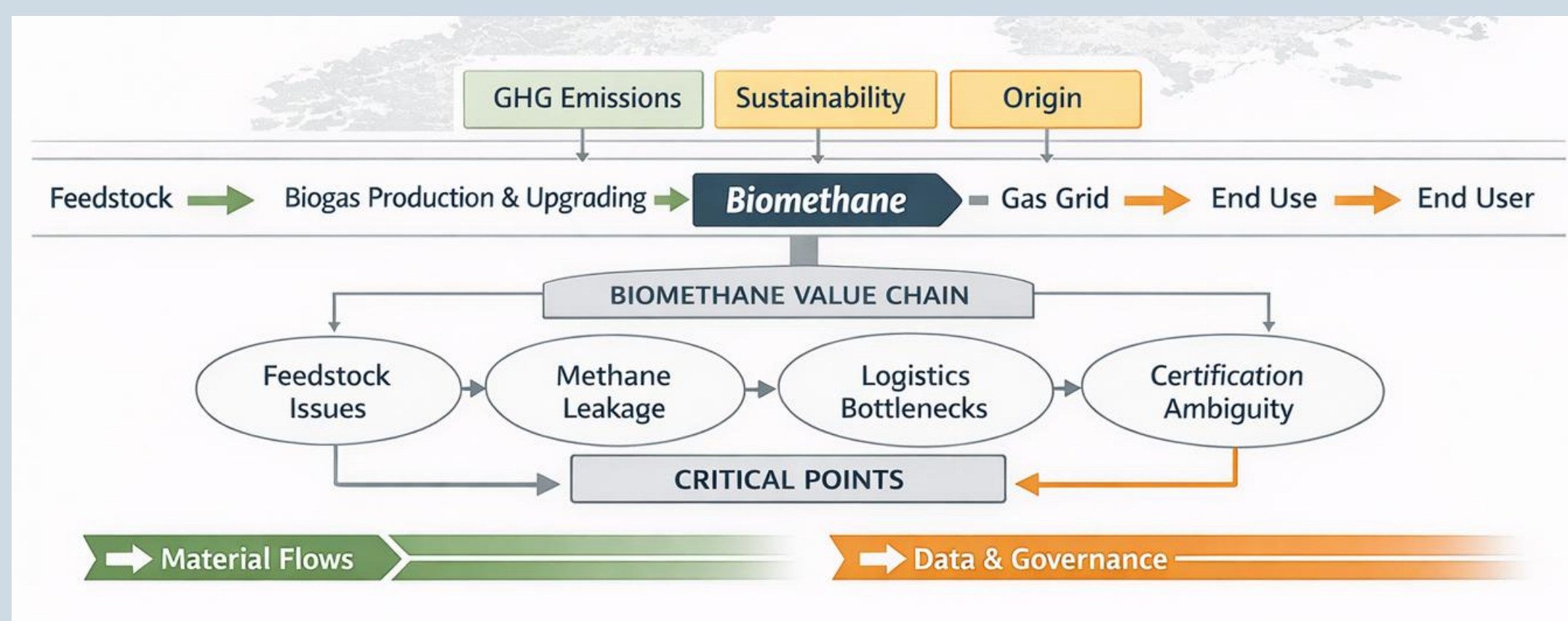


Identifying Governance-Related Critical points



The study develops a structured conceptualisation of the biomethane value chain as a socio-technical system, integrating material, informational, and governance dimensions. A key outcome is the identification of governance-related critical points, particularly at interfaces between physical processes and data-driven sustainability requirements. The research highlights post-grid-injection stages as a key area of uncertainty, where biomethane attributes are detached from physical flows and managed through certificate-based mechanisms, creating potential inconsistencies in attribution. The framework provides a basis for further quantitative assessment and supports the integration of environmental, economic, and institutional factors in project evaluation, contributing to improved decision-making in emerging biomethane markets, particularly in the Baltic region.

Introduction

Biomethane is increasingly recognised as a key renewable energy carrier for decarbonising sectors where electrification remains limited. Despite advances in production and upgrading technologies, large-scale deployment is often constrained by challenges across the value chain, including feedstock mobilisation, logistics, greenhouse gas (GHG) accounting, and post-grid-injection sustainability verification.

Existing research typically addresses these aspects separately, with limited integration of technological, environmental, and governance dimensions. This gap is particularly evident in post-grid-injection contexts, where biomethane attributes are detached from physical gas flows and managed through certification systems.

This study addresses this gap by developing a conceptual framework that analyses the biomethane value chain as a socio-technical system and identifies governance-related critical points affecting project feasibility and market credibility.

Challenges

Feedstock variability – Inconsistent availability and quality of biomass affects system stability and project feasibility.

Methane leakage & GHG accounting – Emission losses and uncertainties in measurement impact the accuracy of sustainability assessments.

Logistics bottlenecks – Transport distances, infrastructure limitations, and scaling challenges increase costs and complexity.

Certification, verification & attribution ambiguity – Post-grid-injection systems may create uncertainty in sustainability verification and attribute allocation

Methodology

The study applies a literature-based approach to conceptualise the biomethane value chain as a socio-technical system. Scientific publications and regulatory frameworks are analysed to map material, informational, and governance processes. Based on this, critical control points are identified, with a focus on post-grid-injection stages where certificate-based attribute management may create inconsistencies.

Results and conclusions

The study develops a conceptual framework of the biomethane value chain as a socio-technical system, integrating material flows with governance and data processes. A key outcome is the identification of governance-related critical points, particularly at interfaces between physical production processes and certification mechanisms. Post-grid-injection stages are identified as a major source of uncertainty, where biomethane attributes are decoupled from physical gas flows and managed through certificate-based systems, leading to potential inconsistencies in certification, verification, and attribute allocation.

The findings indicate that constraints to biomethane deployment arise primarily from system-level interactions rather than technological limitations. Integrating material and governance dimensions is therefore essential for robust evaluation and informed decision-making. The proposed framework enhances transparency and provides a structured basis for future quantitative analysis and the development of decision-support tools for policy and planning contexts.