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Research Paper

Techno-economic-environmental study and artificial intelligence-assisted optimization of a multigeneration power plant based on a gas turbine cycle along with a hydrogen liquefaction unit

Tao Hai [a b c], Mohammed M. Alhaider [d], Pooya Ghodratallah [e], Pradeep kumar singh [f], Fahad Mohammed Alhomayani [g], Husam Rajab [h]

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Highlights

- Proposing a solar-based system for hydrogen production and liquefaction.
- Utilizing an LNG regasification process to improve hydrogen production.
- Enhancing the liquefaction characteristics through hydrogen

Abstract

According to the literature, there is a research gap concerning the practical heat recovery in solar-driven systems that have the capability to produce liquid hydrogen. In this study, an innovative combination of dual-loop solar-driven organic Rankine cycle and liquefied natural gas (LNG) heat recovery is designed to produce and liquefy hydrogen. The proposed system includes parabolic trough solar collectors (PTSCs), a Rankine cycle, a dual-loop organic Rankine cycle, LNG regasification process, proton exchange membrane (PEM) electrolyzer, and Claude hydrogen liquefaction cycle. A data-driven method is developed to analyze the system from techno-economic and environmental perspectives. The results show that LNG energy recovery improves the liquefaction work by as much as 7.96 kWh/kgH_2. It is also concluded that the optimum compaction pressure range for the liquefaction cycle is 4.67 MPa, which is associated with better results. In these conditions, liquefaction work, liquefaction Coefficient of Performance (COP), and liquefaction exergy efficiency are 164.6 kJ/kg, 0.157 and 17.05%, respectively. To find optimum operating conditions, a supervised learning approach is applied to the developed code and the trained network is optimized using the genetic algorithm (GA). The optimization results reveal that a 10.98 $/h increase in total cost rate causes an 18% improvement in hydrogen production rate.