NAVSEA Reducing Fleet Energy Consumption

Shipboard Efficiencies Include Hybrid Electric Drive

IN ANY DRIVEWAY across America, it's not uncommon to see two vehicles: one shiny and new with the latest technology and efficiencies; the other older, and a bit of a gas-guzzler.

While it would be ideal to always have two new cars, economically, it doesn't work. The older model is still meeting the family's needs, and represents a significant investment. Instead, most invest in regular maintenance; add on systems, such as Global Positioning System; and use recommended driving techniques to make the vehicle operate more efficiently.

It's not that different for the Navy's Fleet. Newer ships joining the Fleet have the latest engineering advancements and efficiencies, but aging ships are equally valuable assets that must be maintained, modernized, and operated as efficiently as possible. During 2011, the Naval Sea Systems Command (NAVSEA) enterprise explored a number of initiatives targeted at improving efficiencies and reducing energy consumption of the U.S. Navy Fleet. These initiatives directly support the Navy's energy goals to ensure combat capability, and reduce dependence on foreign oil.

The Hybrid Electric Drive

In 2011, NAVSEA's Surface Warfare Directorate (SEA 21), Program Executive Office for Ships (PEO Ships)

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> *–Dr. Timothy McCoy*

HEDs intended for operation in DDG 51-class destroyers have the potential to save the Navy more than $250 million in fuel costs over a 40-year service life of an individual ship.

USS Makin Island was the first U.S. Navy ship with an HED.
MC1 Douglas Bedford

and NAVSEA's Engineering Directorate (SEA 05) continued explorations into propulsion and power system variants designed to reduce ships' fuel consumption with a land-based proof-of-concept test for a Hybrid Electric Drive (HED) system intended for operation in DDG 51-class destroyers.

"Hybrid drive doesn't denote any one particular system. The term just means a combination of two things—such as the system found on LHD 8; steam and sail on the USS Trenton; or even the paddle wheel, screw propeller, and sails of the SS Archimedes built in Britain back in 1839," explained Dr. Timothy McCoy, PEO Ships Electric Ships Office program manager. "We're maturing and transitioning a number of technologies to support our ships' future power and energy needs more affordably."

USS Makin Island (LHD 8) was the Navy's first big deck amphibious ship to replace steam boilers with gas turbines, and the first U.S. Navy ship with an HED. LHD 8's particular HED-system has an electric motor attached to the mechanical drive's main reduction gear, and uses ship service generator power at low ship speeds, where gas turbines are least efficient. Over her 40-year-service life, Makin Island is expected to save the Navy more than $250 million in fuel costs. The LHA 6-class will use this same HED system.

NAVSEA's latest HED system for DDG 51-class ships also seeks to reduce total fuel consumption, and uses the Ship Service Gas Turbine Generators (SSGTG) to power a motor attached to a main reduction gear. At low speeds, SSGTGs provide propulsion instead of the LM 2500 main engines. Using HED-mode, DDGs are expected to achieve six percent fuel savings. Naval Surface Warfare Center Carderock Naval Ship Systems Engineering Station (NAVSSES) is supporting efforts to design, integrate, test, and provide logistics for an at-sea demonstration of the system.

"In addition to HED proof-of-concept work, NAVSSES completed a trade study comparing various different types and sizes of HED solutions for capability and cost savings," said Patricia Woody, NAVSSES Machinery Research and Engineering department head. "Working with NAVSEA Technical Warrant Holders, NAVSSES led the development effort that resulted in the technical specification for a DDG-51 HED back-fit solution."

The Energy Storage Module

Another energy initiative that made significant progress in 2011 is the Energy Storage Module (ESM).

In most cases, DDG 51's electrical energy needs can be supplied by a single generator set. However, because crews cannot afford the risk of waiting for a second generator set to power up should the first fail, two sets are typically operating underway

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to ensure power reliability. To improve efficiency, NAVSEA began testing an Energy Storage Module prototype developed by the Office of Naval Research (ONR).

ESM is a large, uninterruptible power supply that provides a reliable source of backup power. When multiple units are installed as a system, ESMs provide enough backup emergency power to support the ship's electrical bus following a loss of generator casualty and ensure the system fault does not result in a "dark ship," or loss of all onboard electrical power. (Note: The ship's electric bus is the backbone of a ship's electrical distribution system and connects the main electrical generators to the ship's electrical loads.)

ESMs are not intended as a replacement for existing generator sets. Instead, they provide backup power to ship's systems, giving the crew time to start up another generator set in the event the primary set fails.

"The ESM proof of concept is a 600 kilowatt AC/DC, bi-directional advanced power converter with associated battery strings," said Woody. "Under a joint effort between ONR, PEO Ship's Electric Ships Office and NAVSEA's Fleet Readiness Research and Development Program (FRR&DP), the equipment was delivered and installed in a modified ISO shipping container. The system is being tested at NAVSSES to simulate shipboard conditions as close as possible and demonstrate ESM over a range of scenarios that could exist on a DDG 51 electrical plant."

By enabling single generator operations, ESMs are projected to provide

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Energy Dashboard proof-of-concept systems were installed in USS Chafee (top) and USS James E. Williams (right) in 2011.

Advanced Solid State Lighting uses Light Emitting Diodes (LED) to replace conventional fluorescent and incandescent lights. LED replacements require less than 20 percent of the power of equivalent incandescent bulbs, and last close to 100 times longer. Compared to fluorescent lights, LEDs are 50 percent more energy efficient, last seven to ten times longer, and are not considered hazardous waste.

the Fleet with a potential annual fuel savings of more than 5,000 barrels per ship/year. An ESM prototype is anticipated to be tested on a destroyer in 2012. NAVSEA has started planning for a production ESM to be delivered to the Fleet in 2016.

Training the Fleet on Sound Fuel Consumption Practices

While innovative engineering advancements are improving shipboard efficiencies, the manner in which ships are operated by the Fleet also has a significant impact on fuel consumption.

Since the 1990s, the Incentivized Energy Conservation (i-ENCON) program has trained ship crews how to modify operational procedures, strategies, and techniques to reduce energy consumption.

The Smart Voyage Planning Decision Aid (SVPDA) and Shipboard Energy Dashboard are two tools NAVSEA is testing to give Sailors that valuable information. These tools are similar in concept to the computer displays found in most new cars today that give drivers visual feedback on the best navigation routes and how to operate the vehicle to get the best miles per gallon.

SVPDA, a computer software module that uses the ship's Electronic Chart Display and Information System—Navy (ECDIS-N) and available capabilities from the Naval Meteorology and Oceanography Command, takes advantage of optimized route planning whenever missions allow. NAVSEA is analyzing an SVPDA solution that will reduce energy consumption by exploiting real-time knowledge of the physical environment such as weather, waves, currents, and ship-specific hydrodynamic and propulsion data.

The application will be used by the Navy's Fleet Weather Centers in Norfolk and San Diego to push optimized routes to Navy ships for maximum fuel efficiency and safety. Fleet-wide use of SVPDA is expected to save 373,000 barrels per year for a four percent annual fuel savings.

Along with SVPDA, NAVSEA also continued field development tests on the Energy Dashboard in 2011. The dashboard is a computer software update installed in the

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existing Integrated Condition Assessment Systems (ICAS) that provide Sailors a real-time assessment of energy usage and recommended actions to reduce fuel consumption. The dashboard also tracks and displays instantaneous and daily energy consumption rates.

"Energy Dashboard is similar to the systems in today's newer vehicles that show drivers their instantaneous miles per gallon, allowing drivers to modify their driving behaviors to maximize fuel efficiency," said Glen Sturtevant, Team Ships director for Science and Technology. "Energy Dashboard ties into other shipboard computer software systems to tell Sailors the same thing about their ship."

"Energy Dashboard will raise shipboard situational awareness of how certain engineering plant line-ups and equipment affect fuel consumption rates, and will build ownership in energy conservation efforts by showing how the actions instantly and dramatically affect consumption rates," said Bob Steele, director, Fleet Readiness Engineering Office.

"NAVSSES has been supporting Energy Dashboard efforts by collecting energy-related ICAS data to understand how ships operate so we can create energy baselines," explained Woody. "The primary focus has been on DDG 51-class Flight IIA, and we have created energy summary data reports for our In-Service Engineering Agents (ISEA) and other subject matter experts."

Energy Dashboard proof-of-concept systems were installed in USS James E. Williams (DDG 95) and USS Chafee (DDG 90) in 2011. These systems will measure propulsion gas turbine, gas turbine generator, and AC plant energy consumption. Additional dashboard testing is anticipated in other ships in 2012, and is expected to be fielded in other Surface Ships.

In addition to these efforts, SEA 21 plans to install stern flaps on three ships, solid state lighting in five ships, combustion trim loop in five ships, and coat two ship propellers with advanced coatings in 2012. SEA 05 and PEO Ships continue to perform research, development, and testing on new initiatives including upgrades to LM2500, a bow bulb for DDG-51s, and thermal management control systems.

NAVSEA's engineering collaborations in 2011 also supported the Navy's smaller vessels.

For Special Operations Forces, Naval Surface Warfare Center Panama City continued development of a small-boat outboard engine providing operators the option to burn JP-5, JP-8, diesel, bio-diesel, or gasoline. Such flexibility reduces strategic, operational and tactical vulnerabilities in wartime environments.

"No single technology will enable the Navy to achieve its energy goals," said NAVSEA's Chief Engineer and Deputy Commander for Naval Systems Engineering, Rear Admiral Thomas Eccles. "Instead a collection of technologies is being researched, developed and fielded synergistically." ⚓

For More Information

FOR MORE INFORMATION on NAVSEA's ongoing energy initiatives, visit http://www.navsea.navy.mil/OnWatch/energy.html.

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