

## Technical feasibility study of an ammonia-fuelled mega-yacht powered by PEM fuel cells

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Maritime sector forecasts that ammonia will play a pivotal role in decarbonizing ships, since it does not emit carbon dioxide (CO<sub>2</sub>). Nevertheless, ammonia produces nitrogen dioxide (NO<sub>2</sub>) burning in ICEs, which contributes to smog and acid rains, being harmful for human health. Combustion also yields small amounts of nitrous oxide (N<sub>2</sub>O), that is a greenhouse gas significantly more dangerous than carbon dioxide. An option for eliminating harmful emissions is using fuel cell (FC) technology. In this study, a Proton Exchange Membrane (PEM) FC system is considered for the electric energy production on board a 63 m mega-yacht, replacing a traditional Marine Gas Oil (MGO) generating set. Pure hydrogen required for powering the PEM system is produced through an ammonia decomposition reactor and a purification apparatus, to be installed on board as well. Two scenarios are considered: in the first one the PEM provides the hotel loads with 300 kW<sub>e</sub>; in the second one it guarantees an autonomy of 250 nm with a speed of 8 kn. The effect of such a solution on the general arrangement of the ship is discussed. The main outcomes are that the ammonia processing system for generating hydrogen requires additional power, that is in the range 360-475 kW<sub>e</sub>, and it is heavier and bulkier than the gen-set. Despite these cons, its installation on board seems to be feasible and it does not involve significant modifications of the original configuration of the mega-yacht. The ammonia-fuelled mega-yacht reduces the original duration of navigation from 11 to about 5 days, nevertheless this value appears still adequate considering the innovative solution at zero emission proposed.

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