Nafta-Gaz 2026, vol. 82, no. 4, pp. 402–407, DOI: 10.18668/NG.2026.04.08

The Impact of Hydrogen Blending on Natural Gas Distribution Networks and the Reduction of Their Emissions

Wpływ domieszek wodoru na sieci dystrybucyjne gazu ziemnego oraz obniżanie ich emisyjności

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ABSTRACT: Adapting existing gas infrastructure to transport a mixture of natural gas and hydrogen poses numerous technical challenges related to the different chemical properties of hydrogen and natural gas. Due to the specific physicochemical properties of hydrogen, its transport via pipelines is much more difficult than the transport of pure natural gas. The approach most widely recognized in the literature as economically optimal involves the utilization of the existing gas transmission and distribution infrastructure for hydrogen transmission. Existing gas pipelines, after passing technical tests, can be used not only for transport purposes, but also as storage facilities for produced hydrogen. Currently, however, the main disadvantages of hydrogen are its low availability and high production cost. However, rising carbon dioxide taxes may raise the price of natural gas to a level where hydrogen becomes competitive. This article outlines the fundamental physicochemical properties of hydrogen and presents a comprehensive literature review on the effects of hydrogen blending on the operational performance and integrity of individual components of the natural gas distribution system. Furthermore, the paper addresses hydrogen transport options, including both purpose-built hydrogen pipelines and the technical adaptation of existing natural gas pipelines for the transmission of hydrogen–natural gas blends with defined volumetric hydrogen concentrations. It also presents ongoing research on reducing the emissions of gas networks with the addition of hydrogen.

Keywords: hydrogen blending, gas distribution networks, emission reduction.

STRESZCZENIE: Dostosowanie istniejącej infrastruktury gazowej do przesyłania mieszaniny gazu ziemnego z wodorem oznacza konieczność sprostania licznym wyzwaniom technicznym związanym z różnymi właściwościami chemicznymi wodoru oraz gazu ziemnego. Z uwagi na specyficzne właściwości fizykochemiczne wodoru, jego transport rurociągami jest znacznie trudniejszy niż przesył czystego gazu ziemnego. Rozwiązaniem przedstawianym w literaturze jako najbardziej korzystne pod względem ekonomicznym jest wykorzystanie istniejącej infrastruktury gazowej do przesyłu wodoru. Istniejące gazociągi, po pozytywnym przejściu prób technicznych, mogą być wykorzystywane nie tylko w celach transportu, ale także jako magazyny wytworzonego wodoru. Obecnie głównymi wadami wodoru są jego mała dostępność oraz wysoki koszt produkcji. Jednakże, rosnące podatki od emisji dwutlenku węgla mogą podnieść cenę gazu ziemnego do poziomu, przy którym wodór stanie się konkurencyjny. W niniejszym artykule przedstawiono najważniejsze właściwości fizykochemiczne wodoru oraz zaprezentowano przegląd literaturowy dotyczący wpływu jego domieszek na pracę poszczególnych elementów infrastruktury systemu dystrybucyjnego gazu ziemnego. Poruszono również kwestię transportu wodoru z wykorzystaniem zarówno dedykowanych rurociągów wodorowych, jak i dostosowania istniejących gazociągów do transportu gazu ziemnego z określonym procentowym udziałem wodoru. Zaprezentowano także prowadzone badania dotyczące ograniczenia emisyjności sieci gazowych z dodatkiem wodoru.

Słowa kluczowe: domieszki wodoru, sieci dystrybucyjne gazu, redukcja emisji.

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Article contributed to the Editor: 24.02.2026. Approved for publication: 25.08.2026.

Introduction

The issue of using hydrogen admixtures in the existing natural gas transmission and distribution networks is a key stage of the energy transition. The compatibility of gas networks with hydrogen blends is the subject of numerous publications in technical and scientific literature.

One of the vital questions regarding the injection of hydrogen into the gas network is determining what concentration of hydrogen in natural gas is safe for the transmission and distribution gas infrastructure, as well as for end users. The decision as to whether an existing pipeline can transport hydrogen, and at what percentage concentration, must be assessed on a case-by-case basis. Significant factors in this regard include the technical condition and the material from which the pipeline is constructed (Narloch, 2024). Whilst hydrogen transport technologies using pressure vessels are well-developed, the transmission of hydrogen through pipelines remains the subject of extensive research and testing.

Hydrogen in the Gas Industry

Hydrogen is an extremely light gas, 14 times lighter than air. The density of hydrogen is 0.082 kg/m^3 at standard conditions, whereas the density of high-methane natural gas is approximately 0.75 kg/m^3. The combustion of hydrogen does not produce harmful substances; only energy and pure water are generated. To transport hydrogen in gaseous form, compression is required, but due to its lower density, it is necessary to apply higher pressure (Narloch, 2024). The explosive limits of hydrogen are a critical criterion. It ignites at an energy level as low as 0.02 mJ, which is 28 times lower than the minimum ignition energy of methane (0.28 mJ). The lower explosive limits (LEL) of methane and hydrogen are similar (4.0% for hydrogen and 4.4% for methane), but the upper explosive limit (UEL) for methane is 17,7%, compared to as much as 75% for hydrogen (Piwoda et al., 2025). On the one hand, adding hydrogen to natural gas will reduce the safety of gas transmission; on the other, it provides an opportunity to transport hydrogen and increase its utilisation (Hydrogen Portal, 2021). With a 10% hydrogen admixture to natural gas, a significant increase in the upper explosive limit of over 5% was observed (Narloch, 2024).

Hydrogen also possesses the highest net calorific value (119 MJ/kg) and gross calorific value by mass of all gases. For natural gas, this value ranges from 38.2 to 47.2 MJ/kg, while for methane it is 50.0 MJ/kg. Per unit of mass, hydrogen has twice the energy density of methane, but per unit of volume, it contains three times less energy (120 MJ/kg and 10.8 MJ/m^3 for hydrogen, and 50 MJ/kg and 35.8 MJ/m^3 for methane, respectively) (Jakubowski, 2022). Consequently, adding hydrogen to natural gas reduces the calorific value of the gas mixture per unit of volume, as shown in the chart below (Figure 1).

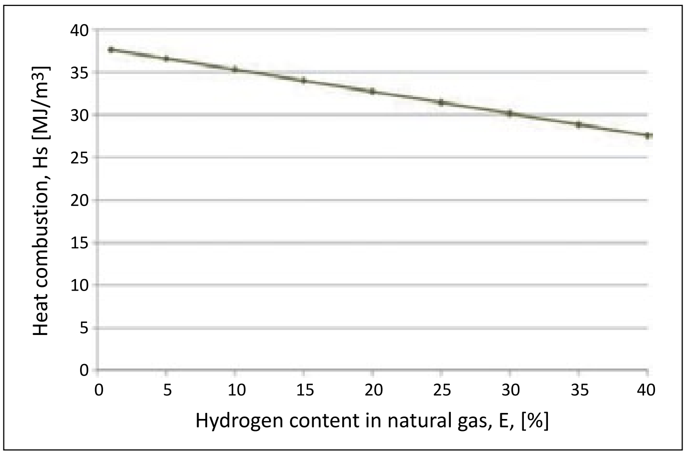

Figure 1. Correlation between the heat of combustion of natural gas and hydrogen content; source: (Jaworski et al., 2019)

Consequently, the capacity of a compressor station designed for natural gas with a hydrogen admixture will be lower than that of a station handling hydrogen-free natural gas. Compressors are the gas infrastructure components with the lowest tolerance for hydrogen; this is the reason for injecting smaller quantities of hydrogen than the network's throughput capacity would otherwise allow. The energy density of gaseous hydrogen is approximately one-third of the energy density of natural gas per unit of volume, therefore a 10% hydrogen admixture by volume reduces the energy value of the transmitted gas by about 7% (Hydrogen Portal, 2021). This necessitates increasing the volume of gas transmitted at the expense of pipeline capacity reserves. In cases where the hydrogen content is increased to 49% (in low-pressure networks), a gas flow rate increase of as much as 75% has been observed (Englart and Jedlikowski, 2023). Due to the requirement to deliver the same energy equivalent per unit of fuel to consumers, it is necessary to compensate for the reduced calorific value by increasing the gas flow rate. For identical volumes and pressure ranges, the amount of energy transmitted via hydrogen is lower than in the case of natural gas. It is therefore essential to precisely assess the impact of hydrogen admixture on the increase in gas flow volume (Hercog et al., 2022). Increasing the volume of gas transmitted leads to higher flow velocities and, consequently, greater pressure drops. The literature cites various permissible maximum gas velocities; for instance, in low-pressure networks, velocities between 4–5 m/s and 10 m/s are recommended. High flow velocities are permitted only on short pipeline sections. In such instances, the pressure drop per linear metre of the pipeline may not adversely affect the final pressure delivered to consumers. Therefore, when anticipating potentially high flow volumes, the primary consideration should be the pressures achieved at the most remote points of the network (Narloch, 2024). In light of the above, decisions to increase the percentage of hydrogen in the natural gas mixture should be made only after thorough hydraulic analyses of the gas network's operation, taking into account peak demand and the lowest recorded pressures in the system. Assuming the same operating pressure and pressure drop along the pipeline, hydrogen will flow at three times the velocity due to its low density. Furthermore, the same pipeline currently transporting primarily natural gas can transport approximately three times more cubic metres of hydrogen over a given period, thereby delivering a similar amount of energy (ENTSOG, 2021; Narloch, 2024).

Hydrogen Transport in Gas Networks

ENTSOG (*The European Network of Transmission System Operators for Gas*) identifies three options for hydrogen transmission:

- via dedicated pipelines;
- as a hydrogen admixture to existing natural gas infrastructure;
- through the injection of e-methane, produced via hydrogen methanation, into the gas network.

For the transport of pure hydrogen, hydrogen pipelines represent the most cost-effective option for long-distance supply. According to the *European Hydrogen Backbone* (EHB), the most economically viable solution for hydrogen transport is the repurposing of existing pipelines. This approach is at least twice as cost-effective as constructing new, dedicated pipelines (Portal wodorowy, 2021). Currently, there are only 1,500 km of dedicated hydrogen transmission pipelines within the EU, most of which are situated on industrial sites and serve local purposes. According to the EHB programme, approximately 40,000 km of pipelines adapted for the transmission of pure hydrogen or its blend with natural gas are to be operational across Europe by 2040; two-thirds of this infrastructure is expected to comprise existing pipelines repurposed for hydrogen transmission (Jakubowski, 2022).

The most advantageous solution is therefore the adaptation and conversion (*retrofitting, repurposing*) of existing pipelines (Jakubowski, 2022). The technical readiness of the repurposed infrastructure should be the subject of further research as well as in-depth hydraulic and material analyses.

In Poland, the presence of hydrogen in gas networks was not permitted until 2022. In 2022, the Ministry of the Environment amended the Regulation on detailed conditions for the functioning of the gas system (Dz.U. /Journal of Laws/ of 2022, item 1899). According to that a hydrogen content of up to 10% is permitted provided that the metering and billing system equipment, installations and gas networks are adapted to the transmission of gaseous fuels with a higher hydrogen content, in a way ensures the safety of end-users equipment. Calculations and analyses conducted by the Oil and Gas Institute – National Research Institute (INiG – PIB) indicate that the maximum hydrogen content in a mixture with natural gas that does not lead to non-compliance with the gas's energy parameters (primarily the Wobbe Index) should not exceed 36% (Jaworski et al., 2019). When considering the efficiency and safety of gas appliances (e.g. cookers), this value should be a maximum of 15%. The updated provisions permit the transmission of natural gas with a hydrogen admixture through gas networks. Depending on the European Union member state, the maximum concentration of hydrogen in natural gas varies from 2% to 10% (Jaworski et al., 2019; ENTSOG, 2021). The EU considering limiting the maximum hydrogen content in transmission networks to 2% in order to maintain a harmonised quality of transported natural gas and system security (European Comission, 2023).

The permissible percentage of hydrogen in natural gas should be determined by considering the network layout, consumer characteristics, and gas composition (Chaczykowski and Osiadacz, 2016). The sensitivity of selected distribution system components to hydrogen content in natural gas is summarised in the table 1.

The permissible percentage of hydrogen in the transmitted gas mixture also depends on the pipeline material. Hydrogen not only escapes from sections of the gas network (through seals and joints) but also penetrates the structure of the pipeline material, increasing the probability of failure. This affects gas system components such as pipes, compressors, metering systems, and others (Narloch, 2024). The durability of certain metal pipes may deteriorate when exposed to hydrogen over a long period of time, particularly in the case of high-concentration, high-pressure hydrogen. This effect can be a concern in situations where hydrogen is injected in high concentrations into an existing high-pressure natural gas pipeline system. The durability of metal pipes depends largely on the type of steel and must be assessed on a case-by-case basis. Molecular hydrogen has a negative effect on the fatigue properties of steels used in pipeline construction. A beneficial effect of adding oxygen to hydrogen on the fatigue properties of materials has been observed. Not only atomic hydrogen but also molecular hydrogen affects the hydrogen embrittlement of steel (Kozikowski and Szymlek, 2022). Research conducted to date on the gas network in Poland indicates that for certain components of the natural gas system, it is possible to inject up to 10% hydrogen by volume into the natural gas (Jaworski et al., 2019; Jakubowski, 2022). A crucial factor is

Table 1. Sensitivity of distribution system components to hydrogen content in natural gas (source: Englert and Jedlikowski, 2023)

Components and devices constituting gas network infrastructure and internal gas installation equipment	H_2 content in natural gas [% vol]		
	Safe range	Technical adaptation / standardisation required	R&D work required
Steel pipelines	0–30	30–50	50–70
Plastic pipelines*	0–70	—	—
Pipe joints and sealing materials	0–30	30–50	—
Flow limiters	0–15	15–50	50–70
Gas meters (diaphragm, turbine, ultrasonic)	0–30	30–70	—
Pressure regulators	0–67	67–70	—
Valves and fittings	0–30	30–50	50–70
Pipes in gas installations	0–30	30–50	50–70
Gas cookers	0–10	10–50	50–70
Atmospheric burners	0–10	10–50	50–70
Forced-draught burners	0–10	10–22	22–70
*depending on the pipe material			

hydrogen embrittlement, which involves a loss of metal ductility and a reduction in load-bearing capacity due to the absorption of hydrogen atoms or molecules by the metal. Consequently, there is an increased risk of pipeline cracking, even at stress levels lower than the metal's yield strength (Narloch, 2024).

Research on Gas Networks with Hydrogen Admixture and Reduction of Their Emissions

Research is being conducted across Europe regarding the reduction of emissions from gas networks transmitting natural gas with a hydrogen admixture. At Keele University, ongoing studies aim to determine the practicality of enriching natural gas used for building heating with a 20% hydrogen blend (CIRE, 2020). The university operates its own private gas network, which has been safely isolated from the rest of the British gas grid. It is estimated that heating residential and industrial buildings accounts for half of the energy consumption and one-third of carbon dioxide emissions in the United Kingdom, with 83% of homes using gas for heating purposes (Narloch, 2024). Calculations suggest that if a natural gas-hydrogen mixture were distributed throughout the UK, carbon dioxide emissions could be reduced by approximately 6 million tonnes annually, equivalent to removing about 2.5 million cars from the roads (CIRE, 2020). In other research (Paglini et al., 2024) a novel methodology for emission estimating rates in natural gas networks during a transition to a 10% hydrogen addition by combining established analytical models with direct methane leakage measurements has been presented. The results revealed that while the overall volumetric emission rates increase, mainly due to hydrogen's lower density, methane emissions decrease by 5.95% in mainlines and 8.28% in service pipelines. However, for the 10% hydrogen blend's effect, the net reduction in CH_4 and H_2 emissions, expressed as CO_2 equivalent and resulting from the incorporation of the analyzed hydrogen admixture, is 5.4% for mainlines and 7.7% for service pipelines. The emission rate changes are not the same across the gas network. Different components of gas network are affected to varying degrees depending on their initial emission rates and the gas flow conditions. Methane emissions, for example, are particularly influenced by the fluid regime, with turbulent conditions having a significant impact. Moreover Paglini et al. (2024) also presented the new mean emissions (methane and hydrogen) by pipeline material. The total emission rate increased by 5.5% for unprotected steel, 5.7% for cast iron, 3.2% for plastic pipelines, and 5.8% for cathodically protected steel. At the same time, methane emissions decreased as a consequence of hydrogen blending, by 6.1% for unprotected steel, 5.9% for cast iron, 8.1% for plastic pipelines, and 5.8% for cathodically protected steel (Paglini et al., 2024). Regarding safety considerations, the analysis reveals that bare steel and cast iron mains constitute the primary sources of hydrogen emissions. Recognizing hydrogen as a secondary greenhouse gas affects the overall greenhouse gas balance, thereby slightly reducing the environmental gains associated with hydrogen blending (Paglini et al., 2024). The study performed by Das et al. (2025) focuses on transporting hydrogen-natural gas mixtures and the impact of using electricity-powered compressors. The results show that higher pressures are essential for efficient hydrogen transport in pipelines. Moreover, hydrogen admixtures reduces CO_2 emissions 2–6% for hydrogen injections of 5–20 vol %, respectively. Electrifying compressor stations reduces compressor station emissions from 430 $ktCO_2$/year to 32 $ktCO_2$/year, although it raises annual operation costs.

Research on hydrogen admixture in gas pipeline systems is also being undertaken in Poland (Englart and Jedlikowski, 2023). Based on its project results, the Oil and Gas Institute – National Research Institute (INiG–PIB) has proposed a 10% of hydrogen admixture, the methodology applied for compressibility factor determination, and 8% due to the explosion safety of measuring devices used in hazardous areas. Similar studies are also being carried out by the Slovak gas company SPP, which launched the H2 Pilot project in 2022. While commercial hydrogen injection into gas networks has not yet been implemented in Poland, it is noteworthy that PSG commissioned the first pipeline enabling the transport of a gas-hydrogen mixture in March 2024 (Portal Samorządowy). The 7-km-long pipeline was constructed in Lower Silesia and subsequently granted a technical assessment certificate confirming its capability for transmitting a mixture of natural gas and hydrogen up to 20% by volume (Narloch, 2024). The hydrogen content in the mixture was established based on an assessment of the products used, construction technology, and the quality of work performed by INiG – PIB. Similar conclusions regarding the transmission of hydrogen-natural gas mixtures have been reached by scientists in Portugal (Quintino et al., 2021) and the Czech Republic (Jachimczyk, 2024; Vodikova strategie České republiky, 2024). Hydrogen content up to 20% appears to be possible to accommodate in current gas infrastructure with some technical modifications according to Quintino et al. Noticely, the Distribution System Operator (DSO) level, the introduction of gas quality tracking systems will be required due to the distributed injection nature of hydrogen (Quintino et al., 2021). In the Czech Republic the gas distribution system is currently considered compatible with natural gas–hydrogen blends containing up to 20% hydrogen by volume. In some regions, the hydrogen concentration in the distribution network may exceed the levels envisaged for the transmission system, depending on local hydrogen production potential and the capacity of end-users to utilize such blends (Jachimczyk, 2024; Vodikova strategie České republiky, 2024). Prior to the introduction of blends with higher hydrogen content into the natural gas network, dedicated studies are planned to assess the economic feasibility and quantify the anticipated benefits of this transition.

Summary

Recognizing the advantages of hydrogen-natural gas blends and the potential for a gradual transition from a fossil fuel-based economy to a hydrogen economy by repurposing existing natural gas networks for hydrogen storage and transport, various projects such as HyDeploy, GRHYD, THyGA, HyBlend, and others are being implemented worldwide (Mahajan et al., 2022). Beyond technical issues, these initiatives also seek a cost-effective pathway to achieving carbon emission reduction goals in the coming decades. The presented studies indicate that the implementation of hydrogen blending in gas distribution networks at levels ranging from 10% to 20% can result in a reduction in greenhouse gas emissions of approximately 5.4–7.7% (Narloch, 2024; Paglini et al., 2024; Das et al., 2025).

For the transition to a hydrogen economy to be successful, a broad range of stakeholders from research institutions and industry requires a comprehensive understanding of the problems and challenges associated with hydrogen, from production and storage to transport and end-use. The allowable hydrogen fraction in the transported gas mixture dependents on the pipeline material. Hydrogen may not only leak from certain elements of the gas network, such as seals and joints, but can also diffuse into the material structure of the pipeline, thereby increasing the risk of failure. This affects various components of the gas system, including pipelines, compressors, metering systems, and other related equipment. Therefore, the assessment of whether an existing pipeline is suitable for hydrogen transport, and of the maximum permissible hydrogen concentration, should be carried out individually, taking into account both its technical condition and the material from which it is constructed.

Currently, Poland lacks clear guidelines defining the parameters for transmitting hydrogen as an admixture to natural gas. Gas infrastructure allows not only for the long-term storage of energy in the form of hydrogen but also for its transmission from the point of generation to the locations of most efficient use. Given that natural gas is an internationally traded commodity, the integration of national systems will be a significant challenge and a key element in supporting the deployment of hydrogen transport technologies using existing infrastructure (Nagy, 2019).

References

Chaczykowski M., Osiadacz A.J., 2016. Technologie Power-to-gas. *Przegląd Gazowniczy*, 49, (1): 40-44.

CIRE, 2020. Gaz ziemny z wodorem - mniej dwutlenku węgla. <https://www.cire.pl/artykuly/serwis-informacyjny-cire-24/154104-gaz-ziemny-z-wodorem-mniej-dwutlenku-wegla> (dostęp: 20.01.2026).

Das P., Rowe A., Wild P., Majumdar Ch., 2025. Modeling and optimization of a hydrogen blended natural gas transmission network: Effect of compressor electrification. *International Journal of Hydrogen Energy*, Vol 127, 2025, p. 497-510. DOI: 10.1016/j.ijhydene.2025.03.380.

Englart S., Jedlikowski A., 2023. Wpływ dodatku wodoru na eksploatację osiedlowej sieci gazowej. *Instal*, 7–8: 14-23. DOI: 10.36119/15.2023.7-8.2.

ENTSOG, 2021. How to transport and store hydrogen – facts and figures. <https://www.entsog.eu/sites/default/files/2021-05/ENTSOG_GIE_HydrogenEurope_QandA_hydrogen_transport_and_storage_FINAL_0.pdf> (dostęp 21.01.2026).

European Commission. Proposal for a Regulation of the European Parliament and of the Council on the Internal Markets for Renewable and Natural Gases and for Hydrogen. Brussels: European Com mission, 2023. <https://eur-lex.europa.eu/legal-content/EN/TXT/?uri= COM%3A2021%3A804%3AFIN>.

H2 Pilot. < https://www.spp-distribucia.sk/o-spolocnosti/co-robime/h2-pilot-en/> (dostęp: 20.01.2026).

Hercog J., Kupecki J., Kiedrzyńska A., Bocian P., Świątkowski B., Kowalik P., 2022. Transformacja przemysłu w kierunku wykorzystania technologii wodorowych. *Przegląd Gazowniczy*, 1(73).

Jachimczyk D., 2024. Zestawienie wyników badań i opracowań nt. wpływu mieszanin gazu ziemnego z wodorem na elementy sieci gazowej, urządzenia użytkowników końcowych i ciepło spalania. *Polska Spółka Gazownictwa*.

Jakubowski P., 2022. Sposoby produkcji i przesyłu wodoru oraz skroplonego wodoru – budowanie przewag konkurencyjnych, Bezpieczeństwo energetyczne. Wybrane zagadnienia. *Oficyna Wydawnicza Politechniki Rzeszowskiej, Rzeszów*.

Jaworski J., Kukulska-Zając E., Kulaga P., 2019. Wybrane zagadnienia dotyczące wpływu dodatku wodoru do gazu ziemnego na elementy systemu gazowniczego. *Nafta-Gaz*, 10, s. 625-632. DOI: 10.18668/NG.2019.10.04.

Kozikowski S., Szymlek K., 2022. Wodór – zielone złoto. Infrastruktura przesyłowa i wpływ wodoru na materiały konstrukcyjne. INSPEKTOR Biuletyn Urzędu Dozoru Technicznego 2/2022. <https://www.udt.gov.pl/images/kampania/biuletyn/pdf/INSPEKTOR_2_2022_v32.pdf> (dostęp: 20.01.2026).

Mahajan D., Tan K., Venkatesh T., Kileti P., Clayton C.R., 2022. Hydrogen Blending in Gas Pipeline Networks—A Review. *Energies*, 15(10), 3582. DOI: 10.3390/en15103582.

Nagy S., 2019. Gospodarka wodorowa a dekarbonizacja przemysłu gazowniczego. *Przegląd Gazowniczy*, 4(64).

Narloch P., 2024. Dynamiczna kontrola ciśnienia w modelowaniu pracy sieci gazowych z wykorzystaniem modeli sieci neuronowych w celu optymalizacji działań inwestycyjnych wspierających redukcję smogu i niskiej emisji. *Rozprawa doktorska. Akademia Górniczo-Hutnicza im. Stanisława Staszica w Krakowie*.

Paglini R., Minuto F.D., Lanzini A., 2024. Estimating Greenhouse Gas Emissions from Hydrogen-Blended Natural Gas Networks. *Energies*, 17(24), 6369. DOI: 10.3390/en17246369.

Piwoda Ł., Michalski S., Piątek K., Stefaniak D., 2025. Badania możliwości wykorzystania urządzeń w wykonaniu przeciwwybuchowym grupy IIA i IIB w atmosferach gazu ziemnego z dodatkiem wodoru. *Przemysł Chemiczny*, 11. DOI: 10.15199/62.2025.11.5.

Portal Samorządowy. <https://www.portalsamorzadowy.pl/gospodarka-komunalna/powstal-pierwszy-w-polsce-gazociag-do-przesylu-wodoru,530604.html> (dostęp 20.01.2026).

Portal wodorowy, 2021. Sieci gazowe mogą posłużyć do przesyłu wodoru. <https://h2poland.eu/en/categories/transmission-storage/gas-network-transmission/sieci-gazowe-moga-posluzyc-do-przesylu-wodoru/ > (dostęp 20.01.2026).

Quintino F.M., Nascimento N., Fernandes E.C., 2021. Aspects of Hydrogen and Biomethane Introduction in Natural Gas Infrastructure and Equipment. *Hydrogen*, 2(3), 301-318. DOI: 10.3390/hydrogen2030016.

Vodikova strategie České republiky, 2024. Ministerstvo průmyslu a obchodu České republiky. <https://mpo.gov.cz/assets/cz/prumysl/strategicke-projekty/2024/7/Vodikova-strategie-CR-aktualizace-2024.pdf> (dostęp 20.01.2026).

Legal acts and regulatory documents

Rozporządzenie Ministra Klimatu i Środowiska z dnia 6 sierpnia 2022 r. zmieniające rozporządzenie w sprawie szczegółowych warunków funkcjonowania systemu gazowego (Dz.U. 2022, poz. 1899).

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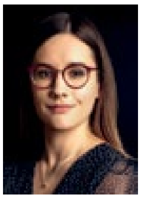

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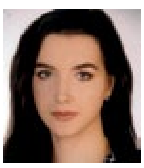

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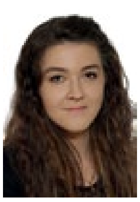

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