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Hydrogen Europe's Rationale for Sectoral Integration

Hydrogen as missing link for the energy transition

Hydrogen is an energy carrier, a fuel and a raw material, which if produced adequately can reduce GHG emissions, strengthen energy independence and mitigate the challenges posed by variability and intermittency of renewable energy systems as it offers a clean, sustainable, and flexible option to convert renewable electricity into a chemical energy carrier for use in mobility, heat and industrial applications. As the "gaseous form of electricity", it is an enabler for sectoral integration.

HYDROGEN STORES RENEWABLE ENERGY

Renewable power generation is characterised by variability and intermittency. As the renewables' penetration increases, the problem of balancing supply and demand for operators of electricity networks also rises. Periods of non-consumption-oriented production of renewable energy are usually managed by curtailing renewable power sources because the electricity cannot be sold at the time of generation. For example, in 2015 Germany curtailed 4.7TWh[1] of renewable electricity and re-dispatching costs equalling 402,5 Mio. Euro[1]. It has been estimated that curtailment could amount to 30% of Germany's electricity consumption by 2050 unless methods for storing and making use of this energy are implemented[2].

Power-to-Hydrogen technologies in a power system integrating high penetration of Renewable Energy Sources (RES) can operate throughout long periods of non-consumption-oriented production of renewable energy by feeding hydrogen into one or more energy sinks (e.g.: the gas grid, the storage tanks of hydrogen refuelling stations, and salt caverns). Stored hydrogen can be used on various timescales for satisfying demands for heat, transport, power or industry achieving high utilisation and absorption of energy. Production of hydrogen (or synthetic natural gas derived from hydrogen and carbon dioxide (SNG)) for injection into the natural gas grid is usually referred to as power-to-gas (P2G). It is currently being demonstrated at approximately 15 sites across Europe. As a major energy conveyor, the gas grid offers an extant energy sink for renewables and, unlike the power system, has a large inherent storage capacity in the TWh scale. Therefore, power from the electricity grid can be transferred readily to the gas grid via P2G.

Hydrogen can also be easily produced by replacing natural gas by biomethane in Steam Methane Reformers (SMR): when using hydrogen produced from biomethane, i.e. from wastes, it will boost the circular economy by giving other market opportunities to biogas.

HYDROGEN ENABLES SECTORAL INTEGRATION

"Sectoral integration means the integration of the power sector with the transport, the industry and the heating and cooling sectors via the use of all energy carriers such as electricity and hydrogen to achieve European climate and energy goals"

The ability of Power-to-Hydrogen to access and integrate each sector of the energy system opens up the opportunity for deploying and utilising renewables to a much greater extent. Power-to-Hydrogen systems can be implemented within the electricity grid utilising contractual obligations, guarantees of origin, in accordance with providing energy storage ancillary services for managing renewables in electricity grids and in direct combination with renewable power sources. Whereas electricity derived from renewables provides the power sector with a profound decarbonisation pathway, the heat and mobility sectors as well as industry do not yet have decarbonisation pathways of equivalent significance. The versatility of hydrogen enables these sectors to be integrated and to contribute to Europe's energy transition.

HYDROGEN FOR TRANSPORT AND AS THE BASIS FOR "RENEWABLE TRANSPORT FUELS OF NON BIOLOGICAL ORIGIN" (REFUNOBIOS)

The commercial introduction of fuel cell electric vehicles (FCEV[3]) has recently enabled one important Power-to-Hydrogen solution to commence. Hydrogen refuelling stations (HRS) incorporating on-site electrolysers[4] are producing, storing and dispensing hydrogen to FCEVs in accordance with grid balancing requirements (e.g. as part of the dynamic Firm Frequency Response service in the UK). The essential hydrogen storage capacity at each station enables production to be decoupled in time phase from demand for refuelling FCEV. In other words, hydrogen can be produced at the HRS when it contributes to stabilising the power grid. Furthermore, the required electrolyser capacities, and the need to implement significant numbers of HRS in a geographical distribution, matches well with the power sector's requirements for balancing increasing amounts of renewable generation in distribution networks. In the coming years, as the numbers of FCEVs (cars, buses, vans and other vehicles) increase, the aggregate electrical load of electrolyser-HRS will become significant for grid balancing at a national level.

This approach is advantageous for further decarbonising both the mobility and power sectors. It facilitates the use of much higher efficiency road vehicles, so reducing the

[1] Bundesnetzagentur (2016), *3. Quartalsbericht 2015 zu Netz- und Systemsicherheitsmaßnahmen Viertes Quartal 2015 sowie Gesamtjahresbetrachtung 2015*. https://www.bundesnetzagentur.de

[2] FCH2 JU (2015), *Commercialisation of Energy Storage in Europe* http://www.fch.europa.eu/sites/default/files/CommercializationofEnergyStorageFinal_3.pdf

[3] FCEV are electric vehicles including a hydrogen tank and a fuel cell to produce the electricity on board.

[4] Electrolysers are devices splitting water (H_2O) into hydrogen (H_2) and oxygen (O_2) using electricity

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energy requirement for road travel while shifting it to a sustainable energy resource. It enables the use of FCEVs which offer similar refuelling periods and travel ranges to conventional petrol/diesel vehicles (e.g.: 3-5min refuelling time with a 500km range).

Aditionnally, the use of hydrogen in the mobility sector reduces direct (CO_2) and indirect (e.g.: NOx and SO_2) GHG emissions so contributing to a decrease in health concerns. Progressive utilisation of such vehicles will foster zero emission transport in urban zones, hydrogen eco-systems and corridors between cities/countries so solving the infrastructure development situation.

Moreover, grid-connected contractual agreements with renewable energy sources, guarantees of origin, grid operators and direct connections offer pathways that certify the renewable character of the hydrogen and enable increasing its share at European and national level.

Finally, Compressed Natural Gas (CNG) vehicles are entering the market. The further decarbonisation of the transport sector be expected to include the utilisation of Synthetic Natural Gas (SNG) as a fuel in these vehicles in the not too distant future.

HYDROGEN FOR THE HEATING SECTOR

Hydrogen and hydrogen admixtures can be used as an alternative to natural gas for space heating, water heating and gas cooking. Hydrogen admixtures or hydrogen can be distributed via the existing gas grid, thus making use of the large available infrastructure asset. Because heat is by far the largest energy demand and has the greatest seasonal variation (disparity between high demand in winter, in times of low RES generation, and high RES generation in the summer), P2G can be applied to decarbonise gas networks and ultimately store excess renewable energy produced in the summer for release in the winter.Therefore P2G can make a major contribution to decarbonising the heating sector and decreasing our dependency on natural gas imports.

The natural gas infrastructure is progressively decarbonising through the introduction, in the short-term, of biomethane and, hydrogen with low concentration admixture or as SNG without requiring any changes to the infrastructure or gas appliances. Long-term objectives of full decarbonisation should therefore focus on enabling increasing shares of hydrogen, SNG and biomethane with needed standardisations.

In order to maximise efficiency in the energy system, combined heat & power (CHP) should be utilised. Fuel Cell CHP[5] has been deployed for commercial and district heat at scale for several decades. Micro-CHP fuel cells are today being deployed in Japan with 190,000 units expected to be installed by the end of the year. Meanwhile the largest European project (PACE) is aiming at 2,650 units.

HYDROGEN AS AN ENABLER FOR GREATER RENEWABLE ENERGY SHARE IN THE INDUSTRY

Hydrogen is today widely used in industry and almost entirely produced by fossil fuels, with a related CO_2 footprint. Using green hydrogen produced from renewables will increase the share of renewable energy sources in industrial processes. As the industry is cost sensitive, green hydrogen needs to serve applications where it offers most benefits.

Steel manufacturing processes offer one such application. One process to produce steel is to use hydrogen (today from SMR of natural gas) for the reduction of ore. Several initiatives are on the way in Sweden, Austria, and Germany; partly supported by European funding.

Refineries could also utilise green hydrogen to decarbonise their refining processes. Today, global hydrogen production is at 55 million metric tons annually with ±50% from SMR. Out of this, ±40% is consumed at refineries [6]. Utilising Power-to-Hydrogen could therefore have a significant beneficial effect on the overall system decarbonisation.

Fuel producers are obliged to reduce CO_2 in their supply chain. This CO_2 reduction can be achieved by using green hydrogen in the refinery process. Although the more costly green hydrogen doesn't compete yet economically with hydrogen produced from fossil hydrocarbons, it does compete with biofuels. To achieve this, regulations should provide non discriminating rules that allow the use of hydrogen in the upstream fuel processes in a fair competition (both in price and GHG mitigation potential) with biofuels to fullfill the obligations for the renewable share in liquid fuels, therefore helping to reduce the dependency of the European Union on natural gas whilst contributing to the reduction of palm oil consumption.

Hydrogen can also be used as a green synthetic substitute for many different applications in the fuel and chemical sectors. Methanol, for example, is a liquid chemical with many different possibilities of application. Many projects are underway, globally, to assess and scale-up the potential of such synthetic fuels/chemicals such as the MefCO2 (synthesis of methanol from captured carbon dioxide using surplus electricity) and the Carbon2Chem (utilisation of steel mill waste gases) projects.

ABOUT HYDROGEN EUROPE

Hydrogen Europe is the leading industry association representing more than 110 companies and national associations, both large and SMEs, working to make hydrogen energy an everyday reality. The association partners with the European Commission and the research community in the public-private partnership Fuel Cells and Hydrogen Joint Undertaking (FCH JU) to accelerate the market introduction of these clean technologies in the energy and transport sectors. More information can be found on www.hydrogeneurope.eu

5 A fuel cell is an electrochemical device that converts the chemical energy of a fuel, such as hydrogen, with an oxidant, such as oxygen, directly into electrical and thermal energy.

6 Ball, M. and Wietschel M. (2009) *the future of hydrogen – opportunities and challenges.* International journal of hydrogen energy 34 (615-627)