Assessment of Underground Hydrogen Production and Storage in Depleted hydrocarbon Fields in Lithuania

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Abstract

Introduction and Objectives: The escalating global concern over carbon emissions and climate change has sparked heightened interest in hydrogen (H2) as a pivotal future energy source. Acknowledged for its potential to facilitate a carbon-free energy revolution and enhance energy flexibility, hydrogen holds significance in addressing the urgent need for sustainable alternatives. Emphasizing its role, the IPCC's 1.5°C Report underscores hydrogen's substantial contribution to mitigating global warming. Aligned with this, the European Union (EU) has committed to transforming into a low-carbon economy by 2050, targeting a 40% reduction in carbon emissions by 2030 and a 32% increase in renewable energy utilization. Lithuania, as an EU member, actively engages in advancing hydrogen resources, particularly focusing on underground hydrogen storage (UHS) technologies. This research endeavors to evaluate hydrogen production potential from depleted hydrocarbon fields and assess the long-term storage of produced hydrogen, addressing critical challenges such as flow properties, storage integrity, and potential impacts on aquifers and geological formations in case of leakage during storage.

The main objectives of this research work are twofold: firstly, to evaluate hydrogen production potential from depleted hydrocarbon fields, and secondly, to assess the long-term storage of produced hydrogen in depleted hydrocarbon fields and saline aquifers.

Procedure: Hydrogen production encompasses various methods, ranging from hydrocarbon reforming to microbial processes. Broadly classified into four groups, hydrogen production technologies include Green, Grey, Blue, Turquoise, and Gold hydrogen.

This research exploits the unique capabilities of anaerobic bacteria, specifically thermophilic strains, to unlock hydrogen production potential from depleted hydrocarbon reservoirs. Thriving in extreme conditions, especially elevated temperatures, these microorganisms showcase resilience and adaptability. The in-situ bio-refinement method utilizes naturally occurring thermophilic bacteria to convert crude oil into hydrogen, presenting a groundbreaking approach to green energy production.

Results: Samples from a Lithuanian oil field, including water, oil, and gas samples, were collected. Gas samples underwent analysis to detect hydrogen presence and isotopic analysis for identifying its biogenic origin.

Metagenomic analysis of oil and brine samples aimed to identify hydrogen-producing microbes. Extracted in-situ microbes were employed for bio-refinement of crude oil into hydrogen. The produced hydrogen underwent analysis for its impact on reservoir properties, evaluating the long-term storage impact. A range of pressure and temperature conditions, simulating in-situ reservoir scenarios, were tested. A feasibility study explored upscaling lab experiments for potential field trials to estimate hydrogen production potential.

Conclusions: The research demonstrates the utilization of in-situ microbes naturally present in depleted hydrocarbon reservoirs for bio-refining residual oil saturation into hydrogen. Testing various pressure and temperature conditions mimicking in-situ reservoir scenarios, the study reveals the potential of utilizing depleted hydrocarbon reservoirs for hydrogen production. This transformative approach holds promise for transitioning from hydrocarbon to hydrogen production, contributing to sustainable energy evolution.