

Rebalancing the Energy Trilemma in Biomass Markets: Blockchain-Based Governance for Efficient and Verifiable Sustainability

Volker Wannack

Blockchain Competence Center Mittweida (BCCM), University of Applied Sciences
Mittweida, Mittweida, Germany

Extended Abstract

[Download file](#)

Abstract Summary

Rebalancing the energy trilemma across energy security, sustainability, and affordability remains a central challenge for European energy systems. Biomass markets are particularly affected due to fragmented value chains, heterogeneous certification regimes, and increasing regulatory complexity. These structural characteristics constrain transparency, hinder scalability, and raise coordination costs across cross-border supply networks.

This paper conceptualizes these challenges as a governance problem characterized by elevated transaction costs and limited market transparency. Existing certification and reporting processes rely on manual verification and fragmented data infrastructures, which restrict interoperability and reduce market efficiency. As a result, sustainability claims lack verifiability, coordination across actors remains costly, and compliance efforts increase overall system costs.

To address these limitations, the paper develops a blockchain-based governance approach as a programmable trust infrastructure for biomass markets. The proposed architecture integrates distributed ledger technology, smart contracts, and dynamic metadata to enable tamper-resistant documentation, real-time traceability, and automated compliance verification. It supports standardized data exchange across heterogeneous stakeholders and reduces dependence on intermediary validation.

The core contribution lies in the design of a modular and interoperable system that connects existing certification schemes, data sources, and regulatory frameworks. The approach aligns with emerging European instruments such as Digital Product Passports and sustainability reporting requirements and enables rule-based validation of compliance criteria with improved auditability.

From an economic perspective, the proposed governance model reduces transaction costs and improves market efficiency in biomass supply chains. Initial prototypical

implementations indicate the potential to streamline certification processes, strengthen trust among market participants, and enhance the scalability of sustainability-compliant biomass markets.

The paper demonstrates how blockchain-based governance can function as an enabling coordination mechanism for efficient, transparent, and regulation-compliant energy markets. It provides a transferable framework for addressing coordination and verification challenges in sustainability-critical supply chains.

Presenting Author Biography

Dr. Volker Wannack is an economist specializing in energy, regulatory, and investment economics. He is Head and Coordinator for blockchain and AI applications in the energy sector at the Blockchain Competence Center Mittweida and Managing Partner of BCCM Inkubator GmbH. His work focuses on digital trust infrastructures, market design, and regulatory innovation in energy systems.