

## Concept Development and Operational Analysis of Using Hydrogen as a Single Naval Fuel

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### Content:

- objectives of thesis
  - This thesis will focus on using liquid hydrogen (LH<sub>2</sub>) technologies as a single naval fuel onboard a seagoing vessel. The case study in this thesis is a 1000 twenty-foot equivalent unit (TEU) catamaran container vessel (CV) as a proxy to the United States (U.S.) Navy's Spearhead Class vessel. These 2 vessels are both built with catamaran hulls, and both have similar tonnage.
- main research ideas
  - The thesis was split into two portions, namely a design portion supplemented with an analysis portion
  - The design portion was proposed thru meeting estimated requirements of ocean-going routes and the list of proposed design changes are as follows:
    - Use of GE LM6000 gas turbines as main propulsion,
    - Modifications to be done on existing fossil fuel tanks to hold LH<sub>2</sub> fuel,
    - Replacement of current compressors to Hydro-Pac C-12-40-7000LX/SS hydrogen compressors,
    - Use of GE10-1 gas turbines as generators,
    - Replacement of current fuel transfer pumps to Becker VFD vacuum pump,
    - Modifications to be done on existing heat exchangers to allow LH<sub>2</sub> operation,
    - Replacement of current valves to WEKA PK-TZV LH<sub>2</sub> valve
- research results
  - For the analysis portion, RetScreen and Microsoft Excel were used to evaluate the proposed system based over a 20-year project life. The following were calculated:
    - Green house gas (GHG) emissions expected to decrease by  $5.37 \times 10^5$  tCO<sub>2</sub> (equivalent to 98,479 cars not used)
    - NPV of \$2.21M.
    - Positive IRR of 1.3%
    - Initial costs of \$37.85M.
    - Payback period of 16.2 years; and
    - Cumulative cash flow of \$4.62M after a 20-year project life
- benefits/potential applications of the research
  - The benefits for this thesis will provide the following:
    - Reduction in PM, NOx and SOx emissions
    - The removal of equipment for fuel oil treatment
    - Lower manpower, maintenance, and operating costs; and
    - The reduction of risk for fire and oil spills
- follow-up research activities etc
  - To separately look at hydrogen fuel cells, and if hydrogen technologies can be coupled together with existing renewable energy sources for military vessels
  - To verify if hydrogen technologies can be extensively used in tropical climates such as Singapore

