Abstract

Establishing a Sustainability Framework for Produced Water Reuse in Renewable Energy Generation

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The increasing demand for sustainable water and energy solutions continues to drive interest in the reuse of produced water, a byproduct of oil and gas extraction. This study develops a sustainability framework for reusing produced water (PW) in renewable energy generation, focusing on Loving County, Texas. Loving County, within the Permian Basin, remains one of the most productive oil and gas regions in the United States, significantly contributing to the country's energy supply with 6,581,125 barrels (bbls) of oil and 44,140,974 thousand cubic feet (mcf) of natural gas produced as of Sept 2024. However, its arid environment and limited water resources create challenges for both local communities and energy producers. The county's sparse population (43 people in 2023) and infrastructure further complicate PW management, making it an ideal case study for developing innovative and scalable reuse strategies.

This research examines the water-energy nexus by analyzing the composition, treatment, and reuse potential of PW while identifying key barriers such as transportation, treatment costs, water quality, and regulatory constraints. A system dynamics approach is employed, integrating the simulation software AnyLogic and ArcGIS Pro to assess and model the use of PW in renewable energy systems. Data from 2017–2022, obtained from IHS, includes PW and deep well injection volumes, along with annual oil and gas production. This data informs the modeling and analysis of water movement from production sites to injection locations. GIS mapping visualizes transportation routes and the spatial distribution of key infrastructure, such as pipelines and roadways, while AnyLogic enables dynamic modeling of real-world interactions in Loving County. Together, these tools provide insights into the economic, environmental, and logistical factors influencing decision-making.

This study enhances the understanding of PW management by demonstrating its potential to support renewable energy generation, particularly through applications such as hydrogen production. It highlights the role of fit-for-purpose PW management in addressing challenges related to transportation costs, water quality, and comprehensive water reuse strategies. Additionally, the framework offers insights into the broader implications of PW reuse for energy and water sustainability in arid, resource-dependent regions, where strategic water management can enable innovative solutions like hydrogen production and carbon capture and storage.

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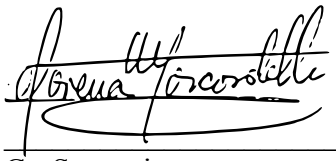

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