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STRUCTURING BIOMETHANE VALUE CHAINS AS SOCIO-TECHNICAL SYSTEMS: IDENTIFYING GOVERNANCE-RELATED CRITICAL POINTS

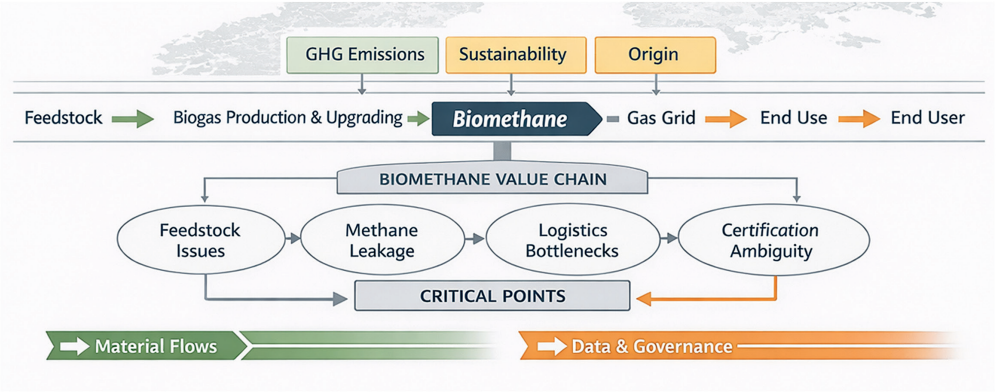
Marta OZOLA[1*], Vladimirs KIRSANOVS[2], Zane KUŠNERE[3]

[1–3] *Institute of Energy Systems and Environment, Riga Technical University, Azenes iela 12/1, Riga, LV-1048, Latvia*

[*] ***Corresponding author.*** *Email address: marta.ozola.lv@gmail.com*

Abstract – Biomethane is increasingly recognised as a key renewable energy vector in sectors where direct electrification remains technically or economically constrained. Despite technological maturity of anaerobic digestion and upgrading processes, large-scale deployment of biomethane infrastructure often encounters systemic barriers that arise beyond conversion technologies. These challenges emerge across multiple stages of the value chain, including feedstock mobilisation, logistics and scaling, lifecycle greenhouse gas (GHG) accounting, methane emission control, and post-grid-injection verification of sustainability and origin. Such factors influence not only environmental performance, but also institutional credibility and economic feasibility of biomethane projects. This study presents a systematic literature-based conceptualisation of the biomethane value chain extending from feedstock sourcing to final energy use. The research frames the value chain as a socio-technical system in which material flows are accompanied by parallel informational and governance processes related to certification, traceability, and regulatory compliance. Within this framework, the study aims to identify critical control points where interactions between physical production processes and data-driven sustainability requirements affect project viability and market access. The initial analytical application of this framework will focus on the Baltic region, reflecting regional resource availability, infrastructure conditions, and emerging policy implementation practices relevant to biomethane deployment. Particular attention is given to post-grid-injection stages, where biomethane becomes physically indistinguishable from fossil gas and its environmental attributes are allocated through certificate-based mechanisms. In such contexts, interactions between sustainability certification schemes and Guarantees of Origin (GO) systems may introduce ambiguities in attribute ownership and transfer logic, potentially affecting the consistency of environmental claims. By structuring biomethane value chains as integrated socio-technical systems, the study contributes to the development of an analytical foundation for subsequent environmental, economic, and multi-criteria evaluation of biomethane deployment at the municipal level.

Keywords – Baltic region; biomethane value chain; chain of custody; energy governance; Guarantees of Origin (GO); Proof of Sustainability (PoS); socio-technical systems; sustainability certification; value chain assessment



Conceptual Structure of the Biomethane Value Chain as a Socio-Technical System