An Engineering-Informed Economic Model for Predicting the CO_2 Market Price in a Carbon Capture Utilization and Storage Infrastructure: A Case Study in the Eastern Mediterranean Basin

Matheos Giakoumi[1,2*]

[1]Hildebrand Department of Petroleum and Geosystems Engineering, The University of Texas at Austin, Austin, TX, USA

[2]Technologies for the Energy Transition, Fondazione Eni Enrico Mattei, Milan, Italy

Abstract

This study presents an engineering-informed economic model for predicting the CO2 utilization/market price as part of the dual commodity price of CO2 under the EU Emissions Trading System (ETS). The model is based on a proposed infrastructure for Carbon Capture Utilization and Storage (CCUS), which connects the Aphrodite Gas Field within Cyprus' Exclusive Economic Zone to the major emitter nodes situated at the ports of Moni, Vassilikos, and Dhekelia, primarily due to electricity and cement production. The energy mix of Cyprus and its associated emissions has been forecasted based on three categories from the IPCC Sixth Assessment Report (AR6) — specifically C1, C3, and C6 — using an hourly dispatch model for the island's power sector in PLEXOS. This model spans fossil fuels and the integration of renewables, as well as the EuroAsia Interconnector, alongside the production plans for the Aphrodite Gas Field from 2027 to 2045. The resulting emissions profile is incorporated into a reservoir engineering model that focuses on injecting CO2 for Enhanced Gas Recovery (EGR). Using displacement principles of reservoir engineering, the increase in production due to EGR is determined and analyzed. This increase is then used to estimate CO2 utilization efficiency, which is integrated into an economic model that evaluates the cooperation among the three emitters and the operator of the Aphrodite field. The cooperation is examined through the cooperative game theory approach, revealing an empty core that necessitates the intervention of a regulator that secures cooperation through subsidization, thereby defining the CO2 utilization/market price, which serves as an anchor of negotiation between the emitters and the operator. This price is determined as a function of engineering parameters, specifically CO2 utilization efficiency, rather than relying solely on policy aspects such as the ETS price. In doing so, the model provides a structured mechanism for coordinating CO2 markets, thereby facilitating the expansion of costly infrastructures like CCUS by aligning technical feasibility with clear economic incentives.

Keywords: Carbon Capture Utilization and Storage, CO2 Market Dynamics, Applied Cooperative Game Theory, Reservoir Engineering, Energy Policy, Engineering-Informed Economic Model