Techno-economic optimisation of three gas liquefaction processes for small-scale applications

Natural gas liquefaction systems are based on refrigeration cycles, which can be subdivided into: the cascade, mixed refrigerant and expansion-based processes. They differ by their design configurations, components and working fluids, and thus have various operating conditions and equipment inventory. The present work investigates three configurations (single-mixed refrigerant, single and dual reverse Brayton cycles) for small-scale applications, which are optimised and evaluated individually. The influences of the refrigerant properties and process technologies are analysed, and the most promising cycle setups are identified. The findings illustrate the resulting trade-offs between the system performance and investment costs, which differ significantly with the type of refrigeration cycle. Although these configurations are suitable for small-scale applications, mixed-refrigerant processes prove to be more efficient (1000-2000 kJ/kg\textsubscript{LNG}) than expansion-based ones (2500-5000 kJ/kg\textsubscript{LNG}) over larger ranges of operating conditions, at the expense of a greater system complexity and higher thermal conductance (250-500 kW/K against 80-160 kW/K). The results show that the use of different thermodynamic models leads to relative deviations of up to 1% for the power consumption and 20% for the network conductance. Particular caution should thus be exercised when extrapolating the results of process models to the design of actual gas liquefaction systems.

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