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Paper ID: 128
Paper title: Reactor design for a greener future: Comparing isothermal and adiabatic CO2 methanation reactors under renewable energy fluctuations

Bio:
Msc. Michelle Denise Mattenet is a mechanical engineer specialized in hydrogen systems and energy transition. She holds a **double MSc in Energy Engineering and Hydrogen Systems & Enabling Technologies (Erasmus Mundus)** from **Politecnico di Milano** and **Universitat Politècnica de Catalunya**, under the **HySET program**. Her research focuses on **reactor design and dynamic modeling for CO_2 methanation** using CFD tools, supporting Shell's net-zero strategy through flexible Power-to-Gas technologies. During her master's thesis at **Shell Global Solutions International (Energy Transition Campus Amsterdam)**, she investigated **thermofluid dynamics in catalytic packed beds** under renewable energy fluctuations.
Previously, Michelle worked for four years as a **Rotating and Mechanical Design Engineer** at **Techint Engineering & Construction**, contributing to large-scale EPC projects in the oil and gas and power sectors. She has experience in **equipment specification, process integration, and procurement coordination** across multidisciplinary environments.

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***Abstract*— Integrating renewable energy into chemical processes is critical to Shell's ambition of producing net zero emissions by 2050, and, given the global commercial importance of liquefied natural gas (LNG), finding ways to enhance the efficiency of the methanation process. A key factor is the performance of the methanation reactor under dynamic conditions. This study explores the dynamic behavior of adiabatic and isothermal fixed-bed reactors for carbon dioxide (CO_2) methanation – a key power-to-gas (P2G) pathway that converts renewable (green) hydrogen and captured CO_2 into synthetic methane. All simulations used the computational fluid dynamics (CFD) software COMSOL Multiphysics to build and validate detailed fixed-bed reactor models. These findings offer direct business value by supporting the development of flexible methanation systems that can be directly coupled to intermittent renewable sources. This reduces the capital and operating costs required for storage while enhancing system responsiveness. This study demonstrates the value of multiscale modeling in optimizing methanation reactor performance under dynamic conditions. Both reactor configurations, adiabatic and isothermal, showed good performance under variable load. The time necessary to stabilize for both was under 5 s.**

Keywords— Methanation, Power-to-Gas, Computational Fluid Dynamics), Renewable Hydrogen, Reactor Design, Dynamic