



Processes

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Special Issue Reprint

New Advances in Low-Energy Processes for Geo-Energy Development

Edited by: Daoyi Zhu, Yibo Li and Qingyuan Chen

This Special Issue presents ten key studies focused on minimizing energy intensity across the geo-energy lifecycle. It is structured around three core themes: unconventional reservoir stimulation and wellbore engineering, data- and intelligence-driven production optimization, and subsurface storage safety with thermal property characterization. The first section introduces transformative low-energy stimulation and wellbore intensification strategies. Innovations include optimized asymmetric fracture networks for efficient proppant placement, integrated acidizing-flowback systems for deep offshore operations, and one-trip shape-memory completion tools that passively reinforce wellbores. The second part pioneers data- and intelligence-driven frameworks for optimization. Advanced deep learning models, such as CNN-BiGRU with multi-head attention and TCN-LSTM-AVOA workflows, achieve high accuracy in predicting downhole pressure and production dynamics. The final segment addresses enablers for sustainable systems, featuring a software tool for crack arrest assessment in CO₂ pipelines and integrated methods for predicting in situ rock thermal conductivity. These contributions enhance the safety of CCUS transport and support the low-energy design of geothermal systems. Collectively, this volume synthesizes experimental, computational, and field-applicable advances to reduce pumping energy, fluid circulation, and operational risks, charting a path toward a more efficient and sustainable geo-energy industry.



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