives. The remaining cost gap needs to be bridged with regulation creating a business case. Hydrogen could thus become a competitive feedstock and more specifically, the most competitive means of producing steel and ammonia which can be used as green fertiliser or coolant in heating, ventilating and air condition (HVAC) applications. In steel production, hydrogen can replace coal in the reduction of iron ore and has great potential to contribute to the de-fossilisation and decarbonisation of the steel sector while bolstering the EU's position from a global trade and strategic outlook. At present, traditional iron and steel production methods rely primarily on fossil fuels as inputs, of which coal products account for 78%. Indeed, hydrogen-based iron making is technically feasible, and various producers are working to develop this option further. A direct reduced iron (DRI) enabled electric arc furnace (EAF) route that uses hydrogen from renewable power reduces CO2 emissions by 80-95%, compared to a blast furnace. However, significant investment is required to realise such scalable reductions in CO2 emissions across the steel industry. It is also imperative to note the steel sector is inherently linked to the uptake of renewable energy projects. Each new megawatt of solar power requires 35 tons to 45 tons of steel, and each megawatt of wind power requires 120 tons to 180 tons of steel.[5]

Hydrogen can be chemically bound with CO_2 to produce synthetic fuels, which is a precursor for a range of hydrocarbons used in the following applications: transport fuels (diesel, jet fuel), fuel additives (methanol) or platform chemicals which are building blocks that can be converted into a wide range of chemicals and materials (e.g. polymers, BTX...). . Apart from the use of hydrogen as a feedstock, hydrogen can also be used in industry to produce high grade heat and steam, replacing natural gas and coal. High grade heat can be produced from hydrogen by retrofitting existing gas furnaces and boilers.

Companies already use hydrogen as feedstock for refining, chemicals (ammonia and methanol), and metal processing (approximately 325 TWh). Currently, roughly 90% of hydrogen feedstock is produced from natural gas through reforming. The decarbonisation of the hydrogen source requires no changes to these industrial processes and offers an opportunity to scale up electrolysis and/or CCS. We need policies to drive this transition towards the use of low carbon and renewable hydrogen. As such, Hydrogen Europe is fully committed to supporting this objective.

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4 Hydrogen Roadmap Europe, FCH-JU, 2019, P.10

5 Arcelor Mittal, Steel is the power behind renewable energy
https://corporate.arcelormittal.com/media/case-studies/steel-is-the-power-behind-renewable-energy

Transport

Hydrogen has an important role to play in the de-fossilisation and decarbonisation of a wide range of transport applications. Hydrogen or Hydrogen made fuels represent the most promising solution for the decarbonisation of heavy-duty or intensive-use vehicles (trucks, buses, large passenger cars, taxis), commercial vehicles, trains, ships and aviation. In land use, given its energy density, hydrogen is the most logical solution for applications requiring long-distances and heavy payload. Land vehicles using hydrogen are zero-emission at the tailpipe and can massively reduce CO2 emissions and improve air quality. They allow for operational flexibility, with a short refueling time and long range compared to their zero emission counterparts, in all weather conditions and topographies. In the case of commercial vehicles, the payload is like that of a conventional vehicle, thus allowing for a high level of productivity and no loss of user convenience. For long-distance transport, hydrogen represents the most promising carbon-neutral solution, providing a clear pathway to meeting the CO_2 emission targets for heavy duty trucks as set by the relevant European regulation. In rail transport, hydrogen is the most promising alternative to diesel propulsion that still accounts for about 20% of main line rail transport in Europe. With regards to passenger cars, hydrogen represents another zero-emission solution alongside battery electric vehicles, thus offering more optionality for consumers, including commercial consumers such as taxi companies, or for policing services whose range and refuelling times are of key importance. Moreover, an adequate planning for recharging and refuelling infrastructure would reduce overall costs and aid the shift to zero emission mobility. Indeed, due to the high energy needs of the transport sector and the challenges associated with recharging (i.e. power infrastructure, space requirements, time, etc.), at scale decarbonisation the transport sector will require a mix of both BEVs and FCEV's.

Hydrogen technology for ships in maritime has come on leaps and bounds and Europe has a strong leadership position to mainstream hydrogen for this sector. By accelerating research, scaling up, and, at the same time, developing hydrogen supply chains, Europe will maintain that position. Hydrogen provides an attractive alternative for ports and regions struggling to combat air pollution and will be used to decarbonize port operations and industrial activities in the port region. In and around ports, greater amounts of renewable energy will be produced (and imported through hydrogen) and this can be converted to green hydrogen for ships. As such, ports will represent an enabling factor to accelerate the pace of decarbonisation in the maritime sector as well as the use of hydrogen as a maritime shipping fuel, especially when ports are embedded in hydrogen valleys that are able to provide and store sufficient amounts of clean hydrogen. Ships that can sail on hydrogen and transport it as cargo must be built safely. Passenger ships, in particular, need to have a clear international regulatory framework developed; technologies for high power applications are under study at small scale and need to be fully upscaled. Developing guidance for safe storage and bunkering operations in ports will facilitate the uptake of hydrogen as a fuel in the shipping sector. It is also worth noting that due to low volumetric energy density compared to hydrocarbons, different hydrogen-based fuels may fit different ships and shipping sectors or routes, sometimes requiring a reconsideration of business models and refuelling strategies.

Also, in aviation, hydrogen and Sustainable Aviation Fuels (SAF)[6] including synthetic fuels based on hydrogen are the only at-scale options for direct decarbonisation. Conventional planes, especially existing fleets, could get synthetic kerosene made from hydrogen and captured carbon. Fuel cell modules can supply electricity to the aircraft electrical system as emergency generator sets or as an auxiliary power unit in the short term. Hydrogen fuelled planes powered by fuel cells have potential in the medium to longer term, especially for regional flights.

Decarbonisation of the gas grid and heating in buildings

Hydrogen offers the potential to futureproof Europe's gas grid while at the same time, Europe's well-connected and far-reaching gas infrastructure network offers a significant comparative advantage for the EU in the development of a hydrogen economy. Today, the gas grid connects Europe's industry and delivers more than 40% of heating in EU households. Electrification with heat pumps can replace natural gas to heat new buildings but can require costly or even impossible retrofits in old buildings, which account for 90% of building's CO_2 emissions. The heating sector is characterized by a high demand in winter, a time of the year that renewable electricity generation shows lower yields. Increasing shares of electricity based heat generation can tax the energy system in terms of power transmission and renewable generation capacities

[6] IATA's Sustainable Aviation Fuel Fact Sheet 3

needed. Renewable gas produced for example from excess electricity in summer for use in gas based heat generation can be the seasonal energy storage that can help overcome these obstacles. It is efficient and as recent studies show also the most efficient strategy to meet CO2-mitigation targets. In the short term, producers can distribute some hydrogen by blending it into the existing grid without the need for major upgrades for up to 20% blending. Furthermore, in order to address the purity demands of sensitive customers membrane filter technology separating H2 from CH4 in an admixture can come into play. Ultimately, infrastructure operators can convert grids (totally or partially) to run on pure hydrogen or methanise hydrogen from injection into the gas grid.[7] Alternatively, the construction of new dedicated hydrogen pipelines is another option for transport and distribution.

Furthermore, hydrogen transport cost by pipeline is about 10-20 times cheaper than electricity transportation by cables[8]. A fundamental difference between electricity transport by cables and hydrogen transport by pipelines is the capacity of the infrastructure. An electricity cable has a capacity between 1-2 GW while a hydrogen pipeline can have a capacity between 15-30 GW. The capacity of the gas infrastructure changes only slightly when blending hydrogen, since hydrogen also has a higher flow velocity despite its larger volume. In terms of storage, hydrogen storage cost in salt caverns are at least a factor of 100 cheaper than electricity storage cost in batteries.[9]

In buildings, hydrogen can be used for heating and power. Hydrogen can replace natural gas or oil in boilers to produce heat especially where heat pumps cannot be installed or where gas-heat pump hybrid solutions are installed. Boiler manufacturers have developed devices that are capable to process i) varying hydrogen-methane blends up to 30% Volume Hydrogen, ii) "pure" hydrogen and iii) methane when initially installed and "pure" after device conversion on-site ("hydrogen-ready"). Hybrid technologies, e.g. a combination of a gas boiler and a heat pump, also support smart sector integration by linking two energy carriers, electricity and gas, in one system. Switching to other energy carriers at electricity peak demand, hybrid heat pumps optimise the use of the existing gas infrastructure, thereby reducing the need for costly expansion of the electricity grid capacity. Next to these technologies, also small fuel cell micro CHP (combined heat and power) installations entered the market. The micro CHP fuel cells provide both electricity and heat to buildings, providing an efficient solution and supporting electricity system stability, including in times of high load e.g. from heat pumps as heat demand peaks and mCHP electricity output are synchronized. With a system efficiency of 95%, micro CHPs have proven to achieve significant primary energy savings and CO2 emission reduction compared to all incumbent technologies[10].

Overall, the use of hydrogen in buildings either via blending, methanisation or 100% will increase economies of scale which in turn decreases costs of hydrogen production.

Power sector

With the EU power sector clearly set on a renewable pathway, the energy system needs to ensure security of supply, coping with imbalances. Indeed, the rapid transition to renewable energies will further accentuate their variability. In 2018, close to €1 billion of renewable on and offshore wind electricity in Germany was curtailed because of capacity constraints in the electricity grid[11]. The lack of storage for excess electricity has also been a major cause of volatile electricity prices. In many EU countries, the main bottleneck standing in the way of further renewable energy production is the capacity of the power grids to cope with additional variable energy sources. As a flexible offtake and storage medium, hydrogen can enable a mass scale up and deployment of renewables (wind and solar), providing mechanisms to store energy through conversion (via electrolysis) and storage of renewable energy as renewable gas. It can be used for energy distribution across sectors and regions and as a buffer for renewables. It can allow the deployment of renewable energy sources going beyond the planned upgrades in capacity of existing power grids. Concretely, "power to gas" (PtG) technology can enable the coupling of the gas

[7] Consider the hydrogen backbone proposal of the German gas TSOs based up to 90% on existing gas infrastructure, https://www.fnb-gas.de/fnb-gas/veroeffentlichungen/pressemitteilungen/fernleitungsnetzbetreiber-veroeffentlichen-karte-fuer-visionaeres-wasserstoffnetz-h2-netz/

[8] Vermeulen U, Turning a hydrogen economy into reality, presentation at 28th meeting Steering committee IPHE, the Hague, 2017

[9] Van Wijk, A & A. Wouters, Hydrogen, the bridge between Africa and Europe, September 2019

[10] http://www.pace-energy.eu/benefits/

[11] Bundesnetzagentur 2019

and electricity sectors (sector coupling) and offers a solution to complement existing and future storage and flexibility sources in the electricity system. Demand side measures and electricity storage can only provide short term measures to stabilise the power system. Electrolysers will bring much needed flexibility as the share of renewables continues to grow. Using hydrogen and the gas system offers a long-term solution to the balancing and storage dilemma and also offers an opportunity to transport energy to meet demand with an energy vector that is flexible across the economy.

Moreover, hydrogen technologies can also provide dispatchable power for the system. Decentralized fuel cells can produce power locally, but hydrogen turbines can also be used in large centralised power plants of systemic relevance. Indeed, hydrogen based power plants are crucial in an integrated energy system to ensure availability of (dispatchable) electricity at all times, and could even be used to provide dispatchable zero emission power at scale during periods or in situations where this is opportune and relevant e.g. in countries that have decided to phase out nuclear.

Numerous companies are exploring the potential to make use of hydrogen as a fuel to be used in traditional gas power plants. Gas fired power plants play an important role in providing a reliable and flexible energy supply and the conversion of gas turbines in gas-fired power plant units to hydrogen turbines is an important step towards achieving 100% fossil-free generation. Leading turbine manufacturers worldwide have committed to increase the hydrogen capability of their turbines.[12] Power plants will be capable to easily upgrade their hydrogen capability to match the share of green hydrogen in the gas mix. This will allow gas turbine technologies to provide 100% dispatchable power without emitting CO2. As such, the European turbine sector considers this a top strategic priority for the future.

Furthermore, the proliferation of renewables can be supported by pursuing off-grid solutions that promote hydrogen, enhance system integrity and energy system efficiencies. Industry is already exploring and planning to bring together the electricity and hydrogen world through innovative projects that link the production of renewable electricity production directly to a hydrogen plant via an electrolyser – what we refer to as "hydrogenewables". This represents a concrete example of energy system integration in action. Such cases, among other, are already being developed in the North Sea and the Baltic region . Among other, this approach unlocks potential to reduce costs, promote efficiencies and enhance system integrity via:

1. technical integration e.g. avoiding AC-DC and DC-AC conversion costs and conversion losses;
2. the result of business integration e.g. integrated project development construction, avoidance of transaction costs, permitting costs, electricity grid costs and taxes; and
3. the potential to counterbalance the cost of managing RES intermittency.

Initial Recommendations

- **Define an EU wide terminology for renewable and low carbon hydrogen together with a methodology to calculate minimum life cycle greenhouse gas emission savings.**

- **Promote and support hydrogen market stimulation programs including quotas and dedicated programs e.g. for large industrial processes, including a Clean Steel Programme.**

- **Develop a hydrogen market design based on a holistic vision of the interactions between various parts of the energy system and recognition of hydrogen's role in integrating these sectors.**

- **Revise the Trans-European Networks Regulation for Energy (TEN-E) Regulation to support the development and roll out of hydrogen networks and ensure synergies with the Trans-Europea Networks for Transport (TEN-T) regulation.**

[12] See more here https://powertheeu.eu/

- **Revise the directive for the Deployment of Alternative Fuels Infrastructure (DAFI) to boost the use of hydrogen in the mobility sector and adding hydrogen to the list of mandatory fuels.**

- **Ensure coherency between ambitions, existing policies and the Taxonomy regulation.**

- **Remove undue barriers to hydrogen production from the Renewable Energy Directive (RED) to unleash potential e.g. limitations created by principle of additionality and the requirement to demonstrate correlation in time and geography.**

- **Establish a "carbon-efficiency-first" principle as the foundation for fair energy taxation and reform the Emissions Trading Scheme**

- **Unlock hydrogen's potential by leveraging innovative financial instruments: scaling up the hydrogen economy needs a dedicated financial engineering as there will be many different sources for public funding enabling a framework for private investment. In order to reduce the complexity a one-stop-shop should be established which could be managed by the Clean Hydrogen Alliance.**

- **Launch the Clean Hydrogen Alliance and establish hydrogen as a key element in global EU climate diplomacy and neighbourhood policy.**

- **Synchronize policies for decarbonization of gas and for market transformation of gas-using appliances under eco-design and energy labelling – ensuring that the majority of future installed end-use appliances are capable to process hydrogen-methane blends or pure hydrogen.**