

Carbon Capture Technologies and Their Role in Climate Change Mitigation

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Abstract

Carbon capture technologies focus on the separation and storage of carbon dioxide from industrial emissions and energy systems. These technologies are essential for reducing greenhouse gas emissions and mitigating climate change. This article discusses the principles, methods, and significance of carbon capture technologies in modern industry. Advances in materials, process design, and integration have improved capture efficiency and feasibility. Carbon capture technologies support the transition toward low-carbon energy systems and sustainable industrial development.

Keywords: Carbon capture technologies, carbon dioxide removal, greenhouse gas reduction, climate mitigation, sustainable industry

Introduction

Carbon capture technologies have emerged as critical tools in global efforts to reduce carbon dioxide emissions and combat climate change. Carbon dioxide is a major greenhouse gas released primarily from fossil fuel combustion and industrial processes. Capturing carbon dioxide before it enters the atmosphere helps limit global temperature rise and supports international climate goals [1]. The fundamental principle of carbon capture involves separating carbon dioxide from gas mixtures produced during industrial operations. Capture methods include pre-combustion, post-combustion, and oxy-fuel combustion processes. Each method has distinct advantages and challenges, depending on the source and composition of emissions. Chemical absorption using solvents remains one of the most widely applied techniques.

Materials play a central role in the efficiency of carbon capture technologies. Advanced adsorbents, membranes, and chemical solvents are designed to selectively bind carbon dioxide while minimizing energy consumption [2]. Research in materials chemistry has led to the development of novel porous materials and hybrid systems with improved capture capacity and stability. Integration of carbon capture technologies into existing industrial infrastructure presents technical and economic challenges. Retrofitting power plants and industrial facilities requires careful process design and optimization. Advances in process engineering and system integration have improved feasibility and reduced operational costs, making

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large-scale deployment more achievable [3]. Captured carbon dioxide can be stored underground or utilized in industrial applications. Carbon storage involves injecting carbon dioxide into geological formations for long-term containment. Carbon utilization converts captured carbon dioxide into fuels, chemicals, or construction materials, adding economic value while reducing emissions [4]. As climate concerns intensify, carbon capture technologies are increasingly recognized as part of a comprehensive climate strategy. Combined with renewable energy and energy efficiency measures, carbon capture supports the transition to low-carbon industrial systems. Continued research and policy support will further enhance the role of carbon capture technologies in addressing climate change [5].

Conclusion

Carbon capture technologies offer an effective approach to reducing carbon dioxide emissions from major industrial sources. Their development and deployment are essential for achieving climate mitigation targets. As technological advancements continue, carbon capture technologies will become more efficient and economically viable. Ongoing innovation and collaboration between scientists, engineers, and policymakers will strengthen their contribution to sustainable and low-carbon development.

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