The Great Green Fleet

Naval Warfighting Imperatives for Energy Security

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U.S. Navy photo by Mass Communication Specialist 2nd Class Gregory N. Juday

What's Past Is Prologue

The U.S. Navy's Liquid Fuel Board in 1904 decided to transition the fleet from coal to oil, as engineers and operators alike had come to believe that oil-fired propulsion would greatly enhance the Navy's fighting trim. Three years later, the 'round-the-world voyage of the Great White Fleet underscored coal's logistical and operational challenges and the need for change.

Today, the Navy has embraced a far-reaching energy-efficiency strategy and is pursuing a broad spectrum of "technology insertions" that include alternative fuels for its ships and aircraft. This is already promising across-the-board enhancements for today's as well as tomorrow's fleet, not unlike the Navy at the turn of the previous century. And in that, the Service is focused on a game-changing target: the 2016 deployment of a "Great Green Fleet," first announced by Secretary of the Navy Ray Mabus in his October 2009 Navy Energy Forum address. The nation's energy vulnerability clearly has military and national security implications, he explained.

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"We do not have operational independence, and we are tied to a vulnerable logistics tail," Mabus said. "[I]n the drive for energy reform the goal has got to be increased warfighting capability."

At the 2010 Navy Energy Forum, Chief of Naval Operations (CNO) Adm. Gary Roughead said the Navy's path to a Great Green Fleet was not a "public relations gimmick" but epitomized the Service's new energy-security research, development, policy and operations.

"It's more than simply how 'green' can we be seen," said Roughead. "It really is an operational issue for us."

The Green Fleet concept signals the Navy's strategic embrace of a dramatic sea change that could break dependence on fossil fuels for powering the future surface ships and provide an alternative energy model for the United States. In short, it's a strategic and operational imperative that cannot wait.

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Leveraging Partners

The U.S. Naval Sea Systems Command (NAVSEA) is working across multiple offices to address energy security and the planning and implementation across the fleet of what the Navy calls Energy Efficiency Enabling Technologies (E3T). Three NAVSEA partners have key roles in the E3T Green Fleet enabling effort: NAVSEA's Naval Systems Engineering Directorate (SEA 05), the Surface Warfare Directorate (SEA 21), and the Program Executive Office (PEO) Ships in the Office of the Assistant Secretary of the Navy for Research, Development and Acquisition.

SEA 05 and SEA 21 have NAVSEA "roles and missions" responsibilities for energy efficiencies and reducing the "carbon footprint" of the Navy. SEA 05 has E3T technical authority and is responsible for the design, engineering and validation of the costs and safety of Green Fleet technologies and systems for both new-construction and in-service assets. SEA 21 has the responsibility for inserting these technologies into existing non-nuclear surface warships, vessels and craft, which promises near-term benefits: 80 percent of the ships that will be in the surface fleet of 2025 are now in service. As its NAVSEA partners prove Green Fleet technologies/systems in the in-service fleet, PEO Ships is responsible for inserting them into new-construction programs, like the littoral combat ship.

NAVSEA is also collaborating with enterprise partners throughout the Navy, DoD, and other federal agencies, as well as with industry and academic communities to enhance the surface fleet's energy efficiency and reduce its environmental footprint. On various energy-efficiency initiatives, NAVSEA has reached out to the fleet, Military Sealift Command, Oceanographer of the Navy, Office of Naval Research, Coast Guard, Maersk Line Limited, Department of Energy, Royal Australian Navy, Royal Navy and Royal Danish Navy.

NAVSEA's energy efficiency efforts afloat are also directly linked to the Task Force Energy Program in the CNO's Energy and Environmental Readiness Division (OPNAV N45), whose director, Rear Adm. Philip Cullom, is dual-hatted as director of Task Force Energy. The CNO stood up the program in October 2008, and a year later, Cullom helped to shape Mabus' strategic energy vision: "Energy reform," Mabus said, "is a strategic imperative."

Task Force Energy comprises Navy headquarters resource sponsors, systems commands, and the fleet to make better use of Navy energy resources. Together, they are advocating new technologies or enhancements to existing technologies that can increase future combat capability and operational responsiveness through energy efficiency. These new technologies reduce mission risks that might result from the lack of available energy or volatile costs that consume Navy operating budgets.

"There are many things NAVSEA and the fleet can accomplish simply by changing the way they operate and changing the culture to emphasize that energy efficiency and alternative energy are critical for today's Navy and the Navy of tomorrow," Rear Adm. James P. McManamon, NAVSEA deputy commander for surface warfare, said in an April 2011 interview.

Reining in Total Ownership Costs

For several years, Team Ships—the lashup of SEA 21 and PEO Ships—has been implementing numerous total ownership cost initiatives effectively at the individual program level. The team is now elevating that approach to reduce the cost of ownership across the entire Surface enterprise. In August 2010, for example, Team Ships leaders—SEA 21's McManamon and former PEO Ships Rear Adm. William E. Landay, III—issued a

"Sailing Direction on Energy Security" that addressed the "direct impact on warfighting effectiveness" of the cost of energy.

To ensure that "direct impact," Team Ships is putting in place an integrated approach to improve energy efficiency and expand the adoption of renewable energy sources. The goal is to address increasing shipboard power demands, historically high operational tempos and the need to reduce costs. Technology development and system integration challenges will increase with the need to reduce fuel consumption, balance mission requirements, and increase available electrical power.

Team Ships is leveraging the ongoing efforts of the Navy's Task Force Energy and Maritime Working Group. Task Force Energy has been developing an energy strategy that includes op-testing of its resilience to possible future energy scenarios. The task force is the place where the innovation pipeline starts as it optimizes design and does the engineering. The task force also oversees the Maritime Energy Roadmap that charts the Navy's collaboration with other services, government agencies, industry, and academia to facilitate energy efficiency initiatives within the acquisition process and lower ownership costs. The Maritime Working Group is developing the Maritime Energy Roadmap to identify the most promising technologies for the Green Fleet for each of its 2012, 2016 and 2020 timeframes. Task Force Energy is looking for technologies having TOCs that are low-cost with near-term breakeven points.

To answer those rudder orders, SEA 21 and SEA 05 have grouped their energy-efficiency technologies into three packages that align with the three-phased rollout of the Great Green Fleet. The first target date is 2012, when the Navy plans to begin demonstrating the Green Fleet in operations near homeports. The first package consists of 11 insertion technologies—several of which in the summer of 2011 are ready for installation—to provide immediate energy efficiencies on the Fleet's conventionally powered surface ships and craft. The first technology package includes: hybrid electric drive, solid state lighting, foul release coatings, online gas turbine water wash and generator efficiency improvements, combustion trim loop, Smart Voyage Planning decision aid, stern flaps, variable-speed motor drives and alternate fuels.

Not breathtaking on an individual basis, but in the aggregate these can have significant impacts on business as usual. The technologies in NAVSEA's 2012 Green Fleet package have a 24-36-month return on investment that is well within the future year's defense plan.

Inserting Technology

Among the numerous initiatives and programs that will contribute directly to the fleet energy efficiencies, several are available now.

Hybrid-Electric Drive (HED) Propulsion. The Navy has two HED system designs: *Makin Island's* Auxiliary Propulsion System, already deployed, and the DDG 51 Flight II Class's Electric Propulsion System, currently in proof-of-concept phase and planned for installation on USS *Truxtun* DDG 103 in 2012. During *Makin Island's* two-month maiden voyage, the ship saved more than $2 million against comparable costs of the steam plant aboard the earlier ships in the class up to USS *Iwo Jima* (LHD 7). The ship logged 33 percent of her transit time on gas turbine propulsion and 67 percent of her transit time on auxiliary electric propulsion. Initial data suggest that the potential (fuel and non-fuel) savings could be as much as $6 million annually or $240 million throughout a 40-year service life. The auxiliary plant technology is also being installed in the USS *America* (LHA 6), the lead ship in what will be the Navy's first—from the keel up—"green" class of ships.

The HED propulsion plant modification allows the ship to operate in two modes: using the ship's gas turbines or the electric motor. The system that is planned for backfit in the DDG 51s offers the potential for fuel savings of 8,000 barrels or $1 million per ship, per year.

Figure 1. Green Fleet Technology Insertion Packages

Energy Efficiency Enabling Technologies		
2012	**2016**	**Future**
Hybrid Electric	Hull Hydrodynamic Mods	New Engines and Generators
Alternate Fuels	Generator Mods	Fuel Cells
Solid State Lighting	Heat Energy Recovery	Wind Energy Harvesting
Foul Release Coatings	High Efficiency Chillers	Solar Energy Harvesting
Online GT Water Wash	Energy Dashboard	Air Film Hull Drag Reduction
GTG Efficiency Improvements	Propulsion Mods	
Combustion Trim Loop	Degaussing Mods	
Smart Voyage Planning Decision Aid	Advanced RO Desalinator	
Stern Flaps	Electric Meters	
Variable Speed Motor Drives	Energy Storage Modules	
Low Solar Absorption Coatings		

Another complementary technology to HED is the ship-wide Energy Storage Module. Today, many ships operate with two gas turbine generators online to prevent a "dark-ship" condition in case of mechanical failure, even though the load could be handled by a single generator. The Energy Storage Module will allow ships to operate a single generator, potentially saving another 8,000 barrels per ship per year.

Solid State Lighting (SSL). Solid State Lighting illumination technology uses light-emitting diodes (LEDs) as sources of light rather than electrical filaments, plasma or gas. LEDs emit visible light when a direct current is passed through them. Luminaries are designed to use numerous small, point-source lights. The potential fuel savings are not dramatic, on the order of 500 barrels per year for a guided missile destroyer. But, assuming $96 per barrel and 65 or so DDGs in the active forces, the Navy could avoid more than $3 million in annual fuel costs. SSL technologies in mid-2011 were onboard the USS *Wasp* (LHD 1), USS *Iwo Jima* (LHD 7), USS *Pearl Harbor* (LSD 52), USS *Chafee* (DDG 90) and USS *Wayne E. Meyer* (DDG 108).

The Green Fleet initiatives will reduce the U.S. Navy's surface ship carbon footprint, enhance efficiencies and lower total ownership costs.

Anti-Fouling Coatings. The Fleet Readiness R&D Program is sponsoring ship demonstrations for two different anti-fouling coating applications. The Aegis guided missile destroyer USS *Cole* (DDG 67) and Aegis cruiser USS *Port Royal* (CG 73) are demonstrating hull coatings, and the USS *Gunston Hall* (LSD 44) is demonstrating propeller coatings. Fouling-release underwater hull coatings mitigate biofouling without relying on biocides. Operators of commercial ships with high operational tempo claim the use of these types of coatings can result in an annual fuel savings of more than 10 percent. Potential fuel savings for a DDG is on the order of 1,800 barrels per year.

Gas Turbine Online Water Wash. Water-wash technology applies to gas turbine generators when they are periodically shutdown and washed to improve compressor performance and extend operating life. The online water wash system allows performance of the compressor wash while the engine is in operation. For affordability, it uses and augments the existing offline wash equipment architecture. In mid-2011 installed in the USS *Preble* (DDG 88), the online water wash will reduce fuel consumption, reduce maintenance costs and improve starter life by extending the time between offline washes. In the interim periods, it will keep the compressor section of the gas turbine cleaner and more energy efficient.

Combustion Trim Loop. The Navy has begun installing combustion trim loop systems onto USS *Wasp*-class (LHD 1) amphibious ships to improve fuel efficiency and save up to 2,400 barrels of fuel per ship annually. This system optimizes the fuel-air mixture for the ship class's two boilers, making them more efficient. The USS *Bonhomme Richard* (LHD 6) and USS *Blue Ridge* (LCC 19) are currently having the system installed, following system validation on board USS *Peleliu* (LHA 5), which completed in July 2010. LHDs 1 through 7 will receive the new system by the end of 2016.

Stern Flaps. The first SEA 05 Fleet Readiness Research and Development Program (FRR&DP) project to complete the process has been the installation of stern flaps on two amphibious class ships. Stern flap technology improves a ship's hydrodynamic characteristics by reducing drag. In April 2009, the USS *Whidbey Island* (LSD 41) was the first amphibious ship to receive the flaps. Based on the data from previous stern flap insertions, the expected fuel efficiencies could yield savings as much as $450,000 in fuel costs per ship annually, based on a fuel price of $96 per barrel. The USS *Kearsarge* (LHD 3) was the second amphibious ship to install a stern flap. Once stern flaps are fleet-wide on all LSDs and LHDs, the Navy expects the project to yield an annual savings of some $6.3 million. Additional installations will go on *Arleigh Burke*-class (DDG 51) Aegis destroyers, *Ticonderoga*-class (CG 47) Aegis cruisers, *San Antonio*-class (LPD 1) amphibious transport dock ships and *Cyclone*-class (PC 1) coastal patrol craft.

Smart Voyage Planning (SVP) Decision Aid. SVP is a tool that allows the Navy to make smarter decisions during in-transit operations. The software application uses hull-form data combined with real-time weather and current information to compute the best route and optimize ship routing on fuel savings. Shipboard applications would extend and interface with the Electronic Chart Display and Information System—Navy (ECDIS-N). The SVP tool would also be used ashore for Fleet Forces ship scheduling. By using real-time data and computing power to plot routes, SVP has the potential to save 4 percent in annual fleet-wide fuel costs. The SVP Decision Aid is on board the USNS *Carl Brashear* (T-AKE 7) dry cargo/ammunition ship and is used at the Naval Maritime Forecast Centers in Norfolk, Va., and Pearl Harbor, Hawaii.

The Biofuels Promise. The operational side of the Great Green Fleet initiative begins in 2012 when the Navy will demonstrate a green strike group of two destroyers and a cruiser running on biofuels in local operations. In 2016, the second phase, it will fully deploy the Great Green Fleet aircraft carrier strike

group keyed to a major exercise. All surface warships will run on hybrid-electric drive and alternative power systems using biofuel. By 2020, Green Fleet phase three, Mabus wants half of the surface Navy's fuel consumption to be alternative fuels. The candidate alternative fuel must meet fuel requirements, will require no change to the ship and can be mixed or alternated with petroleum fuel.

In 2010, the Naval Surface Warfare Center's Carderock Combatant Craft Division completed an at-sea HRD-76 biofuel demonstration on a 7-meter rigid hull inflatable boat at Fort Monroe, Va. CCD then tested a 50/50 blend of NATO F-76 diesel fuel and an algae-based biofuel on the next-generation 49-foot riverine command boat experimental (RCB-X). The RCB-X clocked 44.5 knots and performed sudden stops, reversals, circles, and tight U-turns. NAVSEA conducted the first full-scale diesel component and engine test on a Cummins QSB marine diesel engine, which ran for 256 hours without a hitch. The road map for shipboard demonstrations includes milestones leading to a biofuels introduction into the fleet in 2012.

The Great Green Fleet is not about making the "business case" for biofuels. It has a much broader impact. The Green Fleet initiatives will reduce the U.S. Navy's surface ship carbon footprint, enhance efficiencies and lower total ownership costs. "There's very little funding to jump-start new programs," McManamon explained, "so we are starting with proven technologies and systems and looking for the low-hanging fruit that cumulatively will have significant impacts on the overall Navy—not simply an individual ship or class."

Making Way for the Great Green Fleet

A century ago, President Theodore Roosevelt remarked how "Bully!" it was to witness 16 white-painted battleships of the U.S. Atlantic Fleet and their escorts pass Hampton Roads, Va., in review. "Did you ever see such a fleet and such a day?" he exclaimed that December 1907 morning.

But there was a serious purpose for the Great White Fleet, in addition to broad patriotism. "I want all failures, blunders and shortcomings to be made apparent in time of peace and not in time of war," the president said before the Fleet deployed on its year-long, around-the-world cruise. Only this way could he be assured of a "Navy second to none."

Today, the Great Green Fleet represents an ongoing demonstration and deployment of small, incremental energy efficiency efforts and initiatives that have potentially large—if not game-changing—impacts throughout the Navy. Much like the transition from sail, to coal, to oil....

When it comes to the promise of the Great Green Fleet, McManamon noted, "We're hitting a lot of 'singles' but not many home runs, yet. Those will come."

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