World Academy of Science, Engineering and Technology
International Journal of Transport and Vehicle Engineering
Vol:17, No:04, 2023

Pathway to Sustainable Shipping: Electric Ships

Authors : Wei Wang, Yannick Liu, Lu Zhen, H. Wang

Abstract : Maritime transport plays an important role in global economic development but also inevitably faces increasing pressures from all sides, such as ship operating cost reduction and environmental protection. An ideal innovation to address these pressures is electric ships. The electric ship is in the early stage. Considering the special characteristics of electric ships, i.e., travel range limit, to guarantee the efficient operation of electric ships, the service network needs to be re-designed carefully. This research designs a cost-efficient and environmentally friendly service network for electric ships, including the location of charging stations, charging plan, route planning, ship scheduling, and ship deployment. The problem is formulated as a mixed-integer linear programming model with the objective of minimizing total cost comprised of charging cost, the construction cost of charging stations, and fixed cost of ships. A case study using data of the shipping network along the Yangtze River is conducted to evaluate the performance of the model. Two operating scenarios are used: an electric ship scenario where all the transportation tasks are fulfilled by electric ships and a conventional ship scenario where all the transportation tasks are fulfilled by fuel oil ships. Results unveil that the total cost of using electric ships is only 42.8% of using conventional ships. Using electric ships can reduce 80% SOx, 93.47% NOx, 89.47% PM, and 42.62% CO2, but will consume 2.78% more time to fulfill all the transportation tasks. Extensive sensitivity analyses are also conducted for key operating factors, including battery capacity, charging speed, volume capacity, and a service time limit of transportation task. Implications from the results are as follows: 1) it is necessary to equip the ship with a large capacity battery when the number of charging stations is low; 2) battery capacity will influence the number of ships deployed on each route; 3) increasing battery capacity will make the electric ship more cost-effective; 4) charging speed does not affect charging amount and location of charging station, but will influence the schedule of ships on each route; 5) there exists an optimal volume capacity, at which all costs and total delivery time are lowest; 6) service time limit will influence ship schedule and ship cost.

Keywords : cost reduction, electric ship, environmental protection, sustainable shipping
Conference Title : ICMTCPE 2023 : International Conference on Maritime Transport Costs and Port Efficiency
Conference Location : Tokyo, Japan
Conference Dates : April 17-18, 2023