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The Role of Biomethane in Achieving Net-Zero Emissions in the Global Energy Sector

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ABSTRACT

The conscious effort in mitigating climate change on a global scale has generated an increased pursuit of sustainable and low-carbon solutions to energy crisis. Biomethane is a methane-rich gas that is renewable, obtained from organic wastes and a major player in the move towards net-zero emissions. Biomethane offers benefits on reduction of greenhouse gas emissions by capturing methane and a circular economy solution through the valorization of agricultural residues, municipal solid waste, and wastewater. As the world accelerates its decarbonization efforts, biomethane stands out not merely as a transitional fuel, but as a cornerstone of a resilient, circular, and carbon-neutral energy future. This review explores the diverse role of biomethane in reducing the carbon in the global energy sector, examining the production pathways, integration into existing infrastructure, and potential to displace fossil fuels across power generation, transportation, and heating. The review concludes that biomethane, when strategically integrated with other renewable energy sources and supported by robust policy, can significantly contribute to achieving net-zero targets while enhancing energy security and rural development.

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LIST OF ABBREVIATIONS

Anaerobic Digestion - AD
Carbon dioxide - CO_2
Combined Heat and Power – CHP
Compressed Biomethane - Bio-CNG
Emissions Trading Schemes - ETS
Feed-in Tariffs - FiTs
Greenhouse gas - GHG
Hydrogen sulfide - H_2S
Liquefied Biomethane - Bio-LNG
Renewable Natural Gas - RNG
Sustainable Development Goals -SDGs
Variable Renewable Energy - VRE

1. INTRODUCTION

The global energy sector is undergoing a profound transformation in response to the escalating climate crisis (Salim et al., 2025). With over 70 countries committing to net-zero greenhouse gas (GHG) emissions by mid-century, the need for scalable, sustainable, and low-carbon energy alternatives has never been more urgent. Biomethane, which is a renewable form of methane produced from organic waste has emerged as a promising solution. Unlike fossil natural gas, biomethane is carbon-neutral over its lifecycle and can be integrated into existing gas infrastructure, making it a strategic asset in the global decarbonization toolkit (Robalo-Cabrera et al., 2025). The global energy sector stands at a critical crossroads as nations intensify efforts to achieve net-zero emissions by mid-century. Rapid industrialization, urban expansion, and the continued reliance on fossil fuels have led to unprecedented greenhouse gas (GHG) concentrations, accelerating climate change and threatening ecological stability, food systems, and public health. In response, the international community—guided by frameworks such as the Paris Agreement and the United Nations Sustainable Development Goals (SDGs)—is pursuing a transition toward low-carbon and renewable energy systems. Among the emerging solutions, biomethane has gained significant attention as a scalable, carbon-neutral, and versatile energy carrier capable of replacing natural gas across multiple sectors (Lin et al., 2024). Biomethane, a purified and upgraded form of biogas, is produced through anaerobic digestion or thermal gasification of organic wastes including agricultural residues, livestock manure, municipal solid waste, and wastewater sludge. Because its lifecycle emissions are substantially lower than those of fossil methane, biomethane offers a dual climate benefit: it displaces carbon-intensive fuels while simultaneously capturing methane that would otherwise escape into the atmosphere from unmanaged waste streams. These attributes position biomethane as a strategic tool for decarbonizing hard-to-abate sectors such as transportation, heating, and industrial manufacturing (Noussan et al. 2024).

In recent years, many countries particularly in Europe, North America, and parts of Asia, there are investment in biomethane infrastructure, integrating the fuel into gas grids, upgrading biogas plants into biomethane refineries, and establishing policy mechanisms such as feed-in tariffs, carbon pricing, renewable gas mandates, and green certification schemes. These efforts highlight biomethane's rising importance in energy diversification, rural development, and waste-to-energy circular economy models. Furthermore, advances in digital monitoring, digestate valorization, and supply-chain optimization are improving the efficiency, cost-effectiveness, and sustainability of biomethane production. Despite its promise, challenges persist. These include technological limitations, high initial investment costs, policy inconsistencies across regions, feedstock supply issues, and competition with other renewable energy carriers such as green hydrogen. Addressing these constraints will determine the extent to which biomethane can contribute to global decarbonization pathways.

This paper explores the role of biomethane in achieving net-zero emissions in the global energy sector. It examines its production technologies, environmental benefits, market readiness, integration potential, policy frameworks, and prospects. Through a comprehensive analysis, the study highlights how biomethane can serve as a bridge fuel and long-term renewable energy solution in the transition to a climate-neutral world.

2. Biomethane: Definition and Production Pathways

Biomethane is a renewable, high-purity form of methane derived from organic resources and upgraded to meet the quality specifications of conventional natural gas. It is produced by purifying biogas which is generated through anaerobic digestion or thermal gasification to remove carbon dioxide (CO_2), hydrogen sulfide (H_2S), moisture, siloxanes, and other trace contaminants (Pawłowska et al., 2025). The resulting biomethane typically contains 95–99% methane, making it suitable for injection into existing natural gas grids, use as a compressed or liquefied vehicle fuel, or application in industrial and residential heating systems (Reda et al. 2025). As a drop-in substitute for fossil natural gas, biomethane plays a crucial role in decarbonizing waste management, agriculture, transportation, and energy-intensive sectors.

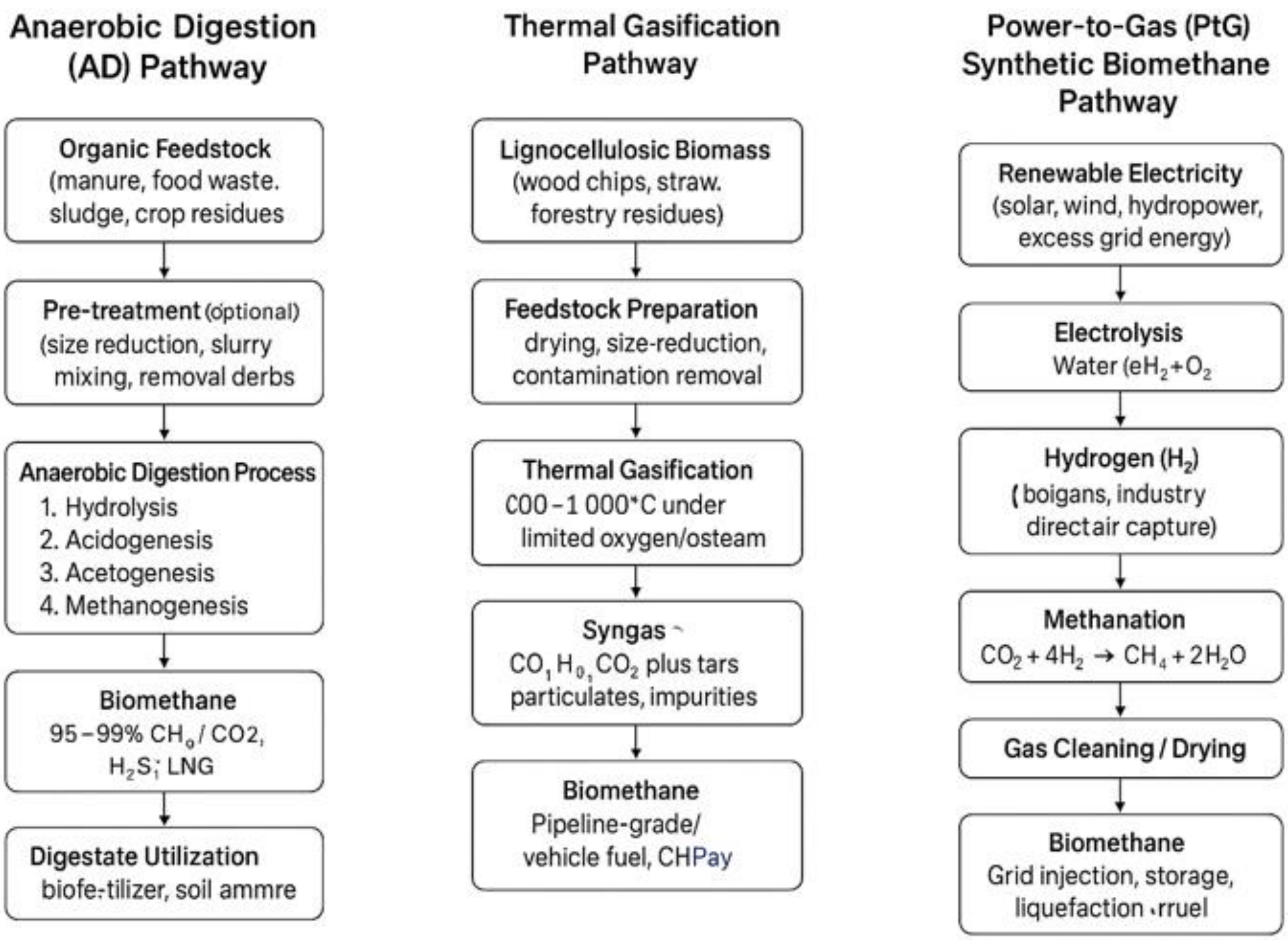

Figure 1: Biomethane production pathways.

2.1 Anaerobic Digestion (AD)

Anaerobic digestion is the most established and widely adopted pathway for biomethane production. It relies on a consortium of microorganisms that decompose biodegradable organic matter in the absence of oxygen. Common feedstocks include livestock manure, agricultural residues, municipal solid waste, wastewater sludge, and food waste. (Sravan et al., 2026)

The AD process occurs in four biochemical stages:

- **Hydrolysis** – complex polymers are broken down into soluble compounds.
- **Acidogenesis** – fermentation produces volatile fatty acids and gases.
- **Acetogenesis** – intermediates are converted into acetate, CO_2, and hydrogen.
- **Methanogenesis** – methanogenic archaea generate methane and CO_2.

The raw biogas produced typically contains 50–70% methane. It is upgraded using technologies such as water scrubbing, membrane separation, chemical absorption, or pressure swing adsorption, yielding biomethane of pipeline quality. AD offers substantial environmental benefits, including methane capture, nutrient recycling via digestate, and reduction of organic waste in landfills (Suleski et al 2022).

2.2 Thermal Gasification

Thermal gasification is a more technologically complex pathway that enables the conversion of lignocellulosic biomass such as wood chips, crop residues, and forestry waste into a combustible gas mixture known as synthesis gas (syngas). The process involves heating biomass to high temperatures (700–1,000°C) under controlled amounts of oxygen or steam (Santana et al., 2025).

The syngas produced (mainly CO, H_2, and CO_2) undergoes a methanation step, typically catalyzed by nickel-based catalysts, to convert the gas mixture into methane and water vapor. Thermal gasification is particularly advantageous because it utilizes feedstocks unsuitable for anaerobic digestion, thereby expanding the resource base for biomethane production. Although still emerging at commercial scale, it offers high energy efficiency, flexible feedstock compatibility, and potential integration with carbon capture systems (Josh et al., 2024).

2.3 Power-to-Gas (PtG) Integration

Power-to-Gas is an innovative and rapidly advancing technology that links the electricity and gas sectors (Angelico et al., 2025). It converts surplus renewable electricity often from intermittent sources like solar and wind into hydrogen through electrolysis. The hydrogen is then combined with captured CO_2 in a methanation reactor to produce synthetic biomethane, also known as renewable methane (Reda et al., 2025; Sravan et al., 2026). PtG offers several strategic advantages such as seasonal energy storage, and mitigating fluctuations in renewable power generation. There is grid balancing which enables better integration of variable renewable energy (Calise et al., 2023). The circular carbon use, as the CO_2 required can be sourced from biogas plants, industrial emissions, or direct air capture (Ozturk and DIncer 2021). Although currently limited by high capital costs and energy conversion inefficiencies, PtG represents a promising pathway for future large-scale biomethane production, particularly in regions aiming for deep decarbonization and sector coupling (Gotz et al. 2016).

3.0 Environmental and Climate Benefits

Biomethane provides substantial environmental advantages that position it as a key component of global decarbonization strategies. Its lifecycle offers multiple pathways for climate mitigation, resource efficiency, and reduced environmental footprints across waste, agriculture, and energy systems (Sravan et al.. 2026). The carbon flow is presented in Figure 2.

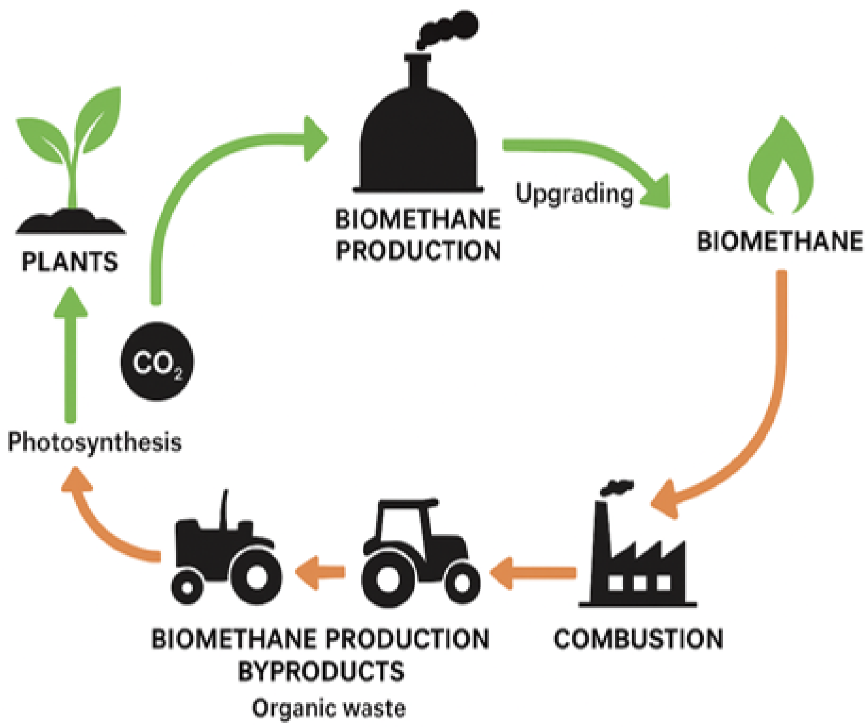

Figure 2: Carbon flow in biomethane systems

3.1 Reduction of Greenhouse Gas (GHG) Emissions

One of the most significant environmental benefits of biomethane is its ability to dramatically reduce GHG emissions (Alengebawy et al., 2024). By capturing methane from organic waste streams—such as manure, food waste, and wastewater sludge—biomethane projects prevent the release of methane into the atmosphere, where it is more than 25 times more potent than CO_2 over a 100-year timeframe (Pratson et al., 2023).

- **Avoided emissions:** Methane that would have escaped from landfills, open lagoons, and agricultural waste is instead collected and converted into usable energy.
- **Displacement of fossil fuels:** Biomethane replaces carbon-intensive natural gas, diesel, and fuel oil in industry, transport, and heating.

Combined, these impacts result in some of the lowest net carbon footprints among all renewable fuels, with several pathways achieving net-negative emissions.

3.2 Carbon Neutrality and Closed-Loop Carbon Cycling

Biomethane is considered a carbon-neutral energy carrier because the CO_2 released during its combustion is biogenic (Francisco Lopez et al., 2024). It originates from recently living biomass rather than fossil carbon deposits (Jameel et al., 2023).

- **Short-term carbon cycle:** The carbon absorbed by plants through photosynthesis is returned to the atmosphere through biomethane combustion, creating a closed loop.

- **No net increase:** Unlike fossil fuels, biomethane does not introduce ancient carbon into the atmosphere, thus avoiding long-term accumulation of CO_2.

When combined with carbon capture systems or digestate management, biomethane systems can even achieve carbon-negative performance.

3.3 Waste Valorization and Circular Economy Integration

Biomethane production supports circular economy principles by transforming organic waste into multiple high-value products (Salim et al., 2025).

- **Energy production:** Organic waste streams are converted into renewable biomethane.
- **Nutrient recycling:** The digestate from anaerobic digestion is rich in nitrogen, phosphorus, and potassium, serving as an organic fertilizer or soil amendment.
- **Reduced landfill pressure:** Organic waste diversion decreases landfill volumes, leachate formation, and methane emissions.
- **Cleaner urban and rural environments:** Waste-to-energy systems improve sanitation, especially in regions with inadequate waste management infrastructure.

Overall, biomethane contributes to resource recovery, waste minimization, and sustainable agriculture.

4.0 Sectoral Applications of Biomethane

Biomethane, as a high-purity renewable gas, is a versatile energy carrier that can be deployed across multiple sectors traditionally dominated by fossil natural gas (Mignonga et al., 2023). Its chemical equivalence to conventional natural gas enables seamless integration into existing energy infrastructure—pipelines, storage systems, power plants, and industrial equipment—while contributing significantly to greenhouse gas emission reduction and circular economy objectives (Sravan et al., 2026). The key sectors where biomethane in power generation, transportation and Heating and industrial uses are illustrated in Figure 3.

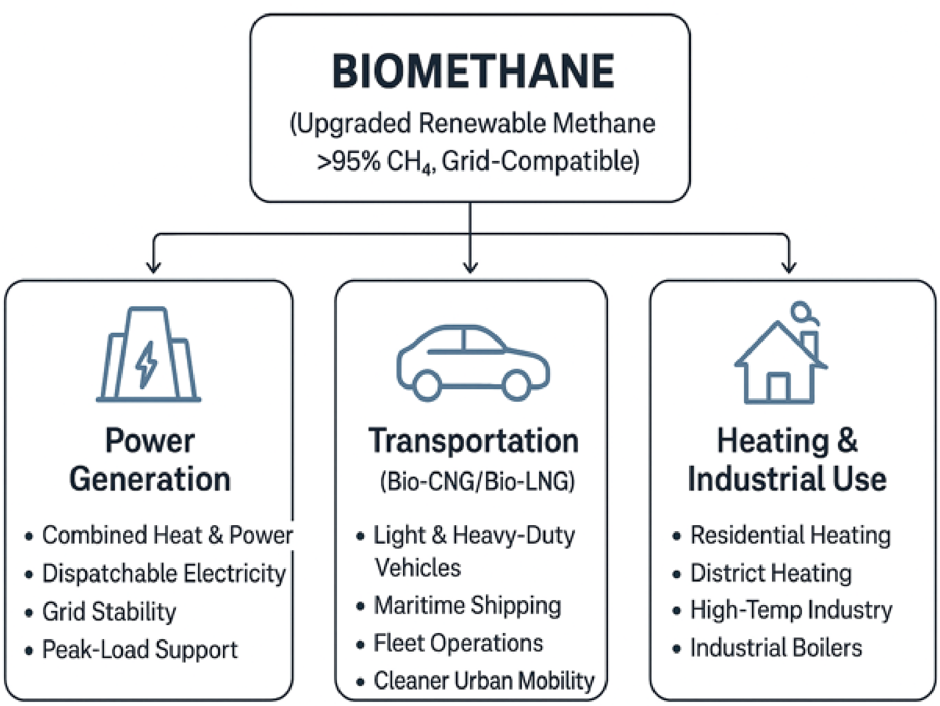

Figure 3: Overview of some uses of biomethane

4.1 Power Generation

Biomethane is a valuable resource for renewable power generation due to its high methane content (typically >95%) and compatibility with established gas-fired generation technologies (Lanni et al., 2023). Some key applications in power generation are:

- **Combined Heat and Power (CHP):** Biomethane fuels CHP systems that simultaneously generate electricity and useful heat. This co-generation approach boosts overall energy efficiency to as high as 80–90%.
- **Grid Stability and Dispatchability**: Unlike intermittent renewables such as solar and wind, biomethane-powered engines can deliver *dispatchable* electricity. This makes biomethane an essential component in balancing variable renewable energy (VRE) sources and enhancing energy security.
- **Peak Shaving and Backup Power**: Power plants fueled by biomethane can support grid operations during peak demand periods or serve as backup generation in remote or emergency settings.

Some of the benefits of power generation are significant reduction in lifecycle greenhouse gas emissions, improved reliability of renewable-dominated electricity systems and utilization of existing natural gas power infrastructure with minimal modification (Francisco Lopez et al., 2024).

4.2 Transportation

Transportation is one of the most promising sectors for biomethane deployment, especially where electrification remains technically challenging, such as heavy-duty, long-haul, and maritime transportation (Lin et al., 2024). Some of the forms of use are in form of Compressed Biomethane (Bio-CNG) which is used in light-duty vehicles, small trucks, buses, and urban fleets and Liquefied Biomethane (Bio-LNG) which is suited for heavy-duty trucks, long-distance haulage, and increasingly in ships due to its high energy density (Pääkkönen et al., 2019; Noussan et al., 2024).

4.2.1 Advantages in Transportation

- **Low-Emission Performance:** Vehicles running on biomethane can achieve 70–120% lower GHG emissions on a lifecycle basis, particularly when derived from waste (due to avoided methane emissions).
- **Air Quality Improvement:** Biomethane combustion emits substantially lower NOx, SOx, and particulate matter compared to diesel.
- **Cost Efficiency:** Operational costs are competitive with diesel, while maintenance costs are generally lower due to cleaner combustion.

There is growing global use in European countries (Sweden, Germany, Italy) and parts of Asia and are rapidly expanding biomethane fueling networks. Bio-LNG is becoming a key marine fuel as the shipping industry transitions toward low-carbon solutions.

4.3 Heating and Industrial Use

Biomethane offers substantial decarbonization potential for heating and industrial energy applications, particularly in gas-dependent regions.

4.3.1 Residential and Commercial Heating:

Biomethane can directly replace fossil natural gas in household boilers, district heating networks, and commercial heating systems. It supports rapid decarbonization without requiring replacement of existing heating appliances (Robalo-Cabrera et al., 2025).

4.3.2 Industrial Processes:

Many industrial sectors rely on high-temperature heat not easily electrified. Biomethane offers a renewable substitute in production of cement and ceramics, manufacturing of food and beverage, processing of metal and glass, and chemical and petrochemical industries (Sinigaglia et al., 2022). Biomethane's consistent combustion characteristics make it suitable for stable, high-temperature industrial operations (Carvalho et al., 2023).

4.3.3 Additional Applications

If can be used as feedstock for green chemicals and hydrogen production, and renewable gas for combined industrial CHP plants (Yuxia et al., 2020). Some of the benefits are observed in the sharp reduction in carbon intensity of heating and industrial operations.

- Immediate compatibility with pipelines and burner technologies.
- Enables progressive greening of gas grids without infrastructure overhaul.

5. Economic and Policy Considerations

5.1 Cost Competitiveness

Although biomethane currently remains more expensive than conventional fossil natural gas, the cost gap is gradually narrowing (Mignonga et al., 2024; Pawlowska et al., 2025). This shift is driven by:

- The advances in anaerobic digestion and upgrading technologies, which reduce operational and capital costs.
- The economies of scale, as more medium- to large-scale plants are established.
- The optimized feedstock management, including agricultural residues, municipal solid waste, and industrial organics, which lower feedstock costs.
- Grid integration and improved distribution infrastructure, which reduce bottlenecks and transportation expenses.

In the long term, biomethane's cost competitiveness improves significantly when considering avoided environmental costs, carbon reduction benefits, and co-benefits, such as waste management and rural job creation (Guerron et al., 2024).

5.2 Policy Instruments

A strong and coherent policy framework are vital for accelerating biomethane deployment (Herbes et al., 2021). The key instruments include:

- Feed-in Tariffs (FiTs) and Production Subsidies which offers guaranteed pricing for biomethane injected into gas grids or used for electricity generation, providing revenue certainty for investors (McKendry 2019).
- **Renewable Gas Quotas and Mandates** - Governments may require gas suppliers to include a specific percentage of renewable gas including biomethane in their portfolios, driving consistent demand.
- **Carbon Pricing and Emissions Trading Schemes (ETS)** - By assigning a monetary value to emissions, carbon markets make biomethane increasingly competitive compared to fossil alternatives.
- **Fiscal Incentives and Tax Credits** - These support capital investments in upgrading technologies, digesters, and storage systems.
- **Investment in Research and Development, Innovation, and Infrastructure -** Funding for technology development and pipeline upgrades enhances efficiency, safety, and market integration (Furszyfer Del Rio et al., 2022).

Overall, well-designed policies reduce investment risks, stimulate private-sector participation, and ensure long-term market stability.

5.3 Market Development

Globally, biomethane markets are expanding, though at varying paces. In Europe, the continent remain the global leader in biomethane production and grid injection (Sulewski et al. 2022). Countries such as Germany, France, Denmark, and the Netherlands have set aggressive targets for renewable gas integration. Robust policy incentives, strong climate commitments, and advanced infrastructure support rapid market growth (Yuxia et al., 2020). In North America, the United States and Canada are emerging as major players, driven by Renewable Natural Gas (RNG) programs, low-carbon fuel standards, and investments from the waste and agricultural sectors. Biomethane is increasingly used in transportation, especially for heavy-duty fleets (Lawson et al., 2021). In Asia, Countries like Japan, South Korea, China, and India are scaling biomethane projects as part of broader efforts to enhance energy security, manage organic waste, and reduce dependence on imported fossil fuels (Huang et al., 2024). The global trend indicates that biomethane will play a significant role in decarbonizing hard-to-abate sectors, supporting circular economy initiatives, and enhancing national energy resilience (Salim et al., 2025).

6. CONCLUSION

The use of Biomethane falls in line with the sustainable, circular and resilient energy approach. When organic waste streams are transformed into clean, renewable energy, multiple challenges are addressed simultaneously such as mitigation of greenhouse gas emissions, reducing the reliance on fossil fuels, and promoting efficient use of resources. The deployment of biomethane within the current energy network is quite easy as it is compactible with existing natural gas infrastructures such as pipelines and storage systems.

Beyond the benefits it offers to the environment, biomethane can support the growth of the economy through the creation of new jobs and markets in feedstock collection, biogas upgrading, and distribution. It also strengthens energy security by diversifying energy sources and reducing the dependence on fossil fuels that are imported. The full potential of biomethane depends on an approach that is synergetic and can combine advanced technological development, policy frameworks that are robust, and targeted investment. To scale production and ensure sustainable supply of feedstock, incentives, standards, and infrastructure planning are very essential. Ultimately, biomethane represents a transformative opportunity for the energy sector. By valorizing waste and enabling low-carbon energy solutions, it contributes directly to global net-zero ambitions, circular economy objectives, and climate resilience. With coordinated action, biomethane can become a cornerstone of a decarbonized and sustainable energy landscape.

Conflicting Interests

The authors state that no conflict of interest exists.

Authors' contributions

All authors were involved in the conceptualization, arrangement, the proofreading and approved the manuscript before submission.

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REFERENCES

Alengebawy, A., Ran, Y., Osman, A.I. *et al.* Anaerobic digestion of agricultural waste for biogas production and sustainable bioenergy recovery: a review. *Environ Chem Lett* **22**, 2641–2668 (2024). https://doi.org/10.1007/s10311-024-01789-1

Angelico, R., Giametta, F., Bianchi, B., & Catalano, P. (2025). Green Hydrogen for Energy Transition: A Critical Perspective. *Energies*, *18*(2), 404. https://doi.org/10.3390/en18020404

Carvalho, F. S. d., Reis, L. C. B. d. S., Lacava, P. T., Araújo, F. H. M. d., & Carvalho Jr., J. A. d. (2023). Substitution of Natural Gas by Biomethane: Operational Aspects in Industrial Equipment. *Energies*, *16*(2), 839. https://doi.org/10.3390/en16020839

Guerron, G.; Nicolalde, J.F.; Martínez-Góme, J.; Dávila, P.; Velásquez, C. Experimental analysis of a pilot plant in Organic Rankine Cycle configuration with regenerator and thermal energy storage (TES-RORC). *Energy* **2024**, *308*, 132964.

Francisco López, A., Lago Rodríguez, T., Faraji Abdolmaleki, S., Galera Martínez, M., & Bello Bugallo, P. M. (2024). From Biogas to Biomethane: An In-Depth Review of Upgrading Technologies That Enhance Sustainability and Reduce Greenhouse Gas Emissions. *Applied Sciences*, *14*(6), 2342. https://doi.org/10.3390/app14062342

Furszyfer Del Rio, D. D., Sovacool, B. K., Foley, A. M., Griffiths, S., Bazilian, M., Kim, J., & Rooney, D. (2022). Decarbonizing the ceramics industry: A systematic and critical review of policy options, developments and sociotechnical systems. *Renewable and Sustainable Energy Reviews*, *157*, 112081. https://doi.org/10.1016/j.rser.2022.112081

Herbes, C., Rilling, B., & Ringel, M. (2021). Policy frameworks and voluntary markets for biomethane – How do different policies influence providers' product strategies? *Energy Policy*, *153*, 112292. https://doi.org/10.1016/j.enpol.2021.112292

Huang, X. (2024). The Promotion of Anaerobic Digestion Technology Upgrades in Waste Stream Treatment Plants for Circular Economy in the Context of "Dual Carbon": Global Status, Development Trend, and Future Challenges. *Water*, *16*(24), 3718. https://doi.org/10.3390/w16243718

Jameel, M. K., Mustafa, M. A., Ahmed, H. S., Mohammed, A. J., Ghazy, H., Shakir, M. N., Lawas, A. M., Mohammed, S. K., Idan, A. H., Mahmoud, Z. H., Sayadi, H., & Kianfar, E. (2023). Biogas: Production, properties, applications, economic and challenges: A review. *Results in Chemistry*, *7*, 101549. https://doi.org/10.1016/j.rechem.2024.101549

Joshi NC, Sinha S, Bhatnagar P, Nath Y, Negi B, Kumar V, Gururani P. A concise review on waste biomass valorization through thermochemical conversion. Curr Res Microb Sci. 2024 Apr 23;6:100237. doi: 10.1016/j.crmicr.2024.100237. PMID: 38706494; PMCID: PMC11067365.

Lanni, D., Minutillo, M., Cigolotti, V., & Perna, A. (2023). Biomethane production through the power to gas concept: A strategy for increasing the renewable sources exploitation and promoting the green energy transition. *Energy Conversion and Management*, *293*, 117538. https://doi.org/10.1016/j.enconman.2023.117538

Lawson, N.; Alvarado-Morales, M.; Tsapekos, P.; Angelidaki, I. Techno-Economic Assessment of Biological Biogas Upgrading Based on Danish Biogas Plants. *Energies* **2021**, *14*, 8252.

Lin, H., Black, M. J., Lin, O., Minter, T., & Borrion, A. (2024). Biogas utilisation – Life cycle assessment of enabling technology for transport biomethane - UK case study, Bore Hill farm Biodigester. *Biomass and Bioenergy*, *190*, 107402. https://doi.org/10.1016/j.biombioe.2024.107402

McKendry, P. Overview of Anaerobic Digestion and Power and Gas to Grid Plant CAPEX and OPEX Costs Citation: McKendry P (2019) Overview of Anaerobic Digestion and Power and Gas to Grid Plant CAPEX and OPEX Costs. *Int. J. Bioprocess. Biotech. Rev. Artic. McKendry P. Int. J. Bioprocess. Biotech* **2018**, *2*, 109

Mignogna, D., Ceci, P., Cafaro, C., Corazzi, G., & Avino, P. (2023). Production of Biogas and Biomethane as Renewable Energy Sources: A Review. *Applied Sciences*, *13*(18), 10219. https://doi.org/10.3390/app131810219

Noussan, M., Negro, V., Prussi, M., & Chiaramonti, D. (2024). The potential role of biomethane for the decarbonization of transport: An analysis of 2030 scenarios in Italy. *Applied Energy*, *355*, 122322. https://doi.org/10.1016/j.apenergy.2023.122322

Pääkkönen, A., Aro, K., Aalto, P., Konttinen, J., & Kojo, M. (2019). The Potential of Biomethane in Replacing Fossil Fuels in Heavy Transport—A Case Study on Finland. *Sustainability*, *11*(17), 4750. https://doi.org/10.3390/su11174750

Pawłowska, M., Zdeb, M., Bis, M., & Pawłowski, L. (2025). State and Perspectives of Biomethane Production and Use—A Systematic Review. *Energies*, *18*(10), 2660. https://doi.org/10.3390/en18102660

Pratson LF, Fay J, Parvathikar S (2023) Market prospects for biogas-to-energy projects in the U.S.A. based on a techno-economic assessment of major biogas sources in North Carolina. Sustain

Energy Technol Assessments 60:103557. https://doi.org/10.1016/j.seta.2023.103557

Reda, B., Elzamar, A.A., AlFazzani, S. *et al.* Green hydrogen as a source of renewable energy: a step towards sustainability, an overview. *Environ Dev Sustain* **27**, 29213–29233 (2025). https://doi.org/10.1007/s10668-024-04892-z

Robalo-Cabrera, I., Alcayde, A., Filgueira-Vizoso, A., Castro-Santos, L., García-Diez, A., & Manzano-Agugliaro, F. (2025). Shipping sector decarbonisation measures: A review. *Sustainable Energy Technologies and Assessments*, *82*, 104549. https://doi.org/10.1016/j.seta.2025.104549

Salim, S. S., Luxembourg, S. L., Smekens, K., Dalla Longa, F., & Van der Zwaan, B. (2025). Pathways to climate neutrality: Europe's energy transition under the Green Deal. *Renewable and Sustainable Energy Reviews*, *226*, 116272. https://doi.org/10.1016/j.rser.2025.116272

Santana, H. E. P., Jesus, M., Santos, J., Rodrigues, A. C., Pires, P., Ruzene, D. S., Silva, I. P., & Silva, D. P. (2025). Lignocellulosic Biomass Gasification: Perspectives, Challenges, and Methods for Tar Elimination. *Sustainability*, *17*(5), 1888. https://doi.org/10.3390/su17051888.

Sravan, J. S., Sahota, S., Sarkar, O., Reddy, M. V., Mohan, S. V., & Chang, Y. (2026). Technology advancements in future waste biorefineries: Focus on low carbon fuels and renewable chemicals. *Fuel*, *404*, 136184. https://doi.org/10.1016/j.fuel.2025.136184

Sinigaglia, T.; Evaldo Freitag, T.; Machado, A.; Pedrozo, V.B.; Rovai, F.F.; Gondim Guilherme, R.T.; Metzka Lanzanova, T.D.; Dalla Nora, M.; Santos Martins, M.E. Current Scenario and Outlook for Biogas and Natural Gas Businesses in the Mobility Sector in Brazil. *Int. J. Hydrogen Energy* **2022**, *47*, 12074–12095.

Sulewski, P., Ignaciuk, W., Szymańska, M., & Wąs, A. (2022). Development of the Biomethane Market in Europe. *Energies*, *16*(4), 2001. https://doi.org/10.3390/en16042001

Yuxia, Y.; Ryssel, M.; Scholwin, F.; Grope, J.; Clinkscales, A.; Bowe, S. (2020). *Biomethane Production and Grid Injection: German Experiences, Policies, Business Models and Standards*; National Energy Administration: Beijing, China; Berlin, Germany, 2020. Available online: https://www.energypartnership.cn/fileadmin/user_upload/china/media_elements/publications/Biomethane_German_Experience_Study_EN_Final.pdf

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