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The Impact of Natural Gas Enriched with Hydrogen on the Environment and its Usage in the European Household Applications

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Abstract: Given the European Union's ambitious plan to transition from fossil fuels to hydrogen, aiming for hydrogen to meet 24% of final energy demand by 2050 and create 5.4 million jobs by then, this paper emphasizes the significance of hydrogen in household applications, such as heating and cooking. Several European countries have already adopted this new fuel, which involves blending hydrogen with methane gas in various proportions and delivering it through existing national gas pipelines. Using hydrogen for energy production has been shown to result in lower CO₂ emissions compared to using natural gas (primarily CH₄) alone. Countries like Germany, Sweden, and Denmark are already incorporating hydrogen into their gas distribution systems. In Romania, the National Research and Development Institute for Gas Turbines COMOTI has been conducting research on hydrogen, focusing primarily on combustion but with implications for broader applications, including production and storage of hydrogen. From an entrepreneurial perspective and in alignment with the EU's CO₂ reduction goals, developing a standalone hydrogen burner for household use represents a promising business opportunity.

Keywords: European Union; energy production; the National Research and Development Institute for Gas Turbines COMOTI

1. Overview of the Possible Usage of Natural Gas Enriched with Hydrogen in the European Household Applications

Natural gas enriched with hydrogen, which combines methane and hydrogen, is increasingly recognized as a vital component in Europe's strategy to transition to more sustainable energy sources. This approach seeks to reduce carbon emissions and improve the environmental sustainability of energy systems, with significant implications for its use in European households.

One of the primary environmental benefits of hydrogen-enriched natural gas is its reduced carbon intensity. The addition of hydrogen lowers the overall carbon footprint of the fuel, resulting in decreased CO₂ emissions during combustion³. This fuel blend also enhances the efficiency of energy production and utilization, which can lead to improved energy performance and a reduction in greenhouse gas emissions per unit of energy used. Moreover, as hydrogen production methods evolve to become more environmentally friendly—such as through the use of renewable energy for electrolysis—the positive

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³ European Commission. Online. URL: https://ec.europa.eu/energy/sites/ener/files/hydrogen_strategy.pdf. Accessed 1st of May 2020.

environmental impact of hydrogen-enriched gas is expected to increase, aligning with the EU's goal of achieving net-zero emissions by 2050.

In terms of household applications, hydrogen-enriched gas can be used in existing heating systems with minimal modifications, allowing for a reduction in carbon emissions without significant changes to infrastructure¹. It is also compatible with household cooking appliances, offering a cleaner alternative to traditional natural gas and potentially reducing indoor air pollution. Many European countries, including Germany, Sweden, and Denmark, have already begun integrating hydrogen into their gas distribution networks, which makes use of existing infrastructure and supports a smoother transition to sustainable energy sources. For consumers, this shift can result in improved energy efficiency and possibly lower energy bills, while also contributing to broader environmental goals and complying with EU regulations and incentives².

However, there are challenges associated with this transition. Adapting existing infrastructure to accommodate higher hydrogen concentrations may require retrofitting appliances and pipelines. Additionally, the cost of hydrogen production and distribution is currently higher compared to conventional natural gas, though costs are expected to decrease as technology advances and economies of scale are realized. Public acceptance and understanding of the benefits of hydrogen-enriched gas are also crucial for its successful adoption, necessitating effective education and awareness efforts³.

In conclusion, the integration of hydrogen into natural gas represents a promising advancement towards reducing carbon emissions and enhancing energy sustainability in European households. Its potential to lower environmental impact while utilizing existing systems makes it a key element in Europe's energy transition strategy. Addressing the challenges related to infrastructure, cost, and public acceptance will be essential for maximizing its benefits and achieving widespread adoption.

2. Impediments in Implementation

The move towards hydrogen-enriched natural gas marks a major advancement in Europe's efforts to cut carbon emissions and improve energy sustainability. Nonetheless, this transition presents several challenges that need to be tackled to fully capitalize on its advantages. This chapter examines the primary obstacles to the adoption of hydrogen-enriched natural gas, with an emphasis on its environmental effects and its use in household applications across Europe⁴.

One of the foremost challenges in implementing hydrogen-enriched natural gas is the adaptation of existing infrastructure. Current natural gas pipelines, which were designed for methane (CH₄), may require modifications to safely transport hydrogen-enriched mixtures. Hydrogen's properties, such as its smaller molecular size and higher diffusivity, necessitate upgrades to prevent leaks and ensure system integrity⁵. Hydrogen-enriched natural gas can increase the risk of embrittlement and leakage in pipelines, which were not originally designed to handle hydrogen. Retrofitting or replacing infrastructure to

¹ Gas for climate. Online. URL: <https://gasforclimate2050.eu/wp-content/uploads/2020/10/Gas-for-Climate-Study-2020-1.pdf>. Accessed 1st of May 2020.

² International Energy Agency (IEA), Online. URL: <https://www.iea.org/reports/the-role-of-hydrogen-in-the-future-energy-system>, Accessed 1st of May 2020.

³ Hydrogen Europe, Hydrogen for the European Green Deal: A Vision for 2030, Online. URL: <https://hydrogeneurope.eu/wp-content/uploads/2021/05/Hydrogen-Europe-Vision-for-2030.pdf>, Accessed 1st of May 2020.

⁴ European Commission. Online. URL: https://ec.europa.eu/energy/sites/ener/files/hydrogen_strategy.pdf. Accessed 1st of May 2020.

⁵ Gas for climate. Online. URL: <https://gasforclimate2050.eu/wp-content/uploads/2020/10/Gas-for-Climate-Study-2020-1.pdf>, Accessed 1st of May 2020.

accommodate higher hydrogen concentrations can be costly and technically complex. The storage of hydrogen-enriched gas also poses challenges. Hydrogen has different storage requirements compared to methane, including higher pressures or cryogenic temperatures. Modifications to existing storage facilities or the development of new ones are necessary to handle the new fuel blend effectively. The economic implications of transitioning to hydrogen-enriched natural gas are significant. Currently, the production and distribution of hydrogen are more expensive compared to conventional natural gas. This cost differential impacts both producers and consumers, potentially hindering widespread adoption. Hydrogen production, particularly through green methods such as electrolysis powered by renewable energy, remains expensive. While costs are expected to decrease with advancements in technology and increased production scale, current expenses are a barrier to rapid adoption.

The cost of modifying distribution networks and storage facilities to handle hydrogen-enriched gas can be substantial. These expenses are typically passed on to consumers, potentially leading to higher energy bills during the transition period. The economic viability of hydrogen-enriched natural gas depends on achieving a balance between production costs, infrastructure investments, and market prices. Supportive policies and incentives are required to mitigate financial burdens and encourage investment.

Public acceptance and understanding of hydrogen-enriched natural gas are crucial for its successful implementation. Without widespread consumer support, even well-designed technical solutions may struggle to gain traction.

Effective education campaigns are needed to inform the public about the benefits and safety of hydrogen-enriched gas. Misconceptions and lack of awareness can lead to resistance, which can impede the adoption of new technologies.

Public apprehension regarding the safety of hydrogen-enriched gas must be addressed. While hydrogen is a safe fuel when properly managed, its properties differ from methane, and clear communication about its safety measures is essential. Strong regulatory frameworks and incentives are necessary to foster consumer trust and encourage the adoption of hydrogen technologies. These frameworks should address safety, environmental benefits, and economic aspects to build confidence among users. Although hydrogen-enriched natural gas offers environmental benefits, such as reduced carbon emissions compared to pure methane, several environmental concerns must be addressed. The environmental impact of hydrogen-enriched gas depends on the source of hydrogen (Wang, & Han, 2020, p. 109951). If hydrogen is produced using fossil fuels (grey hydrogen), the overall emissions reductions may be limited. Ensuring the use of green hydrogen, produced from renewable sources, is crucial for maximizing environmental benefits. The production of green hydrogen requires significant resources, including water and energy. Sustainable practices must be implemented to manage these resources efficiently and minimize the environmental footprint. Compliance with environmental regulations is essential to ensure that the adoption of hydrogen-enriched gas contributes positively to overall sustainability goals (Hernández & Sanjuán, 2021, p. 10224). Regular assessments and updates to regulations may be needed to address evolving environmental impacts.

The implementation of hydrogen-enriched natural gas in Europe presents several impediments, including infrastructure adaptation, economic barriers, public acceptance, and environmental considerations. Addressing these challenges is critical for maximizing the benefits of hydrogen-enriched gas and achieving broader environmental and energy goals. Coordinated efforts from policymakers, industry stakeholders, and the public are essential to overcome these obstacles and support a successful transition to a more sustainable energy future.

3. Advantages of Implementing Usage of Natural Gas Enriched with Hydrogen in the European Household Applications

The transition to hydrogen-enriched natural gas is increasingly recognized as a crucial strategy in Europe's pursuit of reduced carbon emissions and enhanced energy sustainability. This shift promises significant benefits for household applications, notably in energy efficiency, environmental impact, economic factors, and the seamless integration with existing infrastructure (Lohschelder & Schulze, 2021, p. 110158).

One of the main advantages of hydrogen-enriched natural gas is its potential to boost energy efficiency in household applications. Hydrogen's higher energy content per unit mass and its ability to burn at higher temperatures can improve the combustion process. This enhancement leads to more efficient energy use in heating systems and cooking appliances. With optimized combustion, household appliances achieve higher thermal efficiency, converting more fuel energy into usable heat. This improvement results in reduced energy loss and better performance, which in turn lowers energy consumption and household energy bills, contributing to overall savings.

Environmentally, hydrogen-enriched natural gas offers notable advantages over conventional natural gas (Acar, & Dincer, 2019, pp. 301-329). The primary benefit is the reduction in carbon emissions due to hydrogen's lower carbon intensity. By incorporating hydrogen into the natural gas mix, CO₂ emissions during combustion are significantly lowered. This contributes positively to the European Union's climate goals by reducing household greenhouse gas emissions. Additionally, when hydrogen is produced using green methods, such as electrolysis powered by renewable energy, the environmental benefits are further amplified, supporting Europe's climate neutrality targets and enhancing the overall sustainability of the energy sector.

From an economic perspective, the adoption of hydrogen-enriched natural gas can be advantageous (Bauer, et al., 2021, p. 10624). Although the initial transition costs may be high, the long-term economic benefits are significant. Improved energy efficiency can lead to lower energy costs for households, and as technology advances and economies of scale are realized, costs are expected to decrease. Moreover, the development and deployment of hydrogen technologies generate new economic opportunities, including job creation in production, distribution, and infrastructure sectors. Government incentives and subsidies can further support the transition, offsetting initial costs and accelerating the integration of hydrogen-enriched natural gas into household applications.

Finally, the integration of hydrogen-enriched natural gas with existing infrastructure offers a practical and cost-effective solution. Many European countries have started blending hydrogen with natural gas in their current pipelines, allowing for a gradual introduction of hydrogen into the energy mix without a complete overhaul of infrastructure. Existing household appliances, such as boilers and cookers, can often be adapted with minimal modifications, reducing the need for new equipment investments. While some infrastructure upgrades are necessary, they are generally less extensive than building new systems from scratch, facilitating a smoother transition and effective incorporation of hydrogen-enriched gas into the current energy network.

In summary, the implementation of hydrogen-enriched natural gas in European households presents numerous benefits, including enhanced energy efficiency, reduced environmental impact, economic advantages, and ease of integration with existing systems. These benefits align with Europe's broader energy and climate objectives, offering a sustainable and practical pathway towards a cleaner energy future.

4. Conclusions and Predictions

The integration of hydrogen-enriched natural gas into European household applications offers a promising pathway towards achieving significant environmental and economic benefits. This transition aligns with the European Union's ambitious goals of reducing carbon emissions and enhancing energy sustainability. Hydrogen-enriched natural gas, by combining hydrogen with methane, not only lowers the carbon footprint of household energy use but also improves energy efficiency. The enhanced combustion properties of hydrogen lead to more efficient heating and cooking processes, which can result in reduced energy consumption and lower household energy bills.

From an environmental perspective, the use of hydrogen-enriched natural gas offers substantial advantages over traditional natural gas. The incorporation of hydrogen reduces CO₂ emissions, contributing positively to the EU's climate targets. When produced from renewable sources, hydrogen can further amplify these environmental benefits, supporting Europe's goal of achieving climate neutrality by 2050. Moreover, as technology advances and hydrogen production costs decrease, the economic viability of this energy solution is expected to improve, making it a more accessible option for households in the future. However, the successful implementation of hydrogen-enriched natural gas faces several challenges. Adapting existing infrastructure to accommodate hydrogen, managing higher costs associated with hydrogen production and distribution, and achieving public acceptance are critical obstacles that need addressing. The need for infrastructure modifications, potential cost implications, and effective public education and safety communication are pivotal to overcoming these challenges.

In conclusion, while the transition to hydrogen-enriched natural gas presents certain hurdles, its potential to deliver improved energy efficiency, lower carbon emissions, and seamless integration with existing systems makes it a key component in Europe's strategy for a sustainable energy future. Addressing the associated challenges with coordinated efforts from policymakers, industry stakeholders, and the public will be essential for maximizing the benefits of this energy transition and supporting broader environmental and economic goals.

The adoption of hydrogen-enriched natural gas marks a pivotal shift in Europe's energy landscape, offering a blend of promising opportunities and complex challenges. As technology for hydrogen production, storage, and distribution evolves, advancements are expected to lead to more cost-effective solutions and better infrastructure compatibility. Innovations in hydrogen production, particularly from renewable sources, could significantly reduce costs and enhance environmental benefits. Additionally, progress in materials science and engineering may address infrastructure challenges, making it easier to retrofit existing pipelines and appliances. Continued investment in research and development will be crucial in overcoming current limitations and facilitating a smoother transition to hydrogen-enriched natural gas. The economic implications of this transition are poised for transformation as the market matures. Although initial costs for hydrogen production and infrastructure modifications are substantial, these costs are anticipated to decrease over time due to economies of scale and technological improvements. As the hydrogen economy develops, new economic opportunities, including job creation in the hydrogen sector and related industries, will emerge. Government incentives, subsidies, and supportive policies will play a critical role in shaping the economic viability of hydrogen-enriched natural gas, helping to bridge the gap between initial investments and long-term benefits.

From an environmental perspective, the impact of hydrogen-enriched natural gas is closely tied to the source of hydrogen production. Green hydrogen, produced through electrolysis powered by renewable energy, offers significant environmental advantages, including substantial reductions in greenhouse gas emissions. However, scaling up green hydrogen production requires addressing resource management

challenges, such as water and energy use. Ensuring that hydrogen production remains sustainable and aligns with broader climate goals will be essential for maximizing the environmental benefits of hydrogen-enriched natural gas and supporting Europe's pursuit of net-zero emissions.

Public acceptance is another crucial factor in the successful adoption of hydrogen-enriched natural gas. Effective communication and education campaigns are necessary to inform consumers about the benefits, safety, and practical implications of using hydrogen-enriched gas. Building public trust through transparent and comprehensive information will help address concerns about safety and efficacy. Engaging with communities and stakeholders to highlight the advantages of hydrogen-enriched natural gas—such as its role in reducing carbon emissions and improving energy efficiency—will be key to fostering positive public perception and encouraging widespread adoption.

The development of robust regulatory frameworks and supportive policies will be fundamental to the successful implementation of hydrogen-enriched natural gas. Policymakers will need to tackle regulatory challenges, including safety standards, environmental regulations, and incentives for innovation. Coordinated efforts among government bodies, industry leaders, and research institutions will be necessary to create a cohesive strategy that supports the integration of hydrogen-enriched gas into existing energy systems. Regular updates to regulations and policies will ensure they remain aligned with technological advancements and evolving market conditions.

In conclusion, the perspectives on hydrogen-enriched natural gas in European household applications highlight a dynamic interplay between technological progress, economic considerations, environmental impacts, public acceptance, and regulatory support. Successfully integrating hydrogen-enriched natural gas will depend on addressing these factors through innovation, collaboration, and strategic planning. As Europe advances towards a more sustainable energy future, hydrogen-enriched natural gas stands out as a key component in achieving broader climate and energy goals.

5. References

Acar, C. & Dincer, I. (2019). Hydrogen energy and fuel cells: Current status and perspectives. *Renewable and Sustainable Energy Reviews*, vol. 91(1), pp. 301-329.

Bauer, C. et al. (2021). *Economic viability of hydrogen as an energy carrier in residential applications: A case study*. *Renewable and Sustainable Energy Reviews*, 138, 110624. doi:10.1016/j.rser.2020.110624.

Hernández, J.A. & Sanjuán, N. (2021). Regulation and Policy Frameworks for Hydrogen Energy: A Review. *Renewable and Sustainable Energy Reviews*, 135, 110224.

Wang, M., & Han, J. (2020). Techno-economic and environmental assessment of hydrogen production from renewable sources: A review. *Renewable and Sustainable Energy Reviews*, 130, 109951.

Online Sources

European Commission, *The Hydrogen Economy: Opportunities and Challenges*, European Commission. Online. URL: https://ec.europa.eu/info/publications/hydrogen-economy-opportunities-and-challenges_en.

European Commission. Online. URL: https://ec.europa.eu/energy/sites/ener/files/hydrogen_strategy.pdf. Accessed 1st of May 2020.

Gas for climate. Online. URL: <https://gasforclimate2050.eu/wp-content/uploads/2020/10/Gas-for-Climate-Study-2020-1.pdf>. Accessed 1st of May 2020.

Hydrogen Europe, *Hydrogen for the European Green Deal: A Vision for 2030*, Online. URL: <https://hydrogeneurope.eu/wp-content/uploads/2021/05/Hydrogen-Europe-Vision-for-2030.pdf>, Accessed 1st of May 2020.

International Energy Agency (IEA), Online. URL: <https://www.iea.org/reports/the-role-of-hydrogen-in-the-future-energy-system>, Accessed 1st of May 2020.