POLITYKA ENERGETYCZNA – ENERGY POLICY JOURNAL

2025 ✦ Volume 28 ✦ Issue 3 ✦ 179–194

DOI: 10.33223/epj/207101

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Technical adaptation of natural gas infrastructure for hydrogen transport – solutions for the energy transition

Abstract: In the face of the global energy transition and the urgent need to reduce CO_2 emissions, hydrogen is emerging as a key energy carrier whose widespread adoption depends on the development of efficient and safe transmission infrastructure. Constructing new hydrogen networks involves high costs and long implementation times; therefore, this article analyzes the potential for adapting existing natural gas transmission infrastructure for hydrogen transport. Two main approaches are assessed: blending hydrogen with natural gas and repurposing selected pipelines for pure hydrogen transmission. The article discusses critical technical aspects, including the impact of hydrogen on materials, the risk of hydrogen embrittlement, safety, and operational requirements. The regulatory analysis covers both Polish and EU legal frameworks, with special attention to new standards and certification systems that facilitate hydrogen integration into the current energy system. Examples of pilot and commercial projects across Europe are presented, highlighting Poland's strategic role in the development of a hydrogen economy. The findings indicate that adapting existing infrastructure can achieve significant cost savings (up to 90% compared to building new networks) and accelerate the achievement of climate goals. The article also identifies key challenges, such as leak detection, equipment compatibility, and the need for regulatory clarity, which must be addressed to enable

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a safe and effective energy transition. This work aims to provide decision-makers, investors, and experts with interdisciplinary knowledge essential for planning and implementing modern hydrogen infrastructure.

Keywords: hydrogen, gas infrastructure, blending, repurposing, regulations, safety, decarbonization

Introduction

Hydrogen is currently recognized as one of the key energy carriers, playing a strategic role in global efforts to decarbonize industry, power generation, and transportation. According to projections by the International Energy Agency, by 2050, global hydrogen demand could increase by as much as sixfold, and its share in the European Union's energy mix is expected to exceed 10% as early as 2040 (IEA 2023). At present, on an industrial scale, hydrogen is predominantly produced from fossil fuels (Fig. 1).

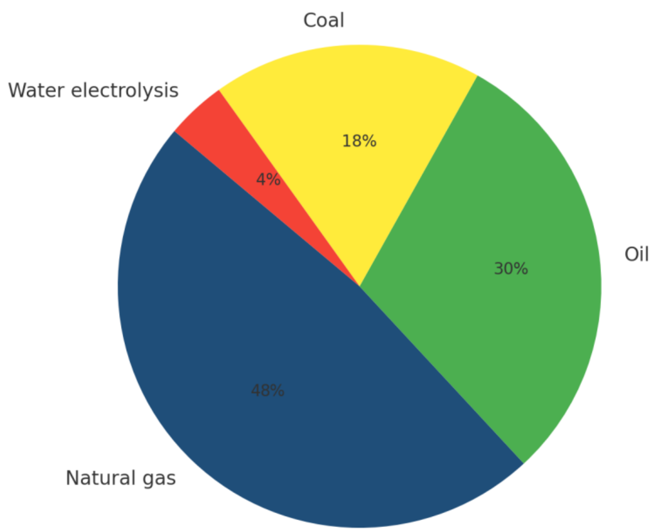

Fig. 1. Share of energy resources in hydrogen production (Gburzyńska 2023)

Rys. 1. Udział surowców energetycznych w produkcji wodoru

Widespread adoption of hydrogen, however, requires the development of a robust, safe, and efficient transmission infrastructure, which currently poses one of the major challenges in the energy transition.

The construction of new hydrogen networks entails extremely high costs – estimates suggest that the cost of 1 km of new hydrogen pipeline may exceed 1.5 million EUR, whereas retrofitting existing gas infrastructure can reduce capital expenditures by as much as 60–90% (Illson 2024; Noordgastransport 2023). Moreover, the implementation timeline for new infrastructure projects is typically measured in years, delaying the achievement of climate and economic objectives.

As a result, increasing attention is being devoted to the possibility of adapting existing natural gas pipelines for hydrogen transport – either through hydrogen blending with natural gas or by repurposing selected pipeline sections for the transmission of pure hydrogen. This approach enables a rapid increase in hydrogen's share within the energy mix, reduces investment costs, and ensures the effective use of already available infrastructure assets.

Poland, with its extensive natural gas transmission network and ambitious climate goals, represents a significant example of a country positioned to play a key role in the development of the hydrogen economy in Central and Eastern Europe. Ongoing pilot projects and technical studies are currently exploring the integration of hydrogen into the national gas system. Polish regulations already permit up to a 10% molar share of hydrogen in the gas grid, provided that specific technical and safety requirements are met.

This article analyzes both the technical and regulatory aspects of hydrogen blending and repurposing, with particular focus on material challenges (e.g., hydrogen embrittlement, equipment compatibility), safety requirements, economic efficiency, and the legal frameworks in place in Poland and the European Union. It also presents examples of pilot projects and implementation initiatives from around the world, highlighting the critical role of infrastructure adaptation in accelerating the energy transition and achieving climate targets.

Research hypothesis: the adaptation of existing gas infrastructure for hydrogen transport is technically feasible and economically viable, and its implementation can significantly accelerate the decarbonization of the energy sector while enhancing the energy security of Poland and Europe.

1. Technical aspects of utilizing gas infrastructure

1.1. Blending – hydrogen admixture in natural gas

Blending hydrogen into natural gas is currently the most commonly analyzed option for the rapid integration of hydrogen (H_2) into existing gas networks (Iwińska et al. 2023a). Utilizing existing gas infrastructure in this manner significantly reduces costs compared to constructing entirely new, dedicated hydrogen networks (Loyola et al. 2024). Across Europe, efforts are underway to integrate hydrogen infrastructure with existing gas systems, taking into account technical, economic, and supply security considerations.

In Poland, hydrogen blending into gas networks has not yet been implemented on a large scale, though research activities are ongoing (Hydrogen technology safety engineering... 2023). Polish regulations permit up to a 10% molar share of hydrogen in gaseous fuels, provided that measurement systems and network components are adapted to such mixtures to ensure end-user safety (Regulation of the Ministry of Climate and Environment 2022).

The Oil and Gas Institute – National Research Institute has issued certifications for polyethylene PE100-RC pipes intended for gas networks that carry gaseous fuels with up to 100% hydrogen content, or pure hydrogen. Polska Spółka Gazownictwa (Polish Gas Company) has received certification for hydrogen-blended gas transmission through polyethylene pipelines on the Jelenia Góra–Piechowice route (Górka 2024).

Technical and pilot studies indicate that blending hydrogen into natural gas networks is technically feasible (Górka 2024). In most European countries and in the United States, it is considered safe to blend 2–10% hydrogen by volume in distribution networks without the need for major system modifications (IEA 2023; Górka 2024). Some pilot projects – such as HyDeploy in the United Kingdom, Hawaii Gas in the U.S., and Energy Storage in Denmark – have tested hydrogen admixtures of up to 20–25% by volume in distribution systems (Fig. 2).

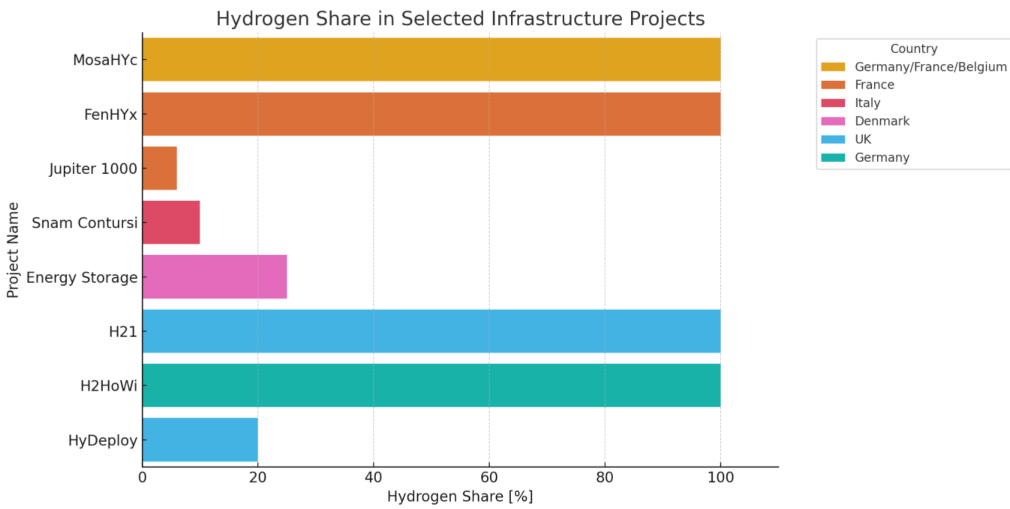

Fig. 2. Active hydrogen blending projects in gas transmission networks (own elaboration based on IEA 2023)

Rys. 2. Projekty mieszania wodoru w sieciach przesyłowych gazu

The European Commission report indicates that hydrogen concentrations of 2–5% by volume generally do not require significant technical modifications. However, higher admixtures (15–20%) may necessitate adjustments to end-use equipment, gas meters, and fittings (Iwińska et al. 2023a).

The addition of hydrogen reduces the density of the gas mixture, lowers its calorific value, and alters its methane number, which can affect the performance of gas engines and boilers.

Hydrogen also has a lower ignition temperature and a broader flammability range, requiring safety systems to be appropriately adapted (Englart and Jedlikowski 2023).

Due to its small molecular size, hydrogen readily permeates through materials, increasing the risk of leakage. Older steel pipelines are particularly susceptible to hydrogen embrittlement. In contrast, polyethylene (PE) pipes are more resistant to hydrogen but are limited in terms of pressure tolerance.

Devices such as burners, gas stoves, boilers, as well as gas meters and pressure regulators, may require certification or replacement at higher hydrogen concentrations. This necessitates extensive testing and the development of standardized procedures (Loyola et al. 2024).

Hydrogen is odorless and difficult to detect using conventional methods (e.g., methane detectors), making the implementation of new monitoring and ventilation protocols essential. Its rapid diffusion and wide flammability range further increase the risk of leaks, necessitating heightened safety precautions.

1.2. Repurposing – conversion of gas pipelines for pure hydrogen transport

Repurposing refers to the conversion of selected sections of the existing gas network for the transport of pure hydrogen. The European Network of Transmission System Operators for Gas (ENTSOG) identifies dedicated hydrogen pipelines as one of the viable pathways for integrating hydrogen into the gas infrastructure (ENTSOG AISBL 2024).

The Polish transmission system operator GAZ-SYSTEM is conducting technical assessments of selected infrastructure segments for potential adaptation to carry pure hydrogen (GAZ-SYSTEM 2024). The construction of new hydrogen infrastructure must adhere to rigorous technical standards and requirements, taking into account the unique physicochemical properties of hydrogen.

Due to its high permeability, hydrogen poses particular challenges in terms of storage and transport. Hydrogen diffusion can lead to material embrittlement, potentially resulting in damage to steel pipelines (ENTSOG AISBL 2024).

Strict safety standards are essential, covering both the design and operation of transmission facilities. These include preventive measures against uncontrolled hydrogen release, as well as the implementation of leak detection systems and operational procedures to mitigate the risk of failure.

As the National Gas Transmission System Operator, GAZ-SYSTEM possesses extensive expertise in operating gas infrastructure. The company carries out routine inspections, technical evaluations, diagnostic tests, and performance monitoring, which are critical elements in preparing for the potential integration of hydrogen into the national gas system (GAZ-SYSTEM 2025; GAZ-SYSTEM 2024).

Compared to blending, repurposing is a more technically advanced solution and requires:

- resistance of steel pipelines to hydrogen embrittlement,
- strength and leakage tests,

- replacement of seals, valves, and other infrastructure components,
- adaptation of compressors for hydrogen operation,
- compliance with international safety standards (e.g., ISO, EN),
- implementation of hydrogen leak detection and monitoring protocols.

1.3. Costs associated with hydrogen blending and infrastructure adaptation

The costs related to hydrogen blending, retrofitting existing pipelines, and constructing new hydrogen pipelines are under analysis, although comparative cost data are not always detailed.

Blending hydrogen with natural gas in existing networks (Iwińska et al. 2023b) is decribed below.

- Hydrogen blending at levels of 2–10% by volume is technically feasible with minimal financial investment in existing gas infrastructure.
- Blends within the 5–15% range are estimated not to require significant operational or technical adjustments to the pipeline.
- However, blends of 15–50% already necessitate substantial modifications to the gas network infrastructure.
- Hydrogen content above 50% introduces multiple challenges, particularly in terms of material selection for pipeline construction.

Repurposing existing gas pipelines for hydrogen transport:

- Polska Spółka Gazownictwa (PSG) has received certification confirming readiness for hydrogen-blended gas transport through existing polyethylene (PE100-RC) pipelines on the Jelenia Góra–Piechowice route, as well as steel pipelines on the Biernatki–Legnica route. While steel pipelines are particularly vulnerable to hydrogen-induced corrosion, advanced technologies have enabled effective mitigation solutions (PSG 2024).
- Although hydrogen transport through gas networks carries a risk of hydrogen corrosion that may lead to severe structural damage, prevention – while challenging – is possible through minimizing stagnation zones, applying suitable coatings, and conducting regular inspections.
- GAZ-SYSTEM is conducting analyses to assess the feasibility and costs of converting selected existing pipelines to transport 100% hydrogen. These studies aim to identify technically viable pipelines, assess their condition, and estimate timelines for conversion while maintaining full functionality of the gas transmission system (Sęk 2025). As part of the Polish Hydrogen Map initiative, GAZ-SYSTEM is evaluating whether the repurposing of specific pipeline segments is justified.
- The European Union allows financial support under the TEN-E policy framework for infrastructure projects contributing to decarbonization, which includes the adaptation of existing pipelines for hydrogen delivery (European Commission 2020).

Construction of new hydrogen pipelines: in general, transporting compressed hydrogen via pipeline is considered the most cost-competitive option compared to other forms (e.g., liquid hydrogen, ammonia, or LOHC). Over a distance of 3,000 km, transmission through a new 48-inch diameter pipeline operating at 75–100% of its design capacity increases costs by approximately USD 0.4–0.5 per kg of H_2 (GAZ-SYSTEM 2024).

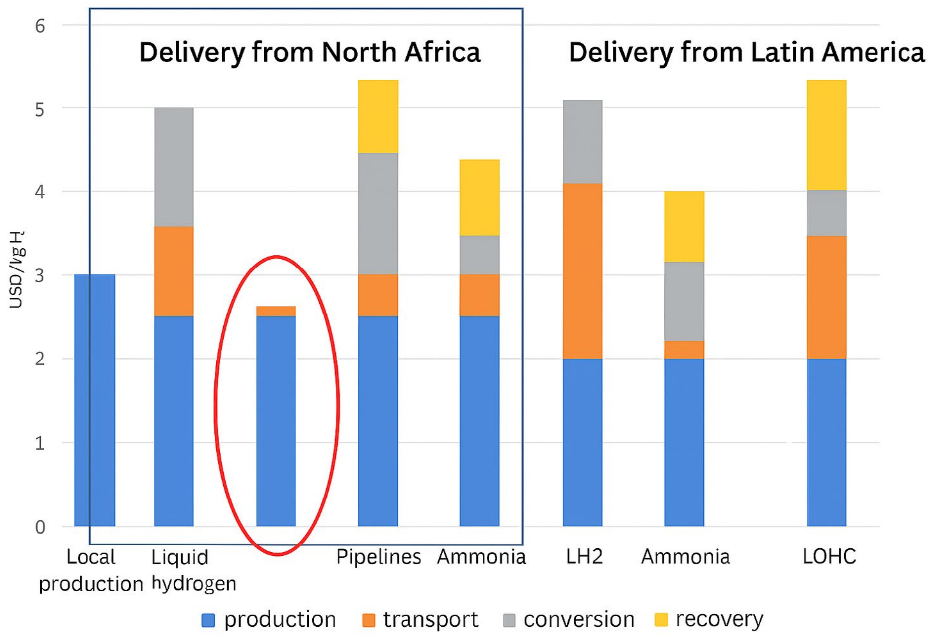

Fig. 3. The cost of hydrogen transport via pipeline (own elaboration based on GAZ-SYSTEM 2024)

Rys. 3. Koszt transportu wodoru za pomocą rurociągu

Nevertheless, infrastructure installations related to the storage, transport, and distribution of compressed hydrogen are generally regarded as highly expensive due to hydrogen's high permeability (UNFCCC Secretariat 2023).

GAZ-SYSTEM plans to establish a new, dedicated transmission network for pure hydrogen, with connection costs and transmission tariffs to be estimated following the identification of potential routes and infrastructure parameters. The average duration of the investment process (including design and construction) for a 100-kilometer pipeline is approximately 5–7 years (GAZ-SYSTEM 2024).

Low-percentage hydrogen blending with natural gas remains the least expensive option. Repurposing existing gas pipelines for higher hydrogen concentrations or pure hydrogen, while technically feasible, presents significant challenges and costs, which are currently under evaluation by operators such as GAZ-SYSTEM.

There is no definitive data comparing the cost of repurposing with that of constructing new hydrogen pipelines. While new pipeline construction is considered the most cost-effective large-scale method for hydrogen transport relative to other carriers, such investments are nonetheless capital-intensive.

1.4. Case studies: gas infrastructure repurposing projects

NGT and NOGAT (Netherlands, North Sea)

Operators of two major offshore transmission pipelines in the North Sea – Noordgastransport (NGT) and Northern Offshore Gas Transport (NOGAT) – have conducted detailed feasibility studies on converting existing offshore infrastructure for hydrogen transport. It is planned that one of the pipelines will be fully dedicated to hydrogen transmission, while the other will continue to carry natural gas. Implementation of this initiative is feasible before 2030, enabling the efficient transmission of hydrogen produced via electrolysis powered by offshore wind farms. The primary benefits include a substantial reduction in capital investment – estimated at up to 90% savings compared to new pipeline construction – and a minimized environmental impact due to the avoidance of new construction and excavation work (Noordgastransport 2023; Illson 2024).

Projects in the United Kingdom

The United Kingdom plans to convert parts of its existing gas pipeline network to carry hydrogen as part of its national gas sector decarbonization strategy. Pilot projects include both hydrogen blending and full repurposing for pure hydrogen transport. These initiatives are supported by technical studies and economic analyses aimed at evaluating the safety, efficiency, and feasibility of such solutions (Illson 2024).

Studies by DNV

DNV has carried out comprehensive assessments of gas pipeline repurposing for hydrogen transport. The cost of repurposing is estimated to be between 10 and 35% of the cost of building new hydrogen pipelines, making this option highly attractive from an economic standpoint. However, detailed integrity assessments are required, including material analyses, technical condition evaluations, and risk assessments related to hydrogen embrittlement (Illson 2024).

Penspen

Penspen emphasizes the critical importance of detailed technical assessments of pipelines prior to repurposing. Inline inspections (ILI) are essential for detecting defects, cracks, and corrosion, along with laboratory testing to evaluate materials' resistance to hydrogen-induced embrittlement. These steps are vital to ensuring the safety and reliability of hydrogen transmission in repurposed pipelines (Cowell 2025).

Case Studies from Poland

Poland's national transmission system operator, GAZ-SYSTEM, is analyzing the feasibility of repurposing selected segments of the natural gas transmission network for hydrogen transport. As part of the "Polish Hydrogen Map" project, optimal locations for hydrogen pipeline development are being identified, including the key Nordic-Baltic Hydrogen Corridor intended to connect Poland with European markets. These efforts align with the country's hydrogen strategy and EU climate policy goals (GAZ-SYSTEM 2024).

Poland is also implementing certified pilot projects to assess the viability of hydrogen blending in existing gas networks. Polska Spółka Gazownictwa (PSG 2024) has obtained certifications confirming readiness to transport hydrogen-blended gas in both polyethylene (PE100-RC) and steel pipelines.

Selected pilot projects:

- Jelenia Góra–Piechowice (PE100-RC pipelines). PSG became the first operator in Poland to receive certification for transporting hydrogen-blended gas through plastic pipelines. The certification was issued by the Oil and Gas Institute – National Research Institute (INiG – PIB) (PSG 2024).
- Biernatki–Legnica (steel pipelines). In June 2024, PSG received a Technical Assessment Certificate for the transport of hydrogen-natural gas mixtures through steel pipelines, confirming the effectiveness of the applied hydrogen corrosion protection measures.

According to studies conducted by INiG – PIB and national regulatory guidelines, permissible hydrogen blending levels vary depending on technical or safety criteria. Table 1 presents a comparative overview of these values.

TABLE 1. Permissible levels of hydrogen admixture in natural gas according to technical and safety criteria

TABELA 1. Dopuszczalne poziomy domieszki wodoru w gazie ziemnym według kryteriów technicznych i bezpieczeństwa

Criterion	Maximum H_2 admixture [% vol.]
Gas energy parameters	36
Combustion safety (general)	23
Combustion – end-use appliances	15
Method for calculating the compressibility factor	10
Explosion safety of equipment	8

Sourve: own elaboration based on Siekierski 2023.

These values reflect a compromise between technical feasibility and safety standard requirements. For instance, although it is technically possible to blend hydrogen into natural gas at concentrations up to 20% by volume with minimal infrastructure investment, current national regulations allow a maximum of 10% [mol/mol], provided that metering equipment and installations are appropriately adapted.

Figure 4 presents a visualization of permissible hydrogen blending levels in gas distribution networks.

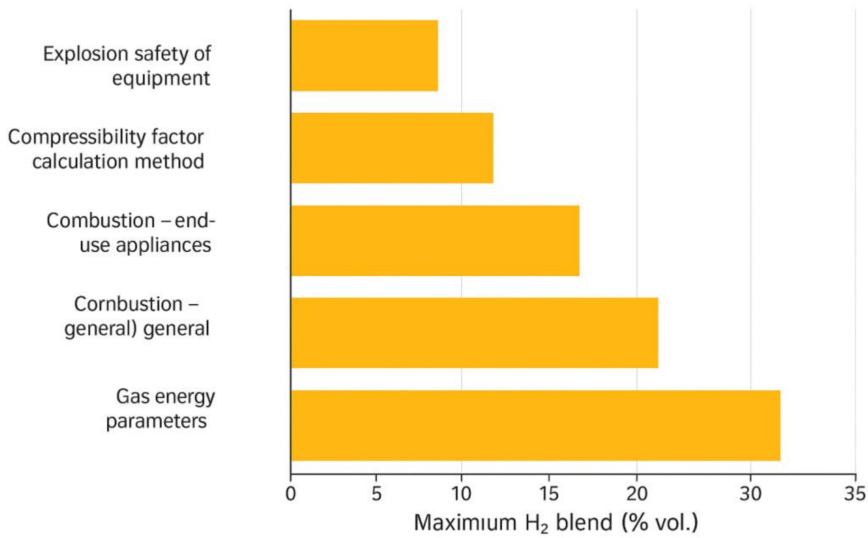

Fig. 4. Permissible levels of hydrogen blending in gas networks depending on technical and safety criteria (own elaboration based on IEA 2023)

Rys. 4. Dopuszczalne poziomy domieszkowania wodoru w sieciach gazowych w zależności od kryteriów technicznych i bezpieczeństwa

Studies indicate that methane-hydrogen mixtures can, in some cases, be less flammable than pure methane, thereby reducing fire hazards. On the other hand, the increased diffusion rate of hydrogen and its potential to cause microcracking – particularly in metallic materials – raises concerns about pipeline integrity. Importantly, available sources do not yet provide detailed operational data, such as precise leakage rates or long-term material degradation following hydrogen exposure. However, current certifications confirm the readiness of certain infrastructure to transport hydrogen-blended gas, representing a significant step toward the decarbonization of Poland's gas system.

Repurposing existing gas pipelines for hydrogen transport is currently considered one of the most promising and economically viable directions for hydrogen infrastructure development. Projects such as NGT and NOGAT in the Netherlands and various initiatives in the United Kingdom demonstrate that existing networks can be rapidly and efficiently adapted for hydrogen transmission – substantially lowering costs and minimizing environmental impact. Nevertheless, detailed assessments of material integrity and targeted adaptation of infrastructure to hydrogen-specific requirements remain crucial.

It is important to note that repurposing is not feasible for all pipeline segments. It requires thorough material analysis, an evaluation of pipeline age and technical condition, and compliance with updated standards.

2. Regulatory aspects

2.1. Poland

In Poland, regulations concerning hydrogen transport via gas networks are currently undergoing rapid development. Until recently, the legal framework lacked clear and comprehensive guidance. This situation is evolving with the implementation of the Polish Hydrogen Strategy to 2030, which envisions the adaptation of selected gas network segments for hydrogen transmission, both through blending (hydrogen admixture into natural gas) and repurposing (conversion of pipelines for pure hydrogen transport). The strategy aligns with Poland's broader energy transition agenda and is consistent with the national energy policy for 2040 (Blaczkowska 2024).

In October 2024, the Ministry of Climate and Environment prepared a draft amendment to the Energy Law, introducing provisions for low-emission and renewable hydrogen. The objective of the proposal is to establish a stable regulatory environment for hydrogen project development in Poland, in line with EU requirements (Blaczkowska 2024). The amendment includes, among other things, definitions of low-emission and renewable hydrogen (RFNBOs), as well as rules for certification and licensing of hydrogen transmission and storage activities.

In March 2025, the President of Poland signed the amended Energy Law, which formally regulates the hydrogen market, facilitates investment, and accelerates the development of hydrogen infrastructure. The act introduces, among others, the designation of hydrogen transmission and storage system operators. The first hydrogen transmission system operator will be a subsidiary of GAZ-SYSTEM, enabling integration with the existing natural gas infrastructure (Enerad 2025).

A key element in the development of hydrogen infrastructure is the certification of materials and equipment. The Oil and Gas Institute – National Research Institute (INiG – PIB) has developed and implemented the H2INiG certification system, which confirms the suitability of products for use in the hydrogen economy. In February 2024, the first certificate was issued for PE100-RC polyethylene pipes, which can be used to transport hydrogen–natural gas mixtures or pure hydrogen (INiG PIB 2024). Polska Spółka Gazownictwa has received certifications for hydrogen transport through polyethylene pipelines, marking a major step toward the practical application of hydrogen blending.

Additionally, work is underway on amendments to the Construction Law and the Act on Electromobility and Alternative Fuels, aimed at simplifying procedures for the construction and operation of hydrogen infrastructure – an essential step for the rapid growth of the sector (Electromobility Act 2025).

The new legislation also enables hydrogen distribution using existing gas systems, reducing investment barriers and market development costs (Enerad 2025). The introduction of clear regulations eliminates the previous legal uncertainty that had hindered investment in the hydrogen sector.

2.2. European Union

At the European Union level, the EU Hydrogen Strategy and the New Gas Package play a pivotal role in establishing the legal and regulatory framework for the development of the hydrogen market in Europe (European Commission 2020; Blaczkowska 2024).

The New Gas Package introduces definitions for renewable and low-carbon gases and outlines a hydrogen certification system intended to ensure market transparency and credibility. The package provides for the creation of the European Network of Network Operators for Hydrogen (ENNOH), modeled after the existing networks ENTSOG (gas) and ENTSO-E (electricity). Member States will be required to establish hydrogen transmission system operators within two years of the directive's entry into force, while adhering to unbundling principles in both ownership and operations (Blaczkowska 2024).

Within the EU, it is proposed that hydrogen content be limited to approximately 2% by volume in transmission networks and 10% in distribution networks to ensure the stability and safety of the gas system (European Commission 2020). Efforts are also underway to harmonize standards related to gas quality, pipeline materials, and end-user equipment, which is essential for the development of an interoperable and safe hydrogen infrastructure.

The hydrogen certification system encompasses various production methods – green hydrogen (from renewable energy), blue hydrogen (with carbon capture and storage), and grey hydrogen (from fossil fuels). While the production method does not affect the technical feasibility of injection into the gas grid, it is critical for certification and guarantees of origin, which in turn influence climate policy compliance and eligibility for financial support (Blaczkowska 2024).

The European Hydrogen Backbone (EHB) initiative highlights the strategic role of hydrogen infrastructure based on both existing and newly built pipelines. Its goal is to support the development of a competitive and integrated hydrogen market across the EU, facilitating climate neutrality by 2050 through the integration of hydrogen into energy systems (EHB 2023).

Hydrogen transport regulations in both Poland and the EU are currently undergoing rapid evolution. Poland is preparing to actively participate in the hydrogen economy through legal amendments and the implementation of certification systems. At the European level, legal and organizational frameworks are being established to ensure the safe and efficient development of the hydrogen market, with emphasis on interoperability and consumer protection. These new regulations aim to create a stable regulatory environment that supports investment and fosters innovation in the hydrogen sector.

Conclusion

The conducted analyses clearly indicate that adapting existing gas infrastructure for hydrogen transport – through both blending and repurposing – constitutes a breakthrough and economically justified strategy for supporting the decarbonization of the energy sector. A key mechanism for the rapid and cost-effective implementation of a hydrogen economy lies in the utilization of existing infrastructure assets, which can reduce investment expenditures by as much as 60–90% compared to the construction of new networks. Case studies from both international and Polish contexts demonstrate that, with the proper application of technical standards, certification procedures, and leak detection systems, the safe and efficient large-scale transmission of hydrogen is achievable.

For the first time in Polish technical literature, this study offers such a comprehensive synthesis of the technical, economic, and regulatory conditions for adapting gas networks for hydrogen, highlighting new interdisciplinary linkages among technology, legislation, and economics. The findings suggest that the greatest business potential lies in the synergy between infrastructure operators, regulators, and the R&D sector, which could enhance the competitiveness of the economy and accelerate the achievement of climate goals.

Key future challenges include the development of advanced hydrogen monitoring and detection systems, standardization of materials and equipment, optimization of operating costs, and clarification of the legal framework at both national and EU levels. Digital tools – such as simulation models and digital twins – are gaining particular relevance, enabling dynamic risk assessment and performance evaluation under diverse economic conditions.

In conclusion, the research hypothesis has been confirmed: the adaptation of existing gas infrastructure for hydrogen transport is both technically feasible and economically viable. Poland, through the proactive engagement of infrastructure operators and regulatory support, is well-positioned to become one of the leaders in Europe's energy transition. Future research should focus on the development of innovative infrastructure assessment methods, the optimization of implementation processes, and the long-term economic and environmental impact of large-scale hydrogen deployment.

The Author has no conflicts of interest to declare.

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Marta Gburzyńska

Techniczna adaptacja infrastruktury gazu ziemnego do transportu wodoru – rozwiązania dla transformacji energetycznej

Streszczenie

W obliczu globalnej transformacji energetycznej i konieczności redukcji emisji CO_2 wodór staje się kluczowym nośnikiem energii, którego szerokie zastosowanie wymaga rozwoju efektywnej i bezpiecznej infrastruktury przesyłowej. Budowa nowych sieci wodoru wiąże się z wysokimi kosztami i długim czasem realizacji, dlatego w artykule analizowano potencjał adaptacji istniejącej infrastruktury przesyłowej gazu ziemnego do transportu wodoru. Przedstawiono dwie główne metody: domieszkę wodoru do gazu ziemnego (*blending*) oraz przekształcenie wybranych gazociągów do przesyłu czystego wodoru (*repurposing*). Omówiono kluczowe aspekty techniczne, takie jak wpływ wodoru na materiały, ryzyko kruchości wodorowej, bezpieczeństwo sieci oraz wymagania eksploatacyjne. Analiza regulacyjna objęła zarówno polskie, jak i unijne ramy prawne, ze szczególnym uwzględnieniem nowych standardów i systemów certyfikacji ułatwiających integrację wodoru z istniejącym systemem energetycznym. Przedstawiono przykłady projektów pilotażowych i komercyjnych realizowanych w Europie, podkreślając strategiczną rolę Polski w rozwoju gospodarki wodorowej. Wyniki wskazują, że adaptacja istniejącej infrastruktury może przynieść znaczące oszczędności kosztów (do 90% w porównaniu z budową nowych sieci) oraz przyczynić się do realizacji celów klimatycznych. Artykuł identyfikuje także wyzwania, takie jak detekcja wycieków, kompatybilność urządzeń oraz potrzeba doprecyzowania przepisów, które muszą zostać rozwiązane, aby zapewnić skuteczną i bezpieczną transformację energetyczną. Praca ma na celu dostarczenie decydentom, inwestorom oraz ekspertom interdyscyplinarnej wiedzy niezbędnej do planowania i wdrażania nowoczesnej infrastruktury wodorowej.

Słowa kluczowe: wodór, infrastruktura gazowa, blending, repurposing, regulacje, bezpieczeństwo, dekarbonizacja