THE DECARBONISATION OF GAS INFRASTRUCTURE IN CENTRAL AND EASTERN EUROPE: IS THERE A ONE-SIZE FITS ALL SOLUTION?

Authors[1]: Clara-Andreea Barsan, Petr Binhack, Silviya Deyanova, Revaz Geradze and Monika Izydorczyk

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Abstract: The current and ongoing challenges relating to decarbonisation of the gas sector in terms of production, consumption and transportation impose a transformation of the energy system. Analyzing the potential of renewable and low-carbon gases in the CEE region requires consideration of the regional markets, their infrastructure and regulatory frameworks. Based on a SWOT analysis the crucial factors for identifying the most suitable decarbonisation pathway were identified. Due to the identified heterogeneity of the CEE region in terms of its energy policies, economic capabilities and perspective to adopt regulatory frameworks for hydrogen and biomethane, authors concluded that a single pathway towards 2050 decarbonisation goals within the region is unlikely. However, a hybrid approach based on combination of tools and regulatory approaches might bring desired outcomes. Several prerequisites should be considered in order to successfully implement this approach. The first is building a competitive and liquid market, which allows smaller decentralized facilities to become active in the energy system. The second step is ensuring a suitable legislation system that ensures regulatory clarity and defines the principles for connection and market access for renewable and low-carbon gases. Important component in the transition process towards decarbonisation is guaranteeing that the infrastructure is able to connect supply and demand. This could be realized by building a new infrastructure or repurposing the existing one (including LNG and storage), however the cost efficiency is the key factor in finding the optimal approach for that. The required steps towards decarbonisation of the CEE region should ensure that the countries across the region develop their potential in renewable and low-carbon gases and implement their policies in the most cost-efficient way considering their heterogenous starting point and dependency on gaseous fuels. The EU-wide legislative action should enable a harmonized development of hydrogen and biomethane markets across the EU to ensure that all regulatory obstacles to decarbonisation of gas infrastructure will be removed.

I. Introduction

Some 300-350 Mtoe of gaseous fuels, mostly natural gas, are consumed in the EU per year. This accounts for roughly 25% of the gross energy consumption in the EU, including around 20% of EU electricity production, and 39% of heat production. Up until 2030, the demand for gaseous fuels is projected to decrease, again driven mostly by decrease in demand for natural gas, to 250 to 300 Mtoe. Nonetheless, according to projections, by 2050 consumption of gaseous fuels should be back around or even above 300 Mtoe but this time driven mostly by increasing consumption of renewable and low-carbon gases with

[1] The information and views set out in this article are those of the author and do not necessarily reflect the official opinion of the European Commission, Ministry of Foreign Affairs of the Republic of Poland, E-Control Austria and Georgian National Energy and Water Supply Regulatory Commission (GNERC).

natural gas share only up to 100 Mtoe.[2]

Despite expected decrease in consumption towards 2030, switching to natural gas-fired power plants can represent a short and medium-term solution for countries going through a coal phase-out both in power and heat production, such as Germany, Poland, Czech Republic and Romania. As the EU moves towards its 2050 targets, a mix of renewable gases and low-carbon gases, mainly hydrogen and biomethane, should represent up to 70% of total gas use. However, the technology, regulations and markets are not yet there. To enable the decarbonisation pathways it is necessary to remove the regulatory barriers that exist and ensure competitive and liquid markets to make the transition cost effective. The speed of the transition to renewable and low-carbon gaseous fuels will ultimately rely on the policy choices made by the EU and the Member States, with the existing and planned infrastructure playing a decisive role in carving out the path to decarbonisation.

In this paper we will evaluate a state of play of the natural gas sector and the potential of renewable and low-carbon gases development in the Central and Eastern European (CEE) region. We will try to identify the most suitable path for decarbonisation of the gas sector in terms of production (central or decentral, hydrogen or biomethane), consumption (sector specific or economy wide) and transportation (dedicated or blended infrastructure) of gaseous fuels in the region based on a SWOT analysis and identification of the most important regulatory elements.

II. Regional overview

CEE region[3] is not a homogenous formation, with Germany and Austria acting as bridge for new economic and energy trends. Despite significant differences and diverging trends over the past decades, most economies in the region continue to rely on the industrial sector and inflexible power production. Heavy dependence on indigenous coal is one of reasons why regional economies tend to resist switching to more environmentally friendly fuels or to renewables. The weighty reliance on energy imports has made these countries very sensitive to security of supply issues. Germany is the biggest gas market in the EU significantly unbalancing the general perspective on the CEE region which, in principle, consists of smaller markets with natural gas playing a rather complementary role in the energy consumption (with the exemption of Hungary, where natural gas has a more significant share on the energy mix).

Historically, the CEE region represented a transit region for volumes of gas flowing in East-West direction to Germany and further to Western Europe. This pattern started to change

[2] European Commission. Impact Assessment Accompanying the Communication „Stepping up Europe´s 2030 climate ambition“ SWD(2020)176. https://ec.europa.eu/transparency/regdoc/rep/10102/2020/EN/SWD-2020-176-F1-EN-MAIN-PART-2.PDF.

[3] For the purpose of this paper, the CEE region includes the following EU Member States: Germany, Austria, Poland, Czech Republic, Slovakia, Hungary, Romania.

after the gas crisis in 2009, with increased focus on diversification of gas supplies and transport routes. In the CEE region, many countries did not have access to liquid markets or LNG and were heavily dependent on a single gas supplier. The possibility of reverse flow (West-East) was created shortly after the 2009 gas crisis and new projects, such as the North-South interconnection have been thus initiated, with most of its elements coming in operational phase in 2021-2022.

Market development and regional interconnectivity are not the only trends we can expect to take place in next 10 years. Given that CEE being a rather land-locked region it took some time to pick up a momentum with LNG phenomenon with Poland being in the forefront of development within the region. In the near future we can expect new facilities coming online especially in Poland and Germany or on its periphery (Croatia) to further deepen benefits for the region in terms of competition and diversification. However, the underlying narrative for the region in years to come is fuel-switching with natural gas at the very center of the discussion. The key question remains: is this foreseen development an opportunity or rather an obstacle for decarbonisation of the gas sector?

Recent studies outlined the necessity of investment in gas infrastructure to serve the decarbonisation goals of the EU. According to the Regional Centre for Energy Policy Research based in Hungary and Norwegian University of Science and Technology decarbonisation goals do not need much investment in new gas infrastructure, as the demand projections are showing a decreasing gas demand, that can be served by the current infrastructure[4]. However, some PCIs are still important to ensure diversified access to a regional gas hub and regional interconnectivity. Despite certain differences in results, the models used in the analysis deliver very similar PCI lists for the CEE countries to be implemented: the Interconnector between Poland and Lithuania, the Baltic Pipe, the Interconnector between Hungary and Slovenia and the BRUA pipeline (Bulgaria, Romania, Hungary, Austria) designed to connect the Romanian national gas transmission system with the gas transportation systems of Bulgaria, Hungary and Austria.

Existing infrastructure including LNG terminals located all over the Europe can create value chains that can help Europe to import liquefied low carbon commodities. Imported liquefied low carbon commodities will contribute to delivering the EU Green Deal in all presented pathways. However, pathways based on emerging technologies will require substantial financial and political support.[5]

[4] European Natural Gas Infrastructure in the Energy Transition, 16th International Conference on the European Energy Market (EEM), 2019;
https://www.researchgate.net/publication/337641708_European_Natural_Gas_Infrastructure_in_the_Energy_Transition.
[5] Büx, A., Readiness of European LNG terminals to receive hydrogen: Regulatory and technical aspects, 34th Madrid Forum, October 2020;
https://ec.europa.eu/info/sites/info/files/energy_climate_change_environment/events/presentations/04.05_mf34_presentation-gle-readiness_of_european_lng_terminals_to_receive_h2-bux.pdf.

III. Regulatory overview

From the regulatory perspective the regional framework is based on rather harmonized set of rules building on legislative packages. The Third Energy Package[6] adopted in 2009 is formally implemented, although this process is still not completely finalized with fully satisfactory effects across the region. Taking a look at the latest Internal Energy Market Report[7] we can conclude that although good progress has been made, improvement in implementation as well as in particular market indicators is needed. In the CEE region this is particularly true when it comes to market concentration, liquidity, new market entries and interconnectivity which also contributes to higher sourcing costs in some parts of the region.

When it comes to the rules applicable to hydrogen, the current EU framework (notably, the Gas Directive[8] and Gas Regulation[9]) will require further adaptation. Based on the recent ACER report[10] some conclusions can be drawn regarding the current state of regulation across the region:

- In Germany, hydrogen injection is allowed up to 10% but only at the TSO level where no gas quality sensitive consumers are connected. If a natural gas filling station for vehicles is connected to the gas network, only 2% of hydrogen is permitted in the gas flowing in the network. The conditions for receiving hydrogen into the gas network are not defined, although the government is drafting this framework.
- In Austria just very low hydrogen quantities have been injected in premix up to now. ÖVGW Norm G31 of 2001 allows for max. 4% of hydrogen. There are plans to increase hydrogen acceptance levels, including cross- border trade and incentives to develop direct injection at the TSO level.
- In Poland, hydrogen injection is technically possible. However, Poland does not have specific regulations and did not lay out specific hydrogen volumes or a percentage limit for blending.

[6] European Commission. Third Energy Package; https://ec.europa.eu/energy/topics/markets-and-consumers/market-legislation/third-energy-package_en.
[7] European Commission. Annex to the 2020 report on the State of the energy union; https://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1602743359876&uri=COM%3A2020%3A950%3AFIN#document2.
[8] Directive 2009/73/EC of the European Parliament and of the Council of 13 July 2009 concerning common rules for the internal market in natural gas and repealing Directive 2003/55/EC.
[9] Regulation (EC) No 715/2009 of the European Parliament and of the Council of 13 July 2009 on conditions for access to the natural gas transmission networks and repealing Regulation (EC) No 1775/2005.
[10] ACER. ACER Report on NRAs Survey. Hydrogen, Biomethane, and Related Network Adaptations; https://www.acer.europa.eu/Official_documents/Acts_of_the_Agency/Publication/ACER%20Report%20on%20NRAs%20Survey.%20Hydrogen%2C%20Biomethane%2C%20and%20Related%20Network%20Adaptations.docx.pdf.

- The Czech technical standard for gas fuels quality states that 2% of hydrogen are possible in the transmission network. However, there is no legal obligation for TSO to measure share of hydrogen and limit for blending is therefore effectively zero. Plans to increase hydrogen acceptance level are under discussion.
- Slovak TSO allows max. 2% hydrogen in natural gas, including imports, provided that some investments are made into the measuring systems, related mainly to gas quality measurement. However, no rules for injection has been adopted.
- In Hungary, hydrogen ingredient in natural gas is not explicitly prohibited under current regulation but it is not mentioned either but plans to increase minimal acceptance limits are under discussion.
- In Romania, there is no regulation for hydrogen ingredient or blending in natural gas at the TSO level and discussion on future national rules appear to be at very initial stages.

Overall, with the exception of Germany and Austria, there are no clear rules for hydrogen minimal acceptance level at the TSO level or for injection across the region. The majority of countries in the region are in the process of initiating national discussions on setting up rules for hydrogen minimal acceptance limits and direct injection at the TSO level, providing an optimistic perspective on blending. The risk however remains that lack of harmonization of these rules will prevent cross-border trade and effective regional/EU-wide internal market in consequence. With regard to hydrogen dedicated infrastructure there is no explicit consensus about regulation of such infrastructure, nevertheless discussions among industrial players suggest that mirroring of existing natural gas regulation would be an natural choice to start with.

IV. SWOT

Strengths	Weaknesses
• Region is fully integrated within the EU internal energy market with harmonized regulatory framework. • General consensus about the important future role for hydrogen and biomethane. • Some MS across the region already adopted hydrogen strategies, many others are having national debates about adopting one. • Rich current experiences with hydrogen (DE, AT, PL) and biomethane (DE, AT, CZ, PL) production and consumption. • Pilot projects and minimal regulatory framework already exists in some MS within the region. • Significant regional potential pro production of biomethane, currently developed only in DE, AT, CZ. • Existing gas storage capacities that could be repurposed for hydrogen. • Well-developed natural gas transmission infrastructure across the region with liquid regional hubs (DE, AT) and another emerging (PL).	• Different energy transition strategies across the region. For some MSs (PL, SK, RO) natural gas plays an important role in the energy mix and the decarbonisation strategy assumes the transition from coal will be via natural gas, while for others it focuses on alternative gases (AT). • Uneven national policies and regulatory frameworks development in the field of hydrogen and biomethane across the region. • Extensive time needed to develop the hydrogen and biomethane infrastructure, (one decade estimated from concept to operational stage for big projects) and it is capital intensive. • Currently underdeveloped regional/EU-wide integrated planning for hydrogen/biomethane infrastructure. No consensus at EU and regional level whether to focus on dedicated, blended or how to approach hydrogen/biomethane injection (TSO or DSO level). • With some exemptions (DE, AT, RO) no major fleet of renewable power generation for green hydrogen production. • Limited competition in some MS with illiquid markets and obstacles for new market entries can restrict competition for alternative suppliers. • Rather land-locked region with limited access to open sea can make it difficult to diversify future hydrogen imports.

Opportunities	Threats
• Ongoing discussion in most of the region allows for coordinated and harmonized approach when setting up the rules if regional/EU action is taken in time. • Extensive regional natural gas infrastructure provides a lot of opportunities for repurposing in case suitable regulatory framework will take place. • In case centralized hydrogen-based consumption centres to emerge, dedicated infrastructure can provide efficient supply chain without raising gas quality issue of blended infrastructure. • Cost-efficient repurposing of up to 20% hydrogen blend provides solution if no consumption/demand centres for hydrogen to be developed. • EU financing for coal regions in transition, the Recovery and Resilience Facility, the Taxonomy Regulation and the revision of state aid rules to enhance financing of sustainable projects. • The European Green Deal, the Hydrogen Strategy[11] and the Strategy for Energy System Integration[12], including upcoming legislative initiatives (e.g. the TEN-e[13] revision) are giving clear signals that a 'liquid and well-functioning hydrogen market' will be in the centre of upcoming legislative initiatives. Regulatory and legal certainty will enhance the use of hydrogen across the region.	• Acceptance of hydrogen/biomethane is in an "exploration" phase; readiness of TSOs, NRAs to discuss the issue differ. • Differences over hydrogen definition/origins, different understanding among member states. For example: Poland is the world's 5th largest producer of hydrogen, but hydrogen produced in Poland is mostly "black". • No or very little legal framework at both EU and national levels for dedicated hydrogen infrastructure. • Technical issues connected to development of hydrogen production as well as for dedicated and blended infrastructure. • Risk of creating an EU framework rewarding only green hydrogen and disregarding benefits of low-carbon hydrogen that can bring benefits to the hydrogen market development in short to mid-term perspective. • Underdeveloped market for hydrogen technologies leading to insufficient decline in technology costs. • Delayed legislative proposals including revision of the TEN-e regulation and the 5th PCI list. • Disregard of integrated planning solutions at EU level could lead to natural gas stranded assets scenario.

[11] COM (2020) 301 final, *A hydrogen strategy for a climate-neutral Europe;* https://ec.europa.eu/energy/sites/ener/files/hydrogen_strategy.pdf.
[12] COM(2020) 299 final, *Powering a climate-neutral economy: An EU Strategy for Energy System Integration*; https://ec.europa.eu/energy/sites/ener/files/energy_system_integration_strategy_.pdf.
[13] Regulation (EU) No 347/2013 of the European Parliament and of the Council of 17 April 2013 on guidelines for trans-European energy infrastructure and repealing Decision No 1364/2006/EC and amending Regulations (EC) No 713/2009, (EC) No 714/2009 and (EC) No 715/2009.

V. Pathways towards 2050

Building on the result of the SWOT analyses of the region as well as current regulatory framework and regional realities, we have concluded that for the CEE region it is very unlikely do develop a single decarbonized gases pathway towards 2050. CEE region is rather heterogeneous in its starting positions both from energy policies and from economic capabilities perspective as well as adopted regulatory frameworks for hydrogen and biomethane.

Based on these assumptions and existing experience with development and implementation of gas market target model, including unbundling, we consider a hybrid approach to be the most suitable one. The hybrid solution should be based on hydrogen dedicated backbone infrastructure connecting hydrogen production and consumption centres, infrastructure for up to 20% blend of hydrogen (deemed to be cost-efficient from repurposing point of view[14]) for economy wide consumption and enabled decentral injection of biomethane at the TSO and DSO level. This approach is not focusing on particular 'silver bullet' solution but rather on building an enabling framework that would stimulate countries across the region to develop its potential in renewable and low-carbon gases and implement designed policies in the most cost-efficient way for the benefit of decarbonisation in line with EU ambition to become the first climate neutral continent by 2050. In order to do so, we have identified following priority areas that would deserve further legislative action.

The first precondition to make any gas decarbonisation pathway cost-effective is building of competitive and liquid market. Natural gas supply in the region is centralised and flows from the transmission system directly to large consumers and to distribution systems, from where it reaches decentralised end-consumers. With increasing production of renewable and decarbonised gases, more production facilities will be connected at the distribution as well as transmission level, mostly because location of Power-to-Gas installations is important for realising overall system benefits. Tradability of decentrally produced gases is today limited due to limited participation of distribution level in the wholesale market, blocking smaller facilities from becoming active components of the energy system.

To ensure a level playing field for renewable and low-carbon gases, and to avoid barriers to their development, access to the wholesale market needs to be enabled. Connection obligations should be extended to cover new types of gases and, to some extent, mirror renewable electricity framework in terms of connection obligation and customers´ rights. Future legislation should clearly define the principles for connection and market access for renewable and decarbonised gases by also including the distribution level in the gas market organization. Harmonized approach to regulatory and administrative requirements for new market entries should ensure that any market opportunity will be addressed.

[14] GRTgaz et al. *Technical and economic conditions for injecting hydrogen into natural gas networks*; http://www.grtgaz.com/fileadmin/plaquettes/en/2019/Technical-economic-conditions-for-injecting-hydrogen-into-natural-gas-networks-report2019.pdf.

In terms of infrastructure, today's local production of hydrogen is based on privately owned point-to-point pipelines or networks. Those networks are small compared to the network for natural gas, but located in areas that may be important for the initial deployment of hydrogen as an energy carrier. Germany already envisages the rollout of dedicated hydrogen networks by 2030.[15] Key precondition for a market uptake of renewable and low-carbon gases is the availability of infrastructure to connect supply and demand. Building a new infrastructure or repurposing existing one (including LNG and storage) to be able to contain new gases as well as its blends is one of the key questions to be answered especially with regard to financial tools available. Gas quality issues hindering EU/regional market integration may arise if very different levels of hydrogen in the grid are established with consequential need for investments not only in case of LNG terminals and transmission networks but also end-user applications. Industrial facilities need to be ready to address impact of blended gases as well. Production, transmission capacity shift to pure hydrogen might be actually in many cases easier than adapting the industrial capacity to use blended/hydrogen gases.

Introducing blending capabilities would require significant investments into well-established and extensive current gas network. They would have to be done in a coordinated manner, and with full compliance with security requirements. The appropriate hydrogen concentration may vary significantly not only between member states but also within balancing zone, as different parts of the system would have different technical ability to sustain blended gas. There are also technical limitations regarding to how much hydrogen you can actually blend into the network. Hydrogen has a broader range of conditions under which it will ignite. Therefore, there is a need to ensure operational security of networks with blended gas, as there is higher probability of ignition and resulting damage compared to the risk posed by natural gas without a hydrogen blend component.

To speed up the learning process for implementation of infrastructure for hydrogen or its blends, TSOs shall be incentivized within the national regulatory framework for research and development projects, carrying out feasibility studies and pilot projects in the area of adaptation an repurposing of the existing gas infrastructure not only for the transport of hydrogen but also as a storage medium, which could unlock a cost-efficient pathway towards the upgrading of hydrogen's role in the energy system. Nevertheless, question of applicability of natural gas networks for financing from the EU budget will be pertinent with the applicable regulatory framework for qualification of renewable and low-carbon gases being of key importance.

An EU common regulatory framework will ensure convergence, facilitating future legislative developments and avoiding costs associated with ex-post harmonisation. Clarifying roles and duties (e.g. ownership and access regimes) creates regulatory certainty for investors. Regulatory clarity is necessary to avoid under-investment in hydrogen

[15] Federal Ministry for Economic Affairs and Energy. *The National Hydrogen Strategy*; https://www.bmbf.de/files/bmwi_Nationale%20Wasserstoffstrategie_Eng_s01.pdf.

infrastructure, compared to other gas infrastructure for which the regulatory framework is clear. For effective stimulation of the market a well-defined and operational regulatory framework is needed, building also on the definitions of renewable and low-carbon gases under the Renewable Energy Directive. This is paramount for the market development including infrastructure financing. The terminology should seek to cover the full range of existing renewable and low carbon gases which will play a role in contributing towards gas decarbonisation and should also include the required sustainability criteria providing for functional system of certification and complementary market with GOs.

VI. Conclusion

We are still at the beginning of the decarbonisation path and achieving European goal will take a lot of negotiations and time. The experiences across countries in the region differ and so does their dependency on gas and the role that gas plays and will play in the future energy mix. Most likely, the development of biomethane potential and its blending will be the first step towards decarbonisation of gas infrastructure, until 2030.

The question of hydrogen transportation and consumption patterns is more complicated as investments of different magnitude will be needed for development of both, dedicated as well as blended hydrogen infrastructure. Major regulatory questions also arise when it comes to financing of infrastructure repurposing in terms of re-use of already depreciated gas infrastructure being part of RAB.

The choice between dedicated and blending infrastructure is also a choice between who benefits and who pays. Current national plans and gas industry studies show that the level of 10 to 20% blending is achievable in cost- effective manner. At the same time, one has to take into account that many countries of the region have no or very little current blending experience at national level and standards regarding regional trade/exchange would have to be introduced. Therefore, member states should have freedom to determine their energy mix and choose their decarbonisation path making best use of their specific conditions and potential being it supply or demand side stimulation.

This being said and taking into account renewable and low-carbon gases national regulatory frameworks across the region being in their infancy, timely EU legislative action could bring benefits in terms of creating robust and transparent EU-wide legislative framework that would enable the creation of an EU internal market for hydrogen and biomethane.