Chapter 18

Opportunities and Challenges of Integrating Methanization and Biogas Technologies Into the Green Hydrogen Economy

Soukaina Agoud
https://orcid.org/0009-0009-8848-4719
Mohammed V University in Rabat, Morocco

Driss Azdem
Mohammed V University in Rabat, Morocco

Hajar Khabouche
https://orcid.org/0009-0003-4466-5784
Mohammed V University in Rabat, Morocco

Khadija Elmoustaqim
https://orcid.org/0009-0007-9193-6638
Ibn Tofail University, Morocco

Jamal Mabrouki
https://orcid.org/0000-0002-3841-7755
Mohammed V University in Rabat, Morocco

Miloudia Slaoui
Mohammed V University in Rabat, Morocco

ABSTRACT

The transition to a green hydrogen economy offers a path toward sustainable energy but faces challenges in production efficiency and cost. This chapter explores integrating methanization and biogas technologies within the green hydrogen landscape, focusing on synergies and obstacles. Methanization, which converts organic waste into methane-rich biogas, could supplement hydrogen production via methods like steam methane reforming and methane pyrolysis. The chapter examines pathways for using biogas-derived methane in hydrogen production, highlighting opportunities to enhance yield and reduce reliance on fossil fuels. It also discusses economic implications, policy frameworks, and offers strategic recommendations for advancing the green hydrogen economy and supporting the global energy transition.

1. INTRODUCTION

The green hydrogen economy is increasingly recognized as a key solution to reducing carbon emissions and fostering global energy sustainability. Green hydrogen, produced using renewable energy sources, is essential for decarbonizing sectors such as transportation, industry, and power generation

DOI: 10.4018/979-8-3693-8980-5.ch018

(Emetere et al., 2024). However, its large-scale implementation faces significant challenges, particularly in terms of production costs, efficiency, and scalability. Emerging research suggests that integrating methanization and biogas technologies into hydrogen production could enhance the feasibility of green hydrogen, providing a sustainable, low-carbon solution to these challenges (Basso et al., 2023). Methanization, the anaerobic digestion of organic waste to produce methane-rich biogas, offers a circular economy approach to hydrogen production. This biogas can be upgraded into biomethane and converted into hydrogen through various methods, such as steam methane reforming (SMR) or methane pyrolysis (Ongis et al., 2023). These processes offer an opportunity to utilize organic waste to supplement hydrogen production, reducing dependency on fossil fuels and lowering carbon emissions. While the integration of methanization and biogas technologies into the hydrogen economy presents promising synergies, it also poses several technical, economic, and policy-related challenges that must be addressed to unlock its full potential (Giocoli et al., 2023). Green hydrogen, produced from water electrolysis powered by renewable energy sources, is considered one of the cleanest forms of hydrogen. It has the potential to decarbonize industries that are difficult to electrify, such as steel production and aviation (Nemmour et al., 2023). However, as of 2024, the cost of green hydrogen production remains significantly higher than hydrogen produced using fossil fuels, primarily due to the high costs associated with renewable energy and electrolysis technology. For instance, the cost of producing green hydrogen can be 2-3 times that of grey hydrogen, which is derived from natural gas (Elhaus et al., 2024). As a result, there is a pressing need to explore alternative methods, such as biogas integration, to make green hydrogen more cost-competitive and scalable. Methanization involves the biological decomposition of organic matter, such as agricultural waste, food waste, and sewage sludge, into biogas (Bertasini et al., 2023). This biogas, composed primarily of methane (CH_4) and carbon dioxide (CO_2), can be upgraded to biomethane, which is chemically identical to natural gas. Biomethane can then be used in SMR or methane pyrolysis to produce hydrogen (Murphy et al., 2024). SMR is a widely used process that reacts methane with steam to produce hydrogen and CO_2. Methane pyrolysis, on the other hand, generates hydrogen and solid carbon, providing a carbon-neutral pathway for hydrogen production. These methods offer a sustainable way to generate hydrogen, especially when the methane is derived from biogenic sources. Despite the technical feasibility of producing hydrogen from biogas, several challenges persist (Lanni et al., 2023). The efficiency of methane conversion technologies, the need for carbon capture and storage (CCS) to mitigate CO_2 emissions in SMR, and the economic viability of biogas-to-hydrogen systems remain significant obstacles. Moreover, the development of robust policy frameworks is crucial to incentivizing investments in biogas technologies and integrating them into the hydrogen economy (Ahmad et al., 2024). Techno-economic assessments highlight that while the initial costs of biogas-to-hydrogen technologies are high, they present long-term cost savings through the reduction of waste disposal fees, production of biofertilizers, and the creation of additional revenue streams. Furthermore, supportive policies, such as renewable energy credits and subsidies for biogas infrastructure, can make these technologies more attractive to investors. As governments worldwide, including the European Union and the United States, continue to push for renewable energy adoption, the integration of methanization and biogas technologies is expected to gain traction in the coming years.