Naval Energy Forum

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Director, Electric Ships Office (PMS 320)

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• Mission Systems Requirements
• Today’s Platforms
• Looking into the future
“OUR SHIPS – THE SYSTEMS THAT WE USE AND THE POWER REQUIREMENTS THAT THEY HAVE ARE GETTING BIGGER ALL THE TIME. EVERY SYSTEM WE’RE PUTTING ON A SHIP NOW OR IN AN AIRCRAFT IS IN SOME WAYS SORT OF A POWER HOG... WE HAVE TO FIND A DIFFERENT WAY TO POWER THE THINGS WE NEED TO POWER.”

- HONORABLE RAY MABUS
SECRETARY OF U.S. NAVY

“OVER THE NEXT 10 TO 15 YEARS, THE NAVY WILL EVOLVE AND REMAIN THE PREEMINENT MARITIME FORCE. THE REACH AND EFFECTIVENESS OF SHIPS AND AIRCRAFT WILL BE GREATLY EXPANDED THROUGH NEW AND UPDATED WEAPONS, UNMANNED SYSTEMS, SENSORS, AND INCREASED POWER.”

- ADMIRAL JONATHAN GREENERT
CHIEF OF NAVAL OPERATIONS

Fundamental Shift Required for Future Acquisition Programs
Warfighting Needs Drive Power Systems

Increased demands for power will continue for the foreseeable future

Available Power (Electric Power Online)

Age of Guns
Age of Guns and Missiles
Age of Guns, Missiles, Directed Energy & Hypervelocity Weapons

Integrated Architectures
Affordability Gap
Traditional Architectures
**SECNAV Energy Goals**

15% Reduction in Fuel Consumption from FY 2008 Baseline

- **Petroleum** 72%
- **Nuclear** 28%
- **Bio Fuels**

Reduce Consumption Through Conservation and Efficiency

- FY 2008
- **2012 Green Strike Group Demo**
- FY 2020
- **2016 Great Green Fleet Deployment**
### Opportunities for Energy Savings

- **Prime Movers**
  - Technical advances
  - Combined cycles

- **Ship Propulsion**
  - Propulsor efficiency
  - Hullform resistance
  - Energy Recovery

- **Electrical Loads**
  - Fans / Pumps
  - Mission Systems
  - Lighting
  - VFD’s

- **Operating Concepts**
  - Alternate Architecture optimizes efficiency

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**Alternate Architectures Maximizes Energy Savings**
Evolutionary Ship Efficiency Gains

Shifting to Integrated Approach

- Operational Energy Requirement
  - Key Performance Parameter
  - Energy-Efficiency Initiatives
  - Life-Cycle Cost Estimates
  - Fully-Burdened Cost of Fuel

- Future Fleet: Next Navy
  - Advanced Hull Forms
  - Integrated Power Systems

COMPONENT BASED APPROACH
ENERGY效率 FOCUS

INTEGRATED REQUIREMENTS BASED APPROACH

PEO SHIPS FOCUS ALIGNED WITH NAVY ENERGY STRATEGY

FEDERATED APPROACH
REDUCED TOC FOCUS

- Hybrid Electric Drive
- Energy Storage Modules
- Smart Voyage Planning
- Advanced Power Generation
- Solid-State Lighting Upgrades

- Stern Flap
- Upgraded Ship Controls
- All Electric Modifications

PREVIOUS
CURRENT
FUTURE

Distro A: Approved for Public Release. Distribution is unlimited
Component Efficiency Gains

Hybrid Electric Drive
Electric Propulsion System

Advanced Power
Generation Module

Energy Storage
Module

Solid State
Lighting

Smart Voyage
Planning

Energy Efficiency
Focus
Mission Systems: Increasing Electrical Power Demands

Deployed Mission Capability

- 2014: 0.4 MW
- 2014: 0.4 MW
- 2016: 2 MW
- 2020: 30 MW
- 2020+: 20 MW

Weapon System Development
- TRL=6
- Active Denial System

Weapon Development
- TRL=4/5
- Laser Weapons
- Solid State Laser

Technology Development
- TRL=3/4
- Electro-Magnetic Rail Gun
- Free Electron Laser

Power Demands per Mount
Multiple Mounts per ship

Sensor and Weapon System Power Demands will soon rival Propulsion Power Demands
## Other Naval Key Technologies

### UK (23 + IPS/hybrid ships)
- Type 23 Frigate, in-service – hybrid electric/mechanical drive
- Type 45 Destroyer, in-service – full Integrated Power System
- Albion Class LPD, in-service – full Integrated Power System
- Wave Class Oiler, in-service – full Integrated Power System
- CV(F) under contract – full Integrated Power System

### Netherlands (2 ships)
- LPD “Rotterdam” Class, in-service – full Integrated Power System
- IPS declared for future surface combatants

### France
- BPC (LPD) in-service, Podded Integrated Power System
- Future CV in design – full IPS, maybe Pods

### France, Italy, Greece, Morrocco
- FREMM Frigate – Hybrid Drive (28 planned, 4 under construction)

### Australia (2 ships)
- Canberra Class LPD - Podded IPS
- Collins Class SSG - diesel-electric

### Germany
- U-212 Submarines
  - Diesel Electric w/ PM Motors
  - AIP systems using fuel cells

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Other Navies are already experiencing the benefits.
• Numerous near-term efforts underway to provide modest fuel savings

• Greater gains are possible through fundamental changes in architectures and design philosophy
Backups
## Today's Platform Initiatives

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<tr>
<th>PLATFORM</th>
<th>RESULTS</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Amphibious Assault (LHD 8 and LHA 6)</strong>&lt;br&gt; - The first U.S. Navy amphibious ship built with Gas Turbine Engines and Hybrid Electric Drive resulting in <strong>significant fuel savings compared with steam driven LHD</strong></td>
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<tr>
<td><strong>Combat Logistics Force (T-AKE)</strong>&lt;br&gt; - T-AKE is powered by a commercial Integrated Power System, realizing <strong>reduced acquisition and life cycle costs</strong></td>
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<td><strong>Surface Combatants (DDG 51)</strong>&lt;br&gt; - USS TRUXTUN (DDG 103) Hybrid Electric Drive (HED) and USS PREBLE (DDG 88) Energy Storage Module (ESM) to <strong>demonstrate significant reductions in fuel usage</strong>. HED acquisition program underway to backfit Flight IIA ships</td>
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**Enhanced Operational Capability at Reduced Costs**
U.S. Navy Fuel Usage and Trends

- Surface ships account for 40% of Navy fuel consumption

- Fuel cost uncertainty increase since FY03 (~400% per bbl)

- Energy (fuel) Demand Increasing
  - Combat / Weapons Power
  - Force Structure Changing: Higher Fuel Consumption
  - Operational Requirements

- Why focus on DDG 51 Class?
  - Provides best opportunity for long term payoff given platform age, production restart, and quantity
DDG 51 Hybrid Electric Drive

DDG's operate over 50% of the time at 14kts or below.

8,000 bbls of fuel saved per ship
Where the losses are:
Energy Flow for Electric Ship

- 62% of energy goes to the air
- 15% of energy
- ~22% of fuel energy provides useful work.
- The rest is left behind in the water or air.
## Todays Platform Initiatives

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<td>Aircraft Carriers (CVN)</td>
<td>- Compared to steam catapults, EMALS weighs less, occupies less space, requires less maintenance and manpower, is more reliable, and uses less energy</td>
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<td>Surface Combatants (DDG 1000)</td>
<td>- ZUMWALT’s Integrated Power System (IPS) combines 78MW of installed power generation for propulsion and ship service into a single unified electrical system</td>
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<td>Submarines</td>
<td>- Replacing conventional hydraulic systems with electric actuators realize significant savings in installation and maintenance costs as well as being cleaner and more safe</td>
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**Enhanced Operational Capability at Reduced Costs**
Where the Losses are:
Energy Flow for Mechanical Drive Ship

LOADS:
- Pumps
- HVAC
- Combat

η = varies

Prime Mover η = .40
Generator η = .96
Main Power Distribution η = .99

Prime Mover η = .40
Reduction Gear η = .98
Shafting η = .99

Propeller η = .60

Fuel

62% of energy goes to the air
15% of energy goes to the sea

Work

- 1% Radiated Energy
- Acoustics
- Electromagnetic
- Kinetic

• ~18-20% of fuel energy provides useful work.

At design operating point