

Transforming Produced Water Management through Clathrate Hydrate-Based Desalination

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Abstract

The management of produced water from oil and gas operations poses significant environmental and operational challenges due to its high salinity and complex composition. Clathrate hydrate-based desalination (CHD) has emerged as a promising approach for selectively recovering freshwater from produced water streams, offering a low-energy alternative to conventional thermal or membrane-based technologies. This presentation will explore the fundamental mechanisms of hydrate formation and salt exclusion, highlighting recent advances in the use of CO₂ and low-global-warming-potential refrigerants as hydrate formers. The roles of kinetic promoters, porous media, and dry water in enhancing hydrate formation rates and water recovery will be discussed. Comparative evaluations of system energy efficiency, scalability, and recovery performance across various hydrate-based configurations will be presented. Particular attention will be given to the integration of CHT systems with upstream processes and renewable energy sources for off-grid water reuse. Key scientific and engineering barriers including hydrate formation kinetics, scale-up limitations, and impurity management will be addressed, along with a roadmap for the transition of CHD from laboratory research to practical deployment. This presentation aims to highlight the potential of hydrate-based processes as a sustainable and economically viable solution for produced water treatment in the energy sector.

Keywords: Clathrate hydrates, gas hydrate desalination, water purification, energy-efficient desalination