Economic Energy Production Quantity for the Optimization of the Battery Size for Innovative Shipping Propulsion Systems Enabling the Sustainable Mobility

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Abstract:

The green transition of naval transportation is currently one of the hardest technological challenges faced by the marine industry which currently accounts 2–3% of global greenhouse gas (GHG). Innovative naval propulsion systems are fundamental enabler of this transition, and full hybrid systems combining the use of endothermic engines and battery powered electric motors, represent most promising technology in such regard. In hybrid systems, the batteries need to be properly dimensioned based on the ship load diagram, considering all the operations performed from the departure to the destination. The objective of the problem is to supply constant through use the endothermic engine, and to use the electric propulsion for shaving power demand peaks (during manoeuvring, cargo unloading or port leaving) and as backup in case of engine failure. To complete the full hybrid system, an Energy Management System (EMS) optimises the interaction of the different power sources and safeguards the battery. All considered, this paper proposes a methodology for optimizing the battery size of a full hybrid system, considering the related management costs. A cost function is thus defined that includes the cost of battery charge from the endothermic engine while at sea, the energy holding cost, the operating cost of the EMS, the fuel cost to cover a route, and the fuel holding cost. Finally, the optimal battery capacity -namely the Economic Energy Production Quantity (EEPQ) – is determined that minimize the cost function.