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ANALYSIS OF PATHWAYS TO REACH NET-ZERO NAVAL OPERATIONS BY 2050, PHASE II

EXECUTIVE SUMMARY

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Project Summary

This analysis considers challenges to integrating emissions reduction measures across the naval operating force and cites reported climate science to assess the impact of four specific decarbonization pathways: alternative force structure, advanced nuclear energy, platform carbon capture and storage, and sustainable fuels. The analysis assumes the Department of the Navy (DON) will not accept measures that could reduce operational capabilities on ships or aircraft and deduces that by 2050, conventional gas turbine and diesel engines will still demand up to 28 million barrels of F-76 and JP-5 fuels (Department of Navy, 2023).

The study reviewed data and analyses from government, international, and industry resources and modeled impacts of greenhouse gas (GHG) emission reductions to the contiguous US using the Coupled Model Intercomparison Project Phase 6 (CMIP6). The assessment concludes that alternative force structure concepts could realize some emissions reductions by 2050, but DON doctrine describes growth in naval force structure which will likely offset those reductions (Office of the Chief of Naval Operations, 2022; Naval Air Systems Command, 2021). Advances in nuclear energy and non-drop-in alternative fuels like ammonia and methanol could enable some future capabilities but will not likely proliferate to scale to support 2050 targets. And the power demand and CO_2 storage requirements for platform carbon capture will likely preclude commissioned warships and naval aircraft. Sustainable drop-in fuels offer the greatest potential for significant emissions reductions on naval ships and aircraft by 2050.

Prioritization and resources toward government-wide efforts in transportation sector decarbonization are enabling the scaleup of biofuels, hydrogen generation and direct air carbon capture, as well as processes to synthesize drop-in aircraft and marine diesel fuels. Coordination with the Department of Energy and Department of Transportation is necessary to increase sustainable fuels production, support net-zero naval operations by 2050, and limit the severity of climate change.

Keywords: *climate change, mitigation, sustainable fuels, carbon capture, CCS, alternative fuels, synthetic fuel, nuclear, unmanned systems, Intergovernmental Panel on Climate Change, IPCC, Environmental Protection Agency, EPA, National Oceanographic and Atmospheric Administration, NOAA*

Background

Since the start of the industrial age, average global surface temperatures have risen 1.1°C, driving heat extremes, sea ice melting, sea level rise, increased intensity of tropical cyclones and heavy precipitation, increased drought and flooding, and numerous other conditions that challenge global stability (Intergovernmental Panel on Climate Change, 2023). These changes are expected to worsen over the next few decades, causing food insecurity, further spurring global instability, and increasingly challenging US national security and response from US naval forces (US National Intelligence Council, 2021).

Correlating global warming and GHG emissions from human activities has been possible by monitoring levels of the various greenhouse gases, analyses of long-term records, tree rings, and ice cores, and computer simulations based on the physics that governs the climate system. The IPCC reports, "it is unequivocal that human influence has warmed the atmosphere, ocean and land since pre-industrial times" (Intergovernmental Panel on Climate Change, 2023). Global warming and

climate impacts are expected to increase over the next several decades, but the severity will depend on global efforts to reduce GHG emissions. Global efforts to limit warming include the Paris Climate Agreement, and target limits of 1.5°C and 2°C. In 2021, President Biden released executive orders addressing climate change and setting targets for a government-wide approach to include net zero GHG emissions (net-zero) by 2050. In response, the Office of the Chief of Naval Operations requested and resourced a research topic for the Naval Postgraduate School (NPS) to assess pathways for naval operating platforms to reach net-zero by 2050. In 2022, NPS executed research to assess sources and levels of GHG emissions from naval operating platforms and identified measures that could enable a net-zero naval force by 2050 (K Fletcher, 2022).

This phase two effort, stemming from the DON's release of Climate Action 2030, looked deeper at the potential and benefits of integrating sustainable fuels, platform carbon capture, alternative force structure concepts, and nuclear energy to further support net-zero goals (Department of Navy , 2022). The research assumed the Department will not accept measures that could reduce combat capability or mission effectiveness. This study also reviewed and summarized established climate science reporting to baseline impact of emissions from naval operations on global reduction objectives.

The research used climate data and analyses from the National Oceanographic and Atmospheric Administration, Environmental Protection Agency, and IPCC to assess historical trends and indicators of climate change and modeled projected climate change impacts to the contiguous US using CMIP6. Two scenarios were modeled to represent 1) projections of impacts from global warming associated with the current level of the GHG emissions and trends, and 2) projections of impacts correlating with GHG emissions reductions to limit global warming to 2°C.

Findings and Conclusions

The analysis showed that global GHG emissions reductions of 17 billion metric tons by 2030 and 37 billion metric tons by 2050 would limit temperature increase as well as sea level rise, increasing precipitation, extreme temperature events, and increasing sea surface temperature—factors that increase climate change hazards like droughts, flooding, and hurricane intensity (Intergovernmental Panel on Climate Change, 2023).

Naval operations account for approximately 12 million metric tons of CO2e annually—less than .1% of the total reductions needed to realize the lesser impacts associated with limiting warming to 2°C (Department of Navy, 2023). Efforts to reduce those emissions will have a corresponding impact to global climate change and support a "do our part" approach where global efforts aggregate to address climate change. However, to have the biggest impact on reducing the severity of hazards to the naval force, the US, and the planet, measures that propagate beyond naval platforms should be prioritized.

This research found that drop-in sustainable fuels (sustainable F-76 and JP-5) have the greatest potential to reduce GHG emissions before 2050. Advancements in nuclear and non–drop-in fuels may benefit the future force and support climate change mitigation but will require significant modification and departure from existing platform designs and therefore will not likely scale ahead of 2050. Future unmanned systems will support more efficient force concepts but may actually increase total emissions as the force architecture grows in accordance with Navy strategy and procurement plans. Lastly, platform carbon capture technologies require significant additional

electrical power and CO2 storage margins, prohibiting integration on naval aircraft and Navy warships. Sustainable drop-in fuels, though, can be immediately integrated on existing platforms and used in proven gas turbine and diesel engines planned for new platforms over the next 20+ years. Near-term efforts to scale production of sustainable aviation fuel and sustainable marine diesel in the US are driving additional innovations that will increase production, lower cost, and allow greater use of low carbon fuels.

To support intent of the president's executive orders, defense strategies, and global efforts to reduce GHG emissions, the pathway to net-zero naval operations by 2050 should engage government and international partners to support near-term scaleup and cost reduction of drop-in fuels, F-76 and JP-5. Continued investment in innovation and future force designs that enable integration of unmanned systems, nuclear energy, and non–drop-in fuels will support emissions reductions beyond 2050 and increase warfighting capability.

Recommendations for Further Research

Recent advancements in small-modular and micro-nuclear reactors are increasing the potential and benefit for advanced nuclear energy on naval platforms. The American Bureau of Shipping and the Maritime Administration are in coordination to develop guides for commercial maritime vessels to safely integrate, maintain, and dispose of nuclear power systems for ships. The Navy's background in nuclear, and the challenge of contested logistics, align the technical competency and demand for advanced nuclear energy on Navy combatants and amphibious ships. Additional research to consider accelerating advanced nuclear for Navy ships could enable earlier proliferation and climate change mitigation.

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Acronyms

CMIP6	Coupled Model Intercomparison Project Phase 6
GHG	greenhouse gas
IPCC	Intergovernmental Panel on Climate Change
NPS	Naval Postgraduate School