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Energy Consumption Estimation for Hybrid Marine Power Systems: Comparing Modeling Methodologies

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Abstract : Hydrogen fuel cells and batteries are one of the promising solutions aligned with carbon emission reduction goals for the marine sector. However, the higher installation and operation costs of hydrogen-based systems compared to conventional diesel gensets raise questions about the appropriate hydrogen tank size, energy, and fuel consumption estimations. Ship designers need methodologies and tools to calculate energy and fuel consumption for different component sizes to facilitate decision-making regarding feasibility and performance for retrofits and design cases. The aim of this work is to compare three alternative modeling approaches for the estimation of energy and fuel consumption with various hydrogen tank sizes, battery capacities, and load-sharing strategies. A fishery vessel is selected as an example, using logged load demand data over a year of operations. The modeled power system consists of a PEM fuel cell, a diesel genset, and a battery. The methodologies used are: first, an energy-based model; second, considering load variations during the time domain with a rule-based Power Management System (PMS); and third, a load variations model and dynamic PMS strategy based on optimization with perfect foresight. The errors and potentials of the methods are discussed, and design sensitivity studies for this case are conducted. The results show that the energy-based method can estimate fuel and energy consumption with acceptable accuracy. However, models that consider time variation of the load provide more realistic estimations of energy and fuel consumption regarding hydrogen tank and battery size, still within low computational time.

Keywords : fuel cell, battery, hydrogen, hybrid power system, power management system
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