SIOI
UNA Italy
OSSERVATORIO
sulle attività delle organizzazioni internazionali e sovranazionali, universali e regionali, sui temi di interesse della politica estera italiana

Green Hydrogen production and pipeline transport from postwar Ukraine to the European Union: market and infrastructure challenges.

Greta Di Mattia
Master's Degree in EU Public Affairs and Policies, College of Europe

1. Hydrogen production: a transition from grey to green.- Most of hydrogen produced nowadays is "grey", meaning that it is generated via chemical processes involving fossil fuels as raw materials which, overall, account for 95% of hydrogen production[1]. More precisely, 48% of hydrogen is currently produced via a chemical process called *steam reforming* using natural gas as a raw material, which is reacted with steam at an elevated temperature to produce carbon monoxide and hydrogen[2]. Steam reforming via natural gas hence holds the largest share of hydrogen production due to the lower cost of gas compared to other fossil fuels.

Unlike hydrogen produced from natural gas via steam reforming, green hydrogen is produced through electrolysis, a process "based on the principle of the decomposition of water into its constituent elements (hydrogen and oxygen) by means of applying an electric current"[3]. Nevertheless, in order to be labelled as green, hydrogen production through the electrolysis process must be carried out with electricity produced from renewable energy sources, such as, mainly, wind and solar.

Nowadays, green hydrogen accounts for around 3,9% of the world's hydrogen. As a consequence, "hydrogen production is responsible for annual CO_2 emissions equivalent to those of Indonesia and the United Kingdom combined"[4]. Making hydrogen production sustainable could hence significantly reduce CO2 emissions: "cleaner technologies for its production enable hydrogen and hydrogen-based fuels to avoid up to 60 Gt CO2 emissions in 2021-2050 in the Net zero Emissions Scenario, representing 6% of total cumulative emissions reductions"[5].

According to the EU Hydrogen strategy, after a first phase envisaging the installation of 6GW of renewable hydrogen electrolysers in the EU by 2024, from 2025 to 2030 40 GW of renewable hydrogen electrolysers could be potentially installed in the Eastern and Southern Neighbourhood, in particular Ukraine[6]. Finally, in a third phase

[1] See Robert Rapier, Estimating the Carbon Footprint of hydrogen production, in *Forbes*, 6 June 2020, accessed 21 April 2022, https://www.forbes.com/sites/rrapier/2020/06/06/estimating-the-carbon-footprint-of-hydrogen-production/.

[2] Ibid.

[3] The Oxford Institute for Energy Studies, Ammonia as a storage solution for future decarbonized energy systems, November 2020, p. 15, accessed 2 April 2022 https://www.google.com/url?sawww.oxfordenergy.org.Ammonia-as-a-storage-solution-for-future-decarbonized-systems-EL-42.pdf

[4] IEA, The future of Hydrogen: seizing today's opportunities. Report prepared for the G20, Japan, June 2019, p. 14, https://www.iea.org/reports/the-future-of-hydrogen.

[5] IEA, Hydrogen: key findings, https://www.iea.org/fuels-and-technologies/hydrogen.

[6] European Commission, Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions, COM(2020) 301 final: A Hydrogen Strategy for a climate-neutral Europe, 8 July 2020, p. 19.

from 2030 to 2050, renewable hydrogen technologies shall be deployed at large scale to reach all hard-to-decarbonise sectors.

These targets are rather ambitious, but the uptake of green hydrogen production is favoured by three main aspects playing on the side of the EU:

- The rapid cost decline of renewable energy
- The cost decline of electrolysers, reduced by 60% in the last 10 years[7]
- The leading role of European technology in electrolysers manufacture

The combination of these three factors represents a winning formula to build fruitful partnerships between European countries and Ukraine in the production of green hydrogen, with the most promising of such partnerships currently being the one between the German energy trading company RWE and the Ukrainian State Gas Company Naftogaz which, in August 2021, signed a memorandum of understanding to explore mutually beneficial cooperation opportunities along the full value chain of green hydrogen[8].

However, for the uptake of a green hydrogen market to take place, production must be met by precise demand drivers, which are going to be described below.

2. The lead markets of Green Hydrogen.- The main reason why hydrogen generation accounts for such a significant share of the global greenhouse gas emissions (6%) is that it represents the first stage of ammonia manufacture, 80 % of which is used to make ammonia fertilizer, a global commodity of fundamental importance, considering that 50% of the world's food production relies on it[9].

However, the aggregate share of CO2 emissions reduction potentially stemming by green hydrogen is much higher if we take into account the new demand drivers envisaged in the future market projections, that encompass two main sectors: steel and chemical industry and heavy transport. These are sectors which are difficult to electrify and could hence use hydrogen as their main energy source to decarbonize their production processes.

In the EU, road transport is the main cause of air pollution in cities and represents around 21% of the EU's total greenhouse gas emissions[10]. While passenger cars and vans (light commercial vehicles) account for the largest share of Co2 emissions produced by

[7] "Close to 70 MW of electrolysis capacity was installed, doubling the previous year's record, and two facilities producing hydrogen from fossil fuels with CCUS became operational, expanding production capacity by about 15%" See IEA, Hydrogen: key findings, https://www.iea.org/fuels-and-technologies/hydrogen.

[8] Naftogaz Group, Naftogaz and RWE sign memorandum of understanding on hydrogen, Essen, 22 August 2021, https://www.rwe.com/en/press/rwe-supply-and-trading/2021-08-22-naftogaz-and-rwe-sign-memorandum-of-understanding-on-hydrogen.

[9] *Supra* note 3, p. 11.

[10] European Commission, Reducing Co2 emissions from vehicles, accessed 3 April 2022 https://ec.europa.eu/clima/eu-action/transport-emissions/road-transport-reducing-co2-emissions-vehicles_it.

road transport (62%)[11], lorries, buses, and coaches (heavy transport) are responsible for around 25% of CO_2 emissions from road transport in the EU[12]. This means that decarbonizing heavy transport via green hydrogen would reduce the total amount of EU greenhouse gas emissions of 5%[13].

The EU steel industry currently accounts for 221 Mt GHG emissions annually (including both direct and indirect emissions). This is 5,7% of total EU emissions[14]. In 2019, EU chemical industry emissions decreased to 124 million metric tons of CO2, hence accounting for 4,3% of total EU emissions in 2019[15]. Thus, the decarbonisation of these sectors via green hydrogen can reduce the total EU's greenhouse gas emission of around 15% before 2030, hence significantly contributing to reach the target – set in the EU Green Deal – of a 55% emissions reduction before that time. In fact, according to the EU Hydrogen strategy, the above-mentioned sectors can be decarbonized via green hydrogen within the two first phases, from 2020 to 2024 and from 2025 to 2030.

As for the aviation sector, it produces 13,9% of the emissions from transport, "making it the second biggest source of transport GHG emissions after road transport"[16], whereas "shipping emissions represent around 13% of the overall EU greenhouse gas emissions from the transport sector (2015)"[17].

Sectors such as aviation and shipping may be decarbonized via green hydrogen in a long-term scenario towards 2050, overall accounting for 26,9 % of the whole transport sector emissions and roughly 5% of the total EU greenhouse gas emissions. Thus, in the long term towards 2050, green hydrogen alone could make 20% of the carbon neutrality target.

However, due to the initial little demand for green hydrogen, demand side support policies are required in order to counter-balance the higher risk of investments into green-hydrogen production and infrastructure development. According to the EU hydrogen strategy, demand could be driven by setting minimum shares or quotas of renewable hydrogen in specific end-users' sectors.

Another policy instrument which is mentioned in the strategy with a view to bridge the cost gap of investors in green hydrogen as compared to conventional hydrogen

---

[11] DE Statis, **Road transport: EU-wide carbon dioxide emissions have increased by 24% since 1990, accessed 16 April 2022,** https://www.destatis.de/Europa/EN/Topic/Environment-energy/CarbonDioxideRoad-Transport.html.

[12] European Commission, Reducing Co2 emissions from heavy-duty vehicles, accessed 3 April 2022 https://ec.europa.eu/clima/eu-action/transport-emissions/road-transport-reducing-co2-emissions-vehicles/reducing-co2-emissions-heavy-duty-vehicles_en.

[13] *Supra* note 9.

[14] European Commission, Commission Staff Working Document SWD (2021) final: Towards competitive and clean European steel, 5 May 2021, https://ec.europa.eu/info/sites/default/files/swd-competitive-clean-european-steel_en.pdf.

[15] Lucia Fernandez, Chemical Industry Greenhouse Gas Emissions 1990-2019, in *Statista*, 5 May 2022, accessed 10 May 2022, https://www.statista.com/statistics/536106/european-union-chemical-industry-greenhouse-gas-emissions/.

[16] European Commission, Reducing emissions from aviation, https://ec.europa.eu/clima/eu-action/transport-emissions/reducing-emissions-aviation_en.

[17] European Commission, Reducing emissions from maritime transport, https://ec.europa.eu/clima/eu-action/transport-emissions/reducing-emissions-shipping-sector_it.

production, is represented by carbon contracts for difference (CCfDs). A carbon contract is a contract by which a government or institution agrees with an agent on a fixed carbon price over a given period during which the agent can sell any carbon emission reductions (allowances) at a strike price. If the market price is lower than the strike price, the agent receives the difference, hence recoupling the higher costs linked to green hydrogen production. If the market price is higher, the agent has to return the additional revenue to the government.

In order to build a coherent investment agenda, the Clean Hydrogen Alliance was created, with the participation of Ukraine being encouraged.

Yet, while the supporting factors of an uptake in green hydrogen production, together with tailored demand side support policies seem to build a promising scenario, a clear regulatory framework is essential to enable the development of a dedicated infrastructure, the backbone of any energy market.

3. Infrastructure development: tackling regulatory barriers.- By the end of the second phase (2025-2030), renewable hydrogen is expected to gradually become cost-competitive. Thus, the main challenge in this phase is related to the development of an EU-wide logistical infrastructure to transport hydrogen from large producing hubs located in Ukraine to demand centers located in other EU Member States such as Germany.

This challenge seems to be far more problematic as compared to the investments boosting. Repurposing of gas pipelines is considered to be the most cost-effective and efficient way to develop hydrogen infrastructure, but the EU is still lacking coherent policy instruments aimed at untapping the potential of Ukraine's up-stream and mid-stream gas companies, whose "extensive system of mainstream gas pipelines and gas distribution network in Ukraine has a significant potential for using the hydrogen both in the national market and for export supplies"[18]. Nevertheless, existing natural gas pipelines are owned by network operators which are not allowed to own or finance hydrogen pipelines.

According to the EU hydrogen strategy, the regulatory framework should be reviewed in order to allow such financing and operation.

Well, the new *hydrogen and decarbonized gas package* – whose proposal was adopted by the Commission 15 December 2021 – beyond extending the existing models of *vertical unbundling*[19] between production and transmission to a nascent hydrogen

[18] UNECE, Draft Roadmap for production and use of hydrogen in Ukraine, March 2021, p. 31.

[19] Vertical unbundling represents the founding principle of the original plan to create a single, liberalised gas market in the EU started with the adoption of the first Gas Directive in 1998. It consists in the separation of energy supply and generation from the operation of transmission and distribution networks, which are regulated monopolies in the EU.

If a single company operates a transmission network and generates or sells energy at the same time, it may have an incentive to obstruct competitors' access to infrastructure, hence preventing fair competition.

Thus, the rationale of unbundling lies in the ultimate goal of fostering competition in order to decrease market concentration and the subsequent power of dominant companies to increase energy prices for consumers.

market, it also introduces a new measure, *horizontal unbundling*, whose crucial shortcomings are going to be described following the description of the concept rationale.

Two different models of horizontal unbundling are proposed in the Package: legal separation, pursuant to article 63 of the revised GD "Horizontal unbundling of hydrogen network operators" and accounts unbundling pursuant to article 64 "Unbundling of accounts for hydrogen system operators".

- Legal separation: "Where a hydrogen network operator is part of an undertaking active in transmission or distribution of natural gas or electricity, it shall be independent at least in terms of its legal form"[20]. In other words, "activities in different regulated fields can be owned by the same company but there must be separate legal entities with separate corporate identities and separate accounts, among others"[21].

- Accounts unbundling: Gas system operators that envisage to also become hydrogen system operators shall keep gas and hydrogen infrastructures in separate regulatory asset bases (RABs). This separation of accounts must be done as *if they would be required to do if the activities in question were carried out by separate undertakings, with a view to avoiding discrimination, cross-subsidisation, and distortion of competition* (Article 69(3) revised GD). This implies different tariffs for hydrogen and natural gas networks[22].

Horizontal unbundling is fueling a particularly intense debate amongst experts and professionals of the gas sector. The rationale is the following: if the same company is allowed to own/operate gas and hydrogen transmission systems, it could cross-subsidize hydrogen infrastructure via gas revenues, with a view of counter-balancing the higher risk of investments.

Such phenomenon would lead to hydrogen investments costs being born by both gas and hydrogen consumers, hence hampering cost-reflectivity.

The most controversial issue regarding horizontal unbundling arises in relation to the repurposing of existing gas infrastructure into hydrogen networks, a method that has proved to be more cost-effective than the construction of new infrastructure[23]. In fact, while horizontal unbundling is aimed at avoiding cross-subsidization and keep cost-reflectivity, it cannot be denied that cross-subsidisation facilitates repurposing of existing gas pipelines to hydrogen.

---

[20] Lavinia Tanase and Ignacio Herreira Anchustegui, The EU Hydrogen and Decarbonised Gas Market Package: Revising the governance and creating a hydrogen framework, *Florence School of Regulation*, 21 March 2022, accessed 30 March 2022, https://fsr.eui.eu/the-eu-hydrogen-and-decarbonised-gas-package-revising-the-governance-and-creating-a-hydrogen-framework/.

[21] Jan Cihlar, Oskar Krabbe, Yvonne Deng, Daan Peters (Guidehouse) and David Bothe, Matthias Janssen, Lino Sonnen, Gregor Brändle (Frontier Economics), *Assistance to the Impact Assessment for designing a regulatory framework for hydrogen*, Brussels: European Commission, November 2021, p. 31.

[22] *Supra* note 20.

[23] ACER, Transporting Pure Hydrogen by Repurposing Existing Gas Infrastructure: Overview of existing studies and reflections on the conditions for repurposing, 16 July 2021, https://extranet.acer.europa.eu//Official_documents/Acts_of_the_Agency/Publication/Transporting%20Pure%20Hydrogen%20by%20Repurposing%20Existing%20Gas%20Infrastructure_Overview%20of%20studies.pdf.

Operating gas and hydrogen networks in a common RAB – that is to say with no horizontal unbundling – allows gas transmission system operators (TSOs) "to finance the networks across users of both energy infrastructure, gas and hydrogen"[24]. This facilitates investments in hydrogen networks, particularly in early development periods where hydrogen networks based on repurposed natural gas pipelines are likely under-utilised: if network operators cannot cross-subsidise between gas and hydrogen consumers, "they face higher investment burdens and risks for hydrogen investments as they must be entirely refinanced by hydrogen consumers"[25], in the absence of direct subsidies to support hydrogen networks. Moreover, different tariffs for hydrogen and gas networks would entail higher prices for hydrogen consumers, who are less "captive"[26] as compared to gas consumers since they can simply choose not to switch to hydrogen and keep consuming natural gas.

On the other hand, no horizontal unbundling could lead to no cost-reflectivity, and residential natural gas users would end up paying for hydrogen grid for industry customers[27].

Article 4 of the revised GR allows for the cross-subsidization of hydrogen networks by natural gas network revenues if done in a transparent way and under three conditions: i) the cost can only be levied on domestic users; ii) limited in time; iii) and subject to regulatory approval. This provision, despite not fully aligned with the regulators' preference against structural cross-subsidies, was welcomed by ACER as a meaningful guarantee[28]. Indeed, the agency will play a key role in determining the value of assets, size and duration of the financial transfer, ensuring its compliance with objective reasons to avoid cross subsidies[29].

Nevertheless, the objective opportunity represented by cross-subsidization for the development of hydrogen infrastructure especially in the form of repurposing, could be compromised by the absence of clear EU guidelines, which could lead to a strict interpretation of article 4 of the revised GR, *de facto* hindering financial transfers aimed at the repurposing of gas pipelines and, as a consequence, the ramp-up of the hydrogen market.

4. Conclusions.- While the scale-up of green hydrogen production in Ukraine seems to be gaining significant momentum in view of the rapid decline in the cost of renewable energy and electrolysers along with targeted policy instruments aimed at

[24] Jan Cihlar, Oskar Krabbe, Yvonne Deng, Daan Peters (Guidehouse) and David Bothe, Matthias Janssen, Lino Sonnen, Gregor Brändle (Frontier Economics), *Assistance to the Impact Assessment for designing a regulatory framework for hydrogen*, Brussels: European Commission, November 2021, p. 34.

[25] Ibid., p. 33.

[26] Ibid., p. 38.

[27] Ibid., p. 35.

[28] The Commission's New Gas and Hydrogen Package, *Florence School of Regulation*, February 2022, https://www.youtube.com/watch?v=ZrBNmqKyKCU.

[29] Ibid.

counter-balancing the initial higher risk of investments, the infrastructure challenges appear to be more critical.

Regarding horizontal unbundling, it is hereby argued that there is one aspect which was probably overlooked when assessing the impact of cross-subsidisation on cost-reflectivity, that is to say: the level of impact on cost reflectivity also depends on the level of the cross-subsidy.

If, on the one hand, the utilization of gas network revenues to finance new hydrogen infrastructure is a capital-intensive investment, which could thus lead to rightful concerns over cost-reflectivity, repurposing is less capital intensive and the consequent cost-bearing on the part of gas consumers should be more limited, hence outweighed by the advantage of a significant incentive to the ramp-up of the green hydrogen market.

Furthermore, the new Hydrogen and Decarbonised Gas Package seems to be modelled on European markets such as the Belgian one, with vertically integrated undertakings such as *Air Liquide* which are active in both green hydrogen production and transmission, having the possibility to apply for derogations from vertical unbundling and third-party access pursuant to article 60 of the revised Gas Regulation.

Such derogations will hardly represent a game changer for the Ukrainian hydrogen market, with Naftogaz envisaging to become a national leader in hydrogen production and storage[30], while the predominant role in hydrogen infrastructure development will be played by GTSOU, which already joined a number of important international partnerships in the field of hydrogen infrastructure development such as the *Central European Hydrogen Corridor* (CEHC) initiative, in September 2021.

The Central European Hydrogen Corridor (CECH) is a very promising infrastructure development project, exploring the technical feasibility of creating a hydrogen "highway" transporting hydrogen from Ukraine to Germany via Slovakia and the Czech Republic.

Promoted by a group of four leading Central European gas transmission infrastructure companies in Ukraine, Slovakia, the Czech Republic, and Germany, the project envisages both creation of new hydrogen pipelines and repurposing of existing gas infrastructure. Beyond the exploration of the technical aspects relating such a majour infrastructure development project, an enabling regulatory framework is needed in order to streamline investments and planning on the part of the involved companies, an issue which the relevant stakeholders involved in the legislative process of the new hydrogen and decarbonized gas package should take into due account.

It is thus evident that infrastructure development is mandated to already unbundled gas transmission operators, meaning that a derogation from vertical unbundling pursuant to article 60 of the revised Gas regulation, while benefitting some vertically integrated

[30] Ukrinform, Ukraine's state energy firm Naftogaz has joined the European Clean Hydrogen Alliance, the company's press service has said, 1 December 2021, accessed 15 April 2022, https://www.ukrinform.net/rubric-economy/3361126-naftogaz-joins-european-clean-hydrogen-alliance.html.

companies in other markets such as the Belgian one, will not make any difference in the ramp-up of hydrogen infrastructure connecting Ukraine to consumers in Central Europe.

For the reasons described in the previous chapter of the present work, that are mainly enshrined in the littler risk of investments deriving from a single RAB, the most crucial derogation for transmission operators involved in hydrogen infrastructure development would be one from horizontal unbundling pursuant to articles 63 and 64 of the revised Gas Directive.

Pursuant to article 47 of the revised Gas Directive, Member States may decide to grant a derogation from the two forms of horizontal unbundling (legal and accounts unbundling), but only for existing hydrogen networks belonging to vertically integrated undertakings on the date of the entry into force of the Directive and "limited in scope to the network capacity *in operation on* [date of entry into force]".

Well, considering that, under the current timeline proposed by the Commission, the new Gas Directive and Regulation are expected to enter into force in 2023, the hydrogen infrastructure planned in the framework of the above-mentioned projects will hardly be in operation by that time, hence falling short of the possibility to be granted a derogation from horizontal unbundling pursuant to article 47 of the revised Gas Directive. Thus, transmission operators will have to transfer hydrogen assets to a separate RAB, hence risking not to recouple the invested capital through the revenue stemming from the few hydrogen consumers in the early stage of the market.

In conclusion, it is hereby argued that, while representing a valuable blueprint for the extremely complex regulation of the nascent hydrogen market, the regulatory framework as designed through the new Hydrogen and Decarbonised Gas Package fails to take the peculiarities of the Ukrainian gas and hydrogen markets into due account, hence potentially hampering the future, most promising partnership for the EU aimed at ending its dependence on Russian gas while crucially meeting the ambitious targets set in the Green Deal.

Settembre 2022