# Nuclear Tanker Producing Liquid Fuels from Air and Water

**LT John Galle-Bishop, USN**

| Dr. Charles Forsberg | Prof. Michael Driscoll | Prof. Mark Welsh |
|---|---|---|
| Thesis Supervisor | Thesis Supervisor | Thesis Reader |

Emerging technologies in $CO_2$ air capture, high temperature electrolysis, microchannel catalytic conversion, and Generation IV reactor plant systems have the potential to create a shipboard liquid fuel production system that will ease the burdened cost of supplying fuel to deployed naval ships and aircraft. Based upon historical data provided by the US Navy (USN), the tanker ship must supply 6,400 BBL/Day of fuel (JP-5) to accommodate the highest anticipated demand of a carrier strike group (CSG).

Previous investigation suggested implementing shipboard a liquid fuel production system using commercially mature processes such as alkaline electrolysis, pressurized water reactors (PWRs), and methanol synthesis; however, more detailed analysis shows that such an approach is not practical. Although Fischer-Tropsch (FT) synthetic fuel production technology has traditionally been designed to accommodate large economies of scale, recent advances in modular, microchannel reactor (MCR) technology have to potential to facilitate a shipboard solution. Recent advances in high temperature co-electrolysis (HTCE) and high temperature steam electrolysis (HTSE) from solid oxide electrolytic cells (SOECs) have been even more promising. In addition to dramatically reducing the required equipment footprint, HTCE/HTSE produces the desired synthesis gas (syngas) feed at 75% of the power level required by conventional alkaline electrolysis (590 $MW_e$ vs. 789 $MW_e$). After performing an assessment of various $CO_2$ feedstock sources, atmospheric $CO_2$ extraction using an air capture system appears the most promising option. However, it was determined that the current air capture system design requires improvement. In order to be feasible for shipboard use, it must be able to capture $CO_2$ in a system only ¼ of the present size; and the current design must be modified to permit more effective operation in a humid, offshore environment.

Although a PWR power plant is not the recommended option, it is feasible. Operating with a Rankine cycle, a PWR could power the recommended liquid fuel production plant with a 2,082 $MW_{th}$ reactor and 33% cycle efficiency. The recommended option uses a molten salt-cooled advanced high temperature reactor (AHTR) coupled to a supercritical carbon dioxide (S-$CO_2$) recompression cycle operating at 25.0 MPa and 670 $^oC$. This more advanced 1,456 $MW_{th}$ option has a 45% cycle efficiency, a 42% improvement over the PWR option. In terms of reactor power heat input to JP-5 combustion heat output, the AHTR is clearly superior to the PWR (31% vs. 22%).

In order to be a viable concept, additional research and development is necessary to develop more compact $CO_2$ capture systems, resolve SOEC degradation issues, and determine a suitable material for the molten salt/S-$CO_2$ heat exchanger interface.

**Master of Science in Nuclear Science and Engineering**
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