Carbon Capture, Transport, and Hubs: Integrating AI for Value Chain Optimization, Business Models, and Policy Incentives

Objective/Scope

Developing carbon capture, transport, and storage hubs is critical for scaling CCUS initiatives and achieving net-zero goals. This study examines value chain integration, business models, and regulatory frameworks that drive CCUS adoption. Additionally, it explores how artificial intelligence (AI) enhances efficiency across the CCUS value chain, from capture optimization to transportation logistics and storage site selection, while assessing policy incentives' role in accelerating deployment.

Methods

This study evaluates the economic and operational dynamics of CCUS value chains, analyzing carbon capture technologies, transport infrastructure, and regional storage hub development. AI applications in CCUS are assessed, focusing on machine learning for real-time monitoring, predictive analytics for transportation efficiency, and AI-driven optimization of business cases. Policy incentives such as carbon pricing, tax credits, and international collaborations are also examined to understand their impact on CCUS hub feasibility. A comparative analysis of global CCUS hubs provides insights into best practices, challenges, and AI-driven solutions for improving cost-effectiveness and regulatory compliance.

Results

Value chain integration plays a pivotal role in making CCUS economically viable. Large-scale CCUS hubs centralize CO_2 capture and storage, reducing costs through shared infrastructure and economies of scale. AI-powered simulations enhance site selection, optimizing pipeline networks for efficient CO_2 transport while minimizing risks. Additionally, AI improves real-time leak detection and predictive maintenance in transport systems, increasing safety and regulatory compliance.

Business models for CCUS hubs depend heavily on policy incentives. Carbon credits, tax incentives, and government funding support large-scale adoption. CCUS hubs have demonstrated financial feasibility in regions with strong regulatory backing, particularly when coupled with enhanced oil recovery (EOR) or CO_2-to-product utilization. However, economic challenges remain, including fluctuating carbon prices and uncertain long-term financial returns. AI-driven financial modeling helps assess investment risks and optimize carbon capture strategies based on regulatory and market conditions.

The study concludes that AI integration in CCUS can significantly enhance value chain efficiency, making carbon capture and storage more accessible and cost-effective. Policy incentives and regulatory frameworks must evolve alongside these technological advancements to ensure the long-term viability and scalability of CCUS hubs.

Novelty

This study provides a unique perspective on integrating AI with CCUS value chains, exploring its role in optimizing carbon capture, transport, and storage hub operations. Unlike previous research, it combines business case analysis, regulatory incentives, and AI-driven process optimization to present a comprehensive roadmap for CCUS scalability. By addressing economic and technological barriers, this work offers actionable insights for industry leaders and policymakers aiming to accelerate CCUS deployment globally.