SUPPLY CHAIN MANAGEMENT OF CARBON CAPTURE TECHNOLOGIES IN NORTH AMERICA: BARRIERS AND ENABLERS

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ABSTRACT

This study evaluates Amine-based Carbon Capture and Storage (CCS) technology's supply chain to investigate the viability of the CCS supply chain and identify the challenges and opportunities within the Amine market in North America, focusing on its role as a key raw material in prevalent CCS applications. Amidst the backdrop of the International CCS Knowledge Centre's (ICCSKC) concerns over supply risks and gaps in the Amine/Amine Market, fueled by an anticipated surge in CCS projects (2028 and 2032) driven by emission reduction policies, this research is timely and essential.

Leveraging the Industry 4.0 paradigm, the study delves into the Amine market dynamics across five dimensions to assess its supply chain readiness. The investigation reveals critical insights for policymakers, industry players, and academics, highlighting the intricate link between government initiatives and supply chain effectiveness. The study provides a roadmap for overcoming barriers and harnessing enablers to promote CCS technology uptake effectively.

RESEARCH QUESTION

The research aims to provide answers to the following questions.

1. Will the global supply chain for CCS projects limit or impact the viability of CCS?
2. What are the Barriers and Enablers to the patented CCS Amine Technology in North America?

OBJECTIVES

ICCS Knowledge Centre (ICCSKC) study on Amine, identified as the most technologically ready material for carbon capture, projects a potential supply gap for Amine. This supply chain gap poses concerns on future demand requiring this research to achieve the follows:

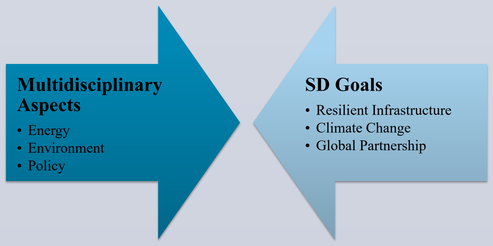
- Assess the Role of Amine-based CCS in North America's Supply Chain: The study investigates the critical role within North America's supply chain, focusing on its viability.
- Identify Barriers and Enablers of the Amine Technology and Market using the Industry 4.0 Paradigm: The research utilizes the Industry 4.0 paradigm to comprehensively evaluate the Amine market, identifying the barriers and enablers that influence its supply chain readiness.

These objectives are expected to lead to the following outcomes:

Policymakers and Stakeholders:

The study offers valuable insights for policymakers, industry stakeholders, and academics, emphasizing the relationship between government policy, supply chain effectiveness and investment, crucial for driving CCS adoption.

Contribute to Climate Change Mitigation Strategies: Ultimately, the research supports governmental initiatives to combat global climate change by highlighting the pivotal role of CCS technologies as an effective mitigation tool in the energy sector.



METHODS

The Research Method

- Qualitative

Data Sources/Collection

- Literature Review from Reputable sources and Public domain
- Academic Research work
- Institutional Research Materials

Analytical framework

- The Industry 4.0 framework to evaluate the amine market for CCS
- Sustainable supply chain performance in multi-tier manufacturing supply chain

HIGHLIGHTS

NORTH AMERICA CCS POLICY LANDSCAPE

North America 's region has established its leadership in Carbon Capture Utilization and Storage (CCUS) by promoting its policy landscape leading to a tremendous increase in CCS projects to meet its Nationally Defined Commitment at the IPCC.

Key Policies:

Canada

Tax Incentives: CCUS Investment Tax Credit (CCUS ITC), Capital Cost Allowance (CCA) Classes.

Govt Programs: Carbon Pricing Certainty programs

US:

Inflation Reduction Act 2022, Carbon Negative Shot etc.

AMINE MARKET OUTLOOK

Amine Market Concentration and Industry Competition

A preliminary analysis of the amine market, emphasizing its core characteristics and the TRL of amine technologies was carried out to establish the capabilities and limitations of the amine and its market dynamics.

INDUSTRY 4.0

Industry 4.0 is a revolutionary advancement that embraces the interconnection of technologies into the manufacturing setup to achieve operational efficiency, productivity, and automation to the highest possible extent. Key element of the Industry 4.0 is the interrelation between the 3 elements of Process Integration, Technology, and Sustainable Outcome in the Amine Market scenario.

Categorizing the factors/characteristics of the Amine market within the dimensions of the Industry 4.0 framework provides a structured approach to understanding the barriers and enablers in adopting advanced technologies in the Amine market.

FINDINGS

Section 1: This research compared the key characteristics of the amine market with the Industry 4.0 sustainable framework to determine the viability and impact of the global supply chain of CCS projects. Industry 4.0 is a sustainable framework used by Multi-Tier Manufacturing Supply Chain (MMSC) experts, which focuses on integrating technology, process integration, and sustainable outcomes for improved product performance. The study specifically focused on the Amine market as an MMSC, highlighting the market's alignment with the Industry 4.0 framework for Market Structure and Competition, Regulatory Environment, Technological Integration and Innovation, and Sustainability and Economic Outcomes.

By applying Industry 4.0 principles, the potential CCS project's viability and impact are established.

Section 2: Building on the findings of Section 1, this study assessed the suitability of the Industry 4.0 framework for analyzing key barriers and enablers affecting the efficiency and deployment of amine-based CCS technologies. Real-world scenarios and market data from existing studies were used to identify drivers and barriers for the Industry 4.0 framework, categorized under five dimensions of technology, organization, economics, environment, and social aspects, which aligned with the classification dimensions of Industry 4.0.

Technology Dimension

Backward Integration Model as an enabler expedites the automation and analytics data, by providing better control over production processes and supply chains. This leads to enhanced production efficiency and supply chain management.

Social Dimension

Moderately Fragmented as a barrier, hinders collaboration and communication among different stakeholders.

Organizational Dimension

Competitiveness in the Market as an enabler drives companies to adopt technological advances to stay ahead. The pressure to innovate, expand production capacity, and engage in ongoing R&D projects fosters an environment where Industry 4.0 technologies can thrive. It is also a barrier as it is a highly regulated market and the adoption of Industry 4.0 technologies requires companies to navigate complex compliance requirements, which may increase costs and reduce the agility needed for rapid technological adoption

Economic Dimension

The Evolving Product Market as an enabler suggests a dynamic environment where demand for new and innovative products is growing and can leverage technology advances to adapt and develop new products and optimize production processes, leading to economic growth.

Environmental Dimension

Dependence on petroleum-based feedstock as a Barrier: Dependence on petroleum-based feedstock in the environmental dimension is a barrier, as it ties the market to the environmental and sustainability challenges of the petroleum industry.

CONCLUSION

The global supply chain for CCS projects significantly influences their viability, with both challenges and opportunities arising from the characteristics of the amine market and the potential of Industry 4.0 technologies. While the amine market faces issues related to regulation, sustainability, and dependency on petroleum-based feedstocks, the Industry 4.0 framework of technological integration, process optimization, and a focus on sustainable outcomes. By applying Industry 4.0 principles, the potential CCS project's viability and impact are established.

Having determined that the global CCS supply Chain of Amine will impact its viability, the identified dimension of Industry 4.0 categorized the Enablers and Drivers of the Amine market. Integrating the barriers and enablers of the Amine market with the Industry 4.0 framework and aligning government policies with net-zero goals can serve as significant enablers for the amine market, driving innovation, efficiency, and market growth. However, barriers such as high costs, technological challenges, market fragmentation, and regulatory uncertainty need to be addressed to fully realize the potential of the amine market in supporting the viability of CCS technology and achieving net-zero emissions.

This study establishes that Amine, a critical component of the CCS supply chain, significantly impacts the viability of CCS projects. Government policies in North America have influenced the demand for CCS projects, leading to a recognized supply chain gap in the Amine market. As the Amine market continues to evolve, technology providers face the challenge of developing solutions tailored to the specific needs of different firms, necessitating detailed supply chain analysis for each.

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