ADVISORY PANEL FOR FUTURE GAS GRIDS

RECOMMENDATION REPORT

JANUARY 2022

DISCLAIMER

The Recommendation report was drafted by ENTSOG. It is based on the input of the Panel stakeholders participating in the meetings and in no way reflects the position of every individual stakeholder or of ENTSOG itself.

The following stakeholders took part in the Panel discussions: Eurogas, Hydrogen Europe, Gas Infrastructure Europe, Council of European Energy Regulators, International Association of Oil & Gas Producers, IFIEC, GEODE, GD4S, European Chemical Industry Council, Fertilisers Europe, European Heating Industry, Gas for Climate, European Federation of Energy Traders, European Engine Power Plants Association, EU Turbines, European Biogas Association, H2GAR, ENTSO-E, Marcogaz, GERG, EASEE-gas, Florence School of Regulation, Copenhagen School of Energy Infrastructure, Gassco, European Union Agency for the Cooperation of Energy Regulators and European Commission.

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1 INTRODUCTION

Based on European Commission's Energy System Integration and Hydrogen Strategies, the gas and hydrogen value chains need to deliver on a European hydrogen economy and on a future role of existing gas infrastructure in development of a European hydrogen market. Timely and efficient implementation of the above Strategies is possible only by addressing how repurposing of existing infrastructure and/or consideration of the proposal for a European hydrogen backbone could support the achievement of this future energy system.

As outlined in the Hydrogen Strategy, the infrastructure needs for hydrogen will depend on the pattern of hydrogen production and demand. Following the stepwise approach indicated in the Strategy, by 2030 the demand for hydrogen may initially be met by production on-site in industrial clusters. In the second phase, local hydrogen networks would emerge to cater for additional industrial demand. After 2030, with increasing demand, longer-range transportation would be needed. The existing pan-European gas infrastructure could be repurposed to provide the necessary infrastructure for large-scale cross-border transport of hydrogen. In this context, repurposing may provide an opportunity for a cost-effective energy transition in combination with (relatively limited) newly built hydrogen dedicated infrastructure.[1]

In January 2021, ENTSOG launched the Advisory Panel for Future Gas Grids (hereby referred to as 'Panel') with the purpose of allowing for transparency and coordination between the entire value chain supporting the transition to the hydrogen economy. The goal was also to identify practical challenges and solutions on various gas grids' pathways to reach net-zero emissions by 2050. Throughout the year, in quarterly meetings, stakeholders along the entire value chain – from production, transmission and distribution, to end-use – discussed the market, technical, planning, regulatory and financing elements of how to repurpose and retrofit the existing gas infrastructure for renewable and low-carbon gases (including hydrogen, biomethane and syngas). Speakers from the European Commission and European Council, as well as industry association regulators also took part in these meetings.

The outcomes of these meetings resulted in the development of this Recommendation Report, which provides an overview of stakeholders' input on key elements needed to effectively establish the repurposing framework for gas grids. The objective of the Report is to summarise a common understanding on the best ways for repurposing and retrofitting the gas grids based on coordinated and best available information in 2021. Hence, the report focuses on retrofitting - an upgrade of existing infrastructure that allows the injection of certain amounts of hydrogen into a natural gas stream up to a technically-sound threshold of H_2/CH_4 mixture (i.e. blending) and repurposing implies converting an existing natural gas pipeline into a dedicated hydrogen pipeline.[2] ENTSOG members are ready to work for possible synergies through TSO management of the facilities for natural gas and hydrogen, either repurposed or new pipelines. Although not in the scope of this report, distribution grids and underground gas storage[3] play an essential role in establishing an integrated energy system and hydrogen economy in Europe by 2050.

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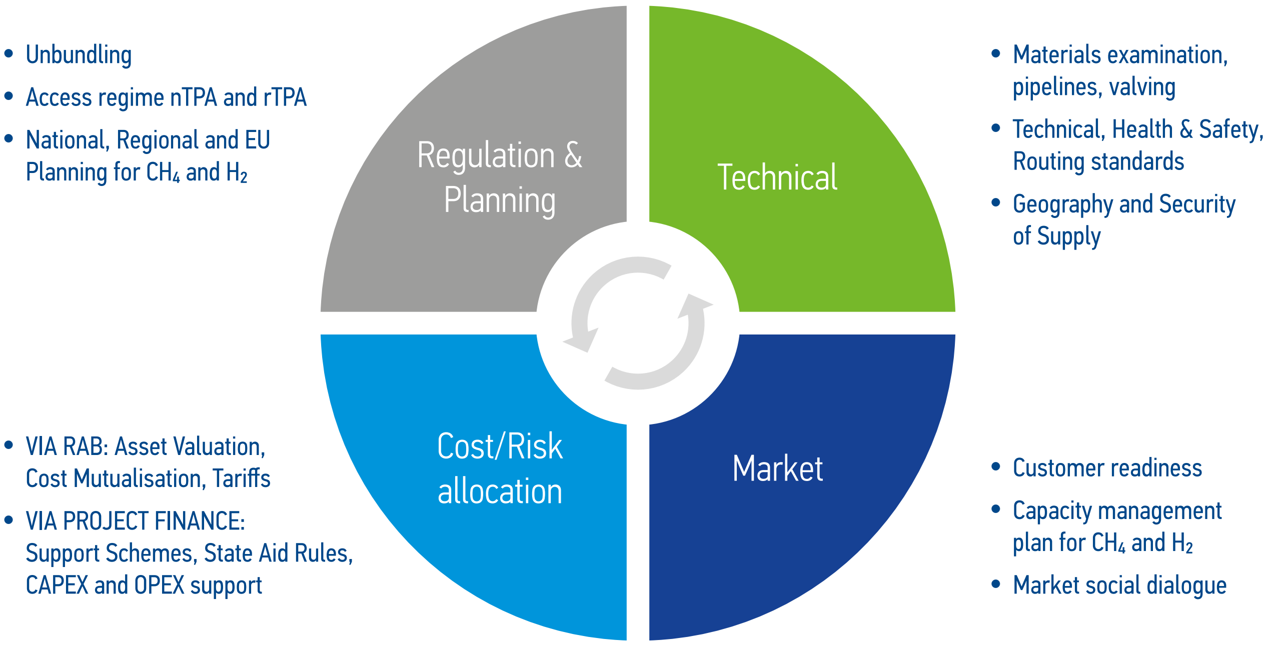
1 A hydrogen strategy for a climate-neutral Europe, European Commission, 2020, p14-15.

2 ENTSOG, GIE and Hydrogen Europe, How to transport and store hydrogen - Facts and Figures, 2021, p 6.

3 Gas Infrastructure Europe, Guidehouse study, Picturing the value of underground gas storage to the EU H2 system, 2021, available here.

2 REPURPOSING FRAMEWORK

In 2021, the Panel stakeholders on several occasions discussed the optimal transition pathway of repurposing gas grids to reach net-zero emissions by 2050. A majority of stakeholders agreed that the repurposing of existing gas infrastructure is likely to have a role to play in future as hydrogen infrastructure, noting in particular the cost advantages of this approach relative to building new dedicated hydrogen assets. [4]



Hence, this report focuses on how to repurpose the gas grids to address technical, regulatory, planning, market and financing elements. The following sections address:

- **Technical elements:** with the injection of renewable and low-carbon gases (including hydrogen, biomethane and syngas) into grids, technical challenges related to gas quality and asset repurposing (pipelines, valves, compressors, etc.) need to be dealt with. Technical and safety standards will need to be developed and interoperability between Member States and Security of Supply ensured. If not addressed, this could lead to increased costs and obstacles to develop a pan-European market. This process will need to ensure that end-users' requirements (in terms of gas quality and hydrogen purity) are fully considered.
- **Market elements:** A market for hydrogen needs to be designed such that hydrogen can be traded as a commodity irrespective of source or origin. Lessons need to be learned from the development of the market for natural gas over the last 25 years and appropriate frameworks to manage costs and risks need to be created. This may include a need to consider policy-measures, on the supply and demand side of the market, to kick-start its development. Market design should include rules on repurposing as well as management of the necessary transport capacities to optimise the utilisation and repurposing of the current gas assets.

4 Gas for Climate, Extending the European Hydrogen Backbone. A European Hydrogen Infrastructure Vision Covering 21 Countries, 2021, see more here.

- **Regulatory and planning elements:** A barrier for kick-starting a hydrogen economy is the lack of a regulatory framework[5]. Investor confidence can be enhanced if key regulatory principles are defined in advance. These principles include unbundling, the access regime (negotiated or regulated Third Party Access) and their application in the hydrogen market. On the planning side, as the energy system becomes ever more integrated and interlinked – and as national policies need to be compatible – a coordinated EU-wide planning approach for all energy carriers, including gas, electricity and hydrogen is essential.
- **Financing elements (cost and risk allocation):** Transmission and distribution infrastructure has significant CAPEX costs. Hence, adequate financing will be needed – either via public or private finance. Consideration for where risks are allocated is required – recognising the different incentives this creates and the need. This may involve various tools at either national or European level (again recognising the need for cooperation) and/or various regulatory processes to transfer assets between asset bases. There are several tools and mechanisms available at EU level. Alternatively, transferring the gas assets into the hydrogen networks could be done via cost mutualisation. The European gas TSOs are actively working and willing to invest in repurposing, but there is a need to understand those new conditions.

2.1 TECHNICAL ELEMENTS

Renewable and low-carbon gases (including hydrogen, biomethane and syngas) will flow in the retrofitted and repurposed gas pipelines. In this regard, end-users mentioned in particular that reliable (in terms of security of supply) and steady flows and gas quality, should be ensured, as security of energy supply and interoperability between Member States are key. Grid operators must map the areas with sensitive customers based on simulation tools, and provide stable gas quality (H_2/NG mix) and the required hydrogen purity.

Several stakeholders are working on solving the technical challenges of transporting hydrogen in repurposed pipelines, while many reports and studies focus on understanding how hydrogen-ready the existing gas infrastructure is. The Re-Stream study[6] by DNV and Carbon Limits, focused on assessing the feasibility of transport of hydrogen and CO_2 in European offshore and onshore oil and gas infrastructures. Key findings indicate that most of the offshore pipelines and close to 70 % of the onshore pipeline total length can be reused for hydrogen, considering the current state of knowledge/standards. The Hydrogen Gas Asset Readiness (H_2GAR) project focuses on sharing current technical knowledge on hydrogen gas asset readiness (pipelines, compressors, metering, etc.). It is an important contribution in the process of creation of new standards and technologies that are essential to the future gas transmission systems.

2.1.1 GAS QUALITY MANAGEMENT TOOLS

TSOs have been relying on gas quality tracking systems for over twenty years, applying measurement data (volumes, pressure, gas composition, calorific value, etc.) as input data for simulation of the flows in the grid. For instance, in a decentralised biomethane production plant located in a rural area without high consumption and excess biomethane productions, gas quality tracking tools are needed to optimise grid usage. Future deployment of smarter gas quality management tools will help to create hub-based data solutions that can serve to optimise the production and injection of gases into a network to allow for cost-efficient activity. It must be considered that with increasing digitalisation, the risk of cyber threats also increases.[7]

2.1.2 HYDROGEN READINESS

In terms of hydrogen blends, the Marcogaz infographic[8] from 2019 provides an overview of the hydrogen tolerance of the existing gas infrastructure and end use applications. Major elements of the gas transmission, storage and distribution infrastructure and residential gas appliances are expected to accept 10 % vol. hydrogen without major modification. Some distribution networks and residential appliances can already handle up to 20 vol.-% of hydrogen. Relevant findings also

5 The Advisory Panel for Future Gas Grids held discussions before the publication of the Hydrogen and Decarbonised Gas Markets package on 15 December 2021.

6 DNV and Carbon Limits, Re-stream: Study on the reuse of oil and gas infrastructure to transport hydrogen and CO_2 in Europe, 2021, available here.

7 Colonial pipeline in the USA – for more information see here.

8 Overview of available test results and regulatory limits for Hydrogen admission into existing natural gas infrastructure and end use, 2019, available here.
The next available update will be released early in 2022.

come from the ENTSOG Prime Mover Group on Gas Quality and Hydrogen[9], which in its report 'Decarbonising the gas value chain: Challenges, solutions and recommendations'[10], provides an overview of each sector's possibilities and vision on the use of hydrogen, as well as key facts about the technical challenges that decarbonisation poses, along with potential solutions to overcome them. The group concludes that, in general, blending percentages up to 2 % vol. hydrogen into the natural gas system are already possible without any additional mitigation efforts.

End-user readiness to receive renewable and low-carbon gases for their systems:

- **The chemical industry** is currently the main industrial consumer of natural gas and the main producer and consumer of (grey) hydrogen. Therefore, hydrogen is expected to play a key role in supporting the chemical industry in the transition towards carbon neutrality. The industry can use hydrogen both as feedstock and as energy carrier, which should be delivered in dedicated pipelines.
- **The heating industry** represents 40 % energy consumption in Europe, and most of today's heating systems are gas based. The majority is old and inefficient (installed before 1960)[11]. Hence, there is need for appliances compatible with renewable and low carbon gases. On the readiness side, hydrogen heating technologies are already available, and these new appliances can work with hydrogen blends and 100 % hydrogen, while boilers installed from 1995 onward can take up admixtures of up to 10 % hydrogen, and many boilers currently on the market even up to 20 %.
- **Gas power plants as hydrogen consumers.** In the electricity sector, hydrogen and hydrogen-based fuels could provide an important climate-neutral or low-carbon source of electricity system flexibility (and heat where needed, thanks to cogeneration plants). This is achieved through new power plants ready for up to 100 % hydrogen or the retrofitting of existing gas-fired capacity for a full switch or to co-fire with hydrogen. Upgrading existing plants needs individual analysis. Up to 20–30 % hydrogen blending requires in most cases only small modifications. Hydrogen-readiness of new plants is already possible – typical readiness levels defined by industry foresee10 %, 25 % and 100 % hydrogen.

2.1.3 HYDROGEN PURITY

Several stakeholders also raised the issue of hydrogen purity, as some end-user applications would need high level purities (e.g. 99.97 % for fuel cells). Currently, several field-tests are ongoing to assess the hydrogen purity that repurposed natural gas grids can deliver. Both EASEE-gas CBP and a German standard examine required purities for hydrogen transport via repurposed natural gas pipelines and concluded that 98 % vol. hydrogen is a reasonable starting value. Also, CEN TC 234 WG 11 has launched a new work item proposal to develop a European standard for hydrogen quality.

2.2 REGULATORY AND PLANNING ELEMENTS

2.2.1 PLANNING OF HYDROGEN NETWORKS

The planning of hydrogen infrastructure will be key in view of a more decentralised and strongly integrated future energy system across all energy vectors. According to some stakeholders, the hydrogen infrastructure should be demand driven and focus first on clusters of demand. This is where hydrogen can be developed in a "no-regrets" approach by developing infrastructure where most needed, avoiding stranded assets and achieving climate, energy, and costs efficiency objectives. A majority of stakeholders agree that integrated planning is important and should be interlinked, including between future hydrogen and electricity grids, offshore networks and gas transmission and distribution networks in order to promote an overall system optimisation. Some parties also stressed the importance of price signals in electricity and gas markets (and in hydrogen markets in due course) to enable efficient decision making . It was also noted that accessing the necessary volume of renewable and low-carbon gases (including hydrogen, biomethane and/or syngas) may require imports into the EU. Thus, EU ports might become important hubs and may need to be included in an integrated planning process.

It was noted that the Ten-Year Network Development Plan (TYNDP), developed under the Trans-European Network for Energy Regulation (TEN-E Regulation), can play an important role in coordinated infrastructure planning.

9 Prime Mover Group on Gas Quality and Hydrogen handling was established in 2020 and is co-chaired by ENTSOG and DSO organisations (Eurogas, Geode, CEDEC, GD4S), more information available here.

10 To be published in January 2022.

11 EHI source.

The planning should be based on an Integrated Infrastructure Modelling approach for electricity and gas systems – the Hydrogen Strategy foresees the planning of hydrogen infrastructure being based on the current Ten-Year Network Development Plan.[12] Currently under the proposed TEN-E Regulation, the hydrogen networks and smart gas grids are included.[13] All Panel stakeholders recognised the need to include all stakeholders, including end users and industry, in planning processes.

Evolution of hydrogen infrastructure
It is widely recognised that in the initial stages, hydrogen valleys will emerge around big industrial clusters. To establish EU-wide logistics infrastructure and an EU market, where necessary, these clusters may be connected by repurposed pipelines, as well as to hydrogen transport infrastructures from areas with large production potential to demand centres located possibly in other Member States. For example, the European Hydrogen Backbone initiative presents a vision for a dedicated hydrogen transport infrastructure of 39,700 km across Europe by 2040 in twenty-one countries, where two thirds of the network is based on repurposed natural gas pipelines.[14]

2.2.2 REGULATING HYDROGEN NETWORKS

It was recognised that clarity on the regulatory framework for hydrogen, which does not yet exist, will be critical and that the sooner this can be clarified, the less likely it is to act as a barrier to the deployment of hydrogen projects. The Hydrogen and Decarbonised Gas package published in December 2021, included legislative proposals on the Gas Directive and Regulation, outlining the framework to regulate hydrogen networks and provisions on who can operate these networks, including provisions on unbundling and access to networks.

Unbundling
During the discussions, gas TSOs expressed the view that they should be able to own, operate and invest in hydrogen networks, providing that they are already involved in several repurposing projects.[15] This view was not supported by some market participants and regulators who stressed that the regulation of hydrogen networks should be gradual and the main regulatory pillars (third party access (TPA), unbundling, tariffs) should apply since the beginning.

On the unbundling of hydrogen systems, discussions focused on vertical and horizontal unbundling. For vertical unbundling, regulators stressed the need for a gradual approach where the final model is ownership unbundling, whereas in initial stages it is up to the national specificities and therefore, authorities, to decide the right model. It was concluded that all three models (OU, ITO, ISO) could deliver well and that there are arguments which suggest it should be for individual Member States to decide. On horizontal unbundling, traders and regulators advocate for separation of accounts to ensure the cost related to operation are kept separate and there is transparency, and any subsidisation is clearly visible. It was concluded that accounts unbundling may be sufficient and additional layers are again to be decided by Member States.

Third party access
Ensuring access on a transparent and non-discriminatory basis for market players is key to achieve effective competition in the sector. The discussion on TPA focused on issues of flexibility, as regulators highlighted the need to regulate TPA in a gradual way – to start with the negotiated TPA for interconnecting hydrogen clusters and ultimately leading to regulated TPA it was concluded that a similar approach as taken in electricity and gas could be foresee.

Some parties suggested that as the hydrogen market is still in its infancy, some exemptions may be applied to support the rapid development of markets or to reflect specific characteristics (e. g. for closed distribution systems or direct lines, P2G operation and investment similarly to current Article 36 of the Gas Directive). Market players felt that, if exemptions or derogations are needed, they should be temporary, clearly justified and the exception rather than the rule.

12 Sound infrastructure planning, such as on the basis of ten year network development plans ('TYNDP'), is needed on the basis of which decisions to invest can be taken. Source: European Commission, Hydrogen Strategy, p15.

13 More than 90 hydrogen projects have been submitted to the TYNDP 2022 for Gas and a further 90 transmission projects have also been submitted that are hydrogen-ready or dedicated to fuel switch.

14 More information available here.

15 Gas for Climate, Extending the European Hydrogen Backbone. A European Hydrogen Infrastructure Vision Covering 21 Countries, 2021, available here.

2.3 MARKET ELEMENTS

Creating a tradeable hydrogen market
Parties felt that an open, competitive and liquid EU market with unhindered cross-border trade should be the long-term goal. At present, the EU hydrogen "market" currently only consists of some industrial clusters, point-to-point pipes connecting industrial players who need hydrogen as feed-stock. The hydrogen production potential varies among EU Member States. An open, competitive and liquid EU market with unhindered cross-border trade is key for competition, affordability, and security of supply.

Financial incentives
In Europe the ambition, as stated by Commission President Ursula von der Leyen, is "to bring the cost below € 1.8 per kilo by 2030"[16]. Market incentives both on production and end-use side are needed to bring the cost down. Some stakeholders in the panel proposed Carbon Contracts for Difference, implementing binding target for renewable gas by 2030 as incentives.

Tradeable certificates
Stakeholders also mentioned the need for a tradable market in Guarantees of Origin (GOs) to demonstrate the characteristics of green energy, such as the primary source of energy and GHG footprint (thus enabling more efficient consumption decisions). The system of GOs should be established in a way which facilitates tradability, is transparent and creates trust in the eyes of consumers. As imports of hydrogen will be needed, international GOs system once established needs to be compatible with EU one (and vice versa)

Value-chain synchronisation
In order to create a truly interconnected EU hydrogen market, value-chain synchronisation is of key importance. Initiatives like the European Clean Hydrogen Alliance provide a platform for stakeholders along the whole value chain to exchange best practices offering great business matchmaking opportunities with other project promoters, with a view to seek interconnected large-scale projects. In order to bring the price of hydrogen down, the volumes need to increase, and the large-scale integrated projects are key in this regard.

2.4 FINANCING ELEMENTS (COST/RISK ALLOCATION)

As pipelines are CAPEX intensive, but much less expensive than power transmission system for equal energy capacity, the cost-effective approach in many cases is for TSOs is to focus on repurposing existing gas infrastructure. The cost estimates vary, but the share of new and repurposed infrastructure will influence the total costs of hydrogen assets. For example, according to the European Hydrogen Backbone initiative the 39,700 km of repurposed pipelines envisaged for 2040 will require an estimated total investment of € 43–81 bn.[17]

Without a well-functioning hydrogen market many project promoters of retrofitting and repurposing transmission infrastructure projects face investment insecurity. Investor's appetite is currently limited due to unclear risks and financing options, as well as lack of practical procedures for financing. For bank lenders when analysing a project's creditworthiness, there are several risks such as feedstock supply risks, product/service marketing and sales (price and volume), construction and commissioning risks, technology and operating risks, political and regulatory risks as well as environmental risks. These risks might be at least partially mitigated by getting the regulatory framework and the market set-up right as discussed above. However, there will always remain the need for additional measures to guarantee the necessary financing.

Panel stakeholders identified in this context several options for financing the repurposing of existing grids to transport hydrogen. They noted complex issues around risk allocation – including how much of the costs are underwritten by hydrogen consumers relative to gas consumers, how to ensure strong incentives for rapid deployment and cost minimisation and the possible role for support mechanisms and EU funds.

a) Mobilise targeted public and private funding
Currently there are several financing tools at EU and national level: Recovery and resilience facility, State aid for IPCEI projects, CEF for TEN-E projects, bank lending programmes (EIB, ING, EBRD, etc.). Access to these public funds could make the projects easier bankable also for private investors and steer their interest to participate financially. However, there is great deal of competition on allocating the support in the value chain and question arises whether the grids could attract enough financing in scale and on time.

b) Accept policy intervention
Like for electricity, tariffs charges for RES connections are not "unheard of". This is a hard sell to tax/energy payers, but as the Green Deal is a political choice largely supported by citizens, it is justifiable provided the charges are transparent, non-discriminatory and fairly distributed.

16 Nikolaus J. Kurmayer, Euractiv, € 2 billion 'Clean Hydrogen Partnership' signals move away from hydrogen cars, December 2021, available here.

17 Gas for Climate, Extending the European Hydrogen Backbone. A European Hydrogen Infrastructure Vision Covering 21 Countries, 2021, available here.

c) Accept the cost mutualisation progressing over time: Walter Boltz and ENTSOG's study on Alternative Financing[18] focused on how a well-balanced cost mutualisation/cost socialisation approach could help finance a European hydrogen transportation network without unduly burdening either gas or hydrogen customers or even state budgets. The bill should be spread between four categories: (1) Users (of hydrogen); (2) Other directly relevant energy users (e.g. gas); (3) Beneficiaries of decarbonisation; (4) Society. According to this rationale, there will be lesser charges for the prime movers/first grids users, and more costs transferred once more market players arrive. Some stakeholders though disagree as the cross-subsidisation due to lack of perceived transparency on financing the hydrogen and gas assets and question whether gas consumers are the right ones to pay for this.

3 CONCLUSION AND NEXT STEPS

Report summarises common understanding on the best ways for repurposing and retrofitting the gas grids based on coordinated and best available information in 2021 from the works of the "Advisory Panel for Future of Gas Grids" in 2021. In any way it does not represent any position of the Panel stakeholders attending the meeting nor ENTSOG, but it shows the scope and positions voiced during the debate.

The works of the Panel will continue in 2022, after the publication of the publication of Hydrogen and Gas Markets Decarbonisation Package on 15 December 2021. ENTSOG will promote and encourage the dialogue amongst stakeholders, concentrating on relevant areas of the package in the adopted structure. ENTSOG shall continue to analyse Technical, Market, Infrastructure and Financial elements necessary for the energy transition and the efficient repurposing of the gas grids to hydrogen ready infrastructure and for inclusion of all renewable and low carbon gases in the existing gas grids.

The works of the Panel in 2022 will be more based on the Panel Stakeholders' established positions, which will make the work of the Panel even more clear and effective:

- Mapping the views and engaging in discussion with the Panel stakeholders on the proposed Hydrogen and Decarbonised Gas markets package.
- ENTSOG will remain open to the dialogue with the Panel stakeholders, specifically in its capacity of the body empowered by the European Commission policy proposal to manage the transition from gas to hydrogen grids.
- ENTSOG will ensure the presence of the European Commission in all the upcoming meetings to have the informed and effective debate.

18 Walter Boltz, Energypost, How to share the cost of an EU-wide Hydrogen network, September 2021, available here.

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