



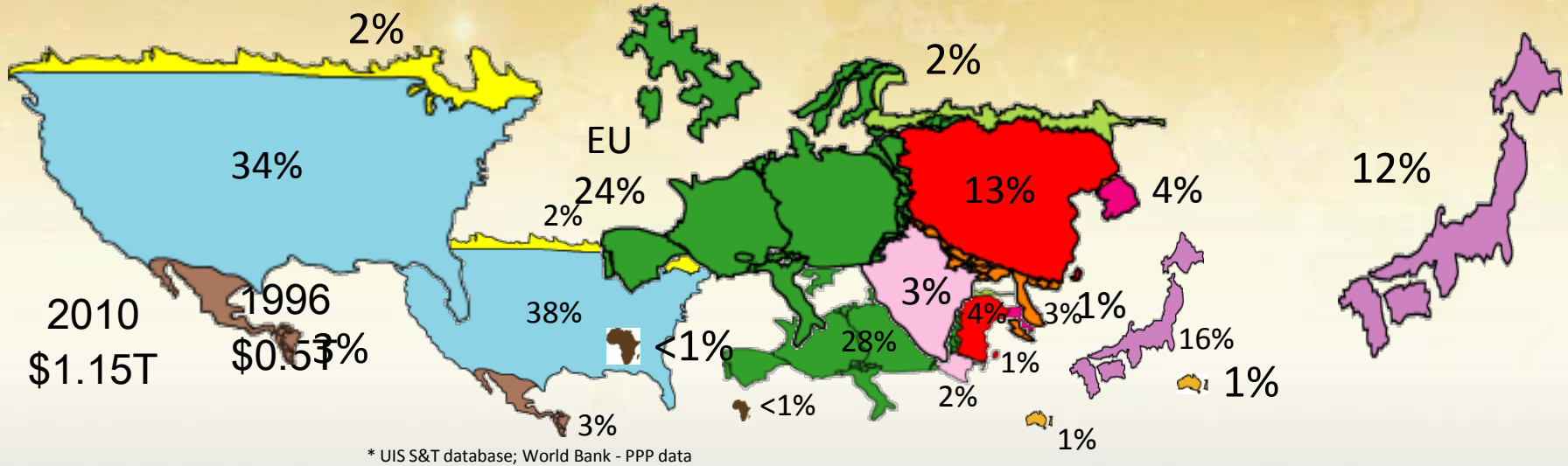
Naval Energy Science & Technology Research

RADM Nevin P. Carr
Chief of Naval Research
October 14, 2011



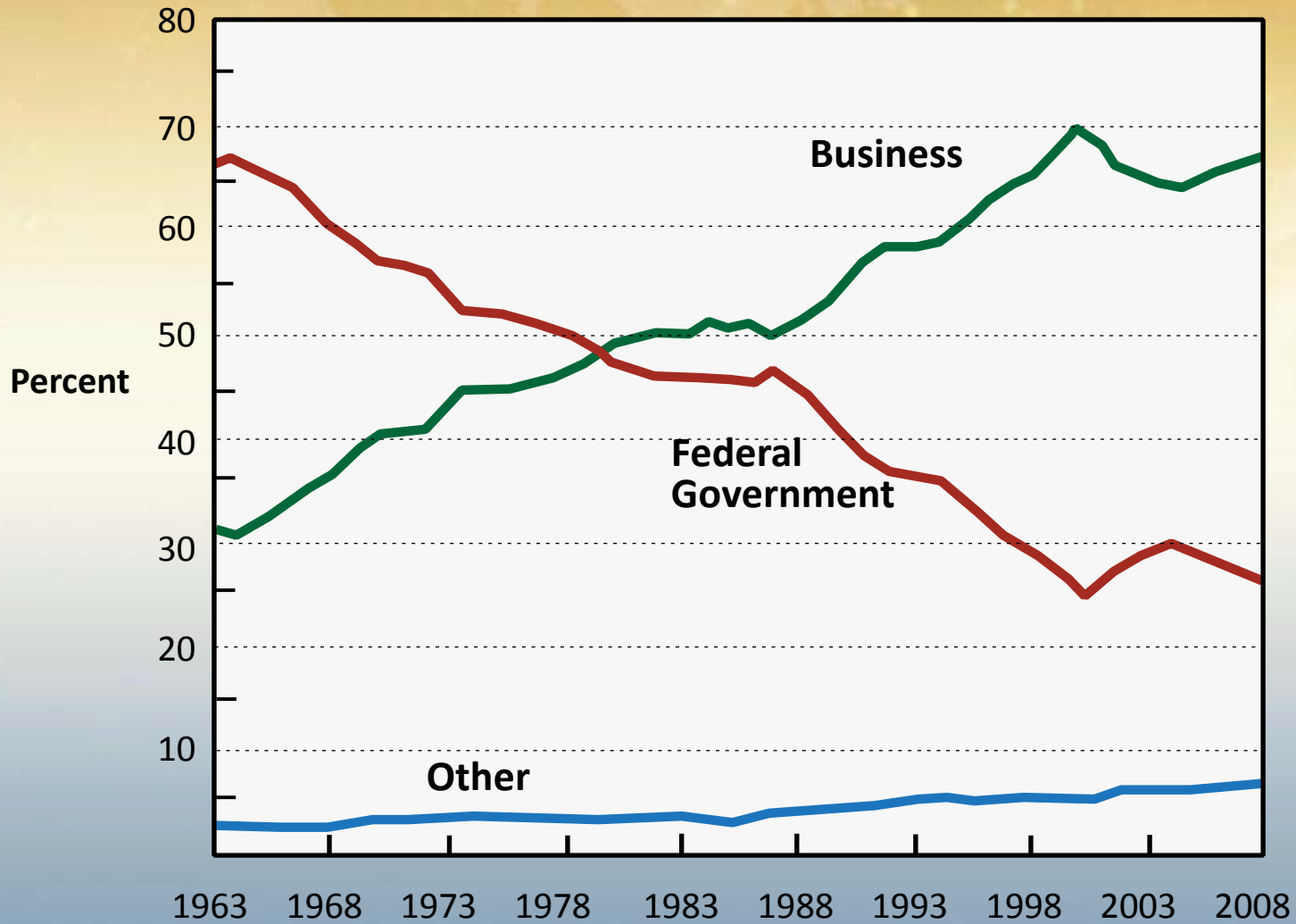
O F F I C E O F N A V A L R E S E A R C H

Global R&D Trends



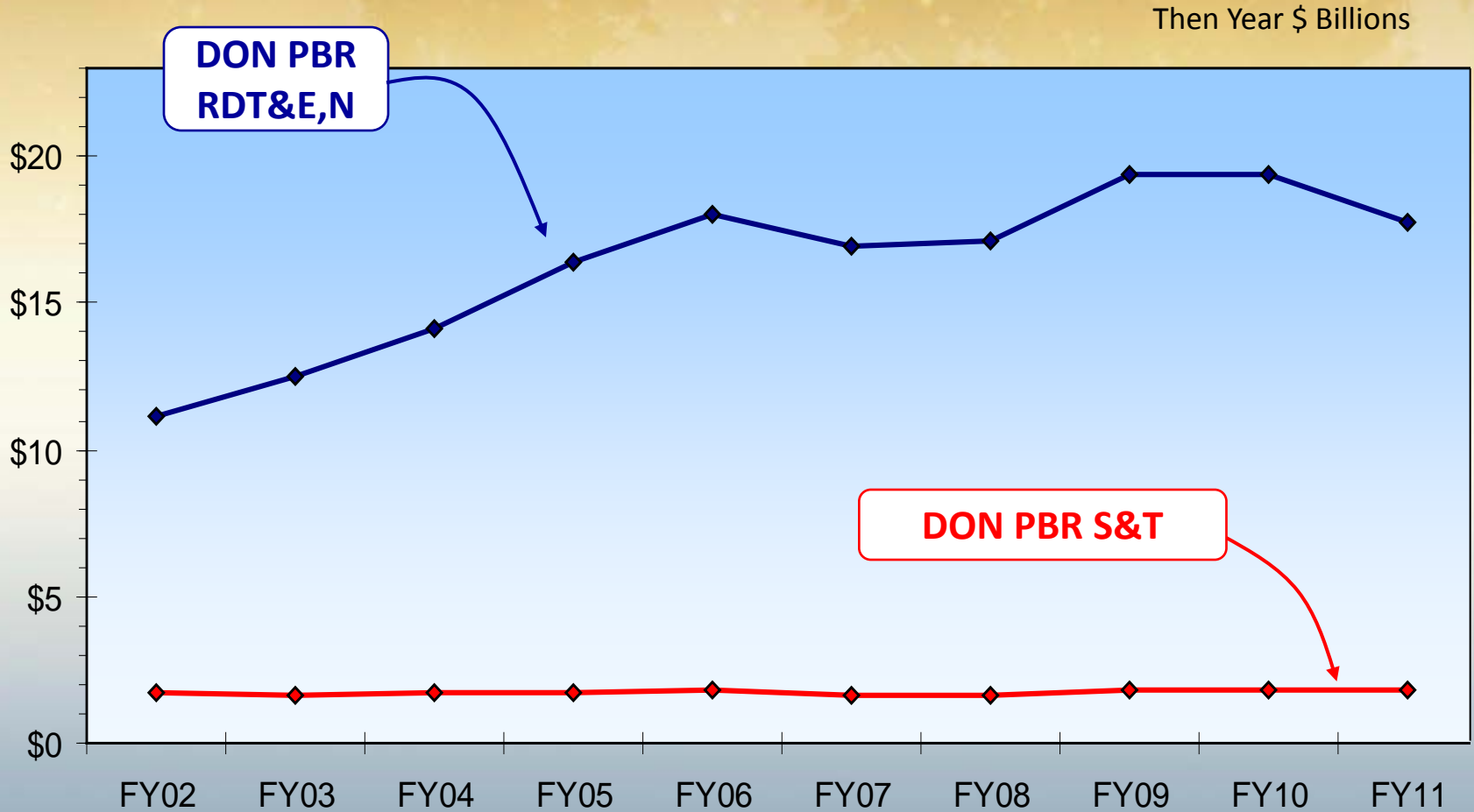
** OECD 2010 PPP; 2010 Global R&D Report (Battelle)

R&D Investment Trends



Source: National Science Foundation, Division of Science Resource Statistics,
Science and Engineering Indicators 2010

RDT&E 6.1 – 6.7 Trend



SECNAV's Energy Goals

- **Energy Efficient Acquisition: Evaluation of energy factors are mandatory when awarding contracts for systems and buildings.**
- **Sail the "Great Green Fleet": DON will demonstrate a Green Strike Group in local operations in 2012 and sail it by 2016.**
- **Reduce Non-Tactical Petroleum Use: By 2015, DON will reduce petroleum use in the commercial fleet by 50%.**
- **Increase Alternative Energy Ashore: By 2020, DON will produce at least 50% of shore-based energy requirements from alternative sources; 50% of DON installations will be net-zero**
- **Increase Alternative Energy Use DON-Wide: By 2020, 50% of total DON energy consumption will come from alternative sources**



Interagency Cooperation

Encourage Maximum Use of Renewable Energy

Strategic Partnership to Enhance Energy Security

Development and Support of a Sustainable Biofuels Industry

MEMORANDUM OF UNDERSTANDING
between the
DEPARTMENT OF AGRICULTURE
and the
DEPARTMENT OF THE NAVY

I. Purpose and Basis for this Memorandum of Understanding
This Memorandum of Understanding (Agreement) formalizes a relationship between the United States Department of the Navy (DON) and the United States Department of Agriculture (USDA) (hereinafter collectively referred to as "the Parties").

This Agreement establishes that the Parties agree to encourage maximum use of renewable energy, including outreach to other Federal, State, Local, and Tribal entities, as well as private entities, with the goal of providing technical assistance and financial products to these entities for the development of advanced biofuels and other renewable energy systems. The Federal Government, States, local governments, counties, utilities, private sector, non-governmental organizations, and other entities must all take steps to decrease nationwide energy use through the investment in and effective utilization of new, more efficient technologies, while also emphasizing the development of renewable energy projects.

Through this Agreement, the Parties will work together to support President Obama's initiative to reduce energy consumption derived from fossil fuels, and to increase energy production from renewable energy sources. Today, the United States depends on imported fossil fuels to meet over 60 percent of its energy needs. This dependence leaves the United States vulnerable to supply disruptions and highly volatile energy prices. Fortunately, the United States has abundant natural resources, including wind, solar, hydrokinetic, ocean thermal, and geothermal sources for electricity generation, and land for energy crops that can be refined into biofuels to meet both commercial and military transportation needs. The Parties are in agreement that developing the United States' renewable energy economy promises to make the United States a global leader in the production of sustainable, clean, and economically beneficial energy.

21 January 2010

Navy & Agriculture

Memorandum of Understanding
Between
U. S. Department of Energy
And
U. S. Department of Defense
Concerning Cooperation in a Strategic Partnership to Enhance Energy Security

I. Purpose
The purpose of this Memorandum of Understanding (MOU) is to identify a framework for cooperation and partnership between the Department of Energy (DOE) and the Department of Defense (DOD), hereinafter referred to as the Parties, to strengthen coordination of efforts to enhance national energy security, and demonstrate Federal Government leadership in transitioning America to a low carbon economy. The MOU covers, but is not limited to, efforts in the areas of energy efficiency, renewable energy, water efficiency, fossil fuels, alternative fuels, efficient transportation technologies and fueling infrastructure, grid security, smart grid, storage, waste-to-energy, basic science research, mobile/deployable power, small modular reactor nuclear energy, and related areas.

II. Legal Authority
DOE enters into this MOU under the authority of section 646 of the Department of Energy Organization Act (Pub. L. 95-61, as amended, 42 U.S.C. § 7236). DOD enters into this MOU under the authority of DOD Instruction 4006.19 "Inter-Service and Inter-Governmental Support" August 9, 1995.

III. Background
In the 2010 Quadrennial Defense Review, the DOD expressed an intent to pursue with other U.S. agencies to research, develop, test, and evaluate new sustainable energy technologies. The DOD aims to speed innovative energy and innovative technologies from laboratories to military and uses, and to use military installations as a test bed to demonstrate and create a market for innovative energy efficiency and renewable energy technologies coming out of DOE laboratories, among other sources. The DOE is currently supporting a range of projects aimed at improving energy efficiency and renewable energy efforts across the military services.

July 22, 2010

Defense & Energy

MEMORANDUM OF UNDERSTANDING
BETWEEN
THE DEPARTMENT OF THE NAVY
AND
THE DEPARTMENT OF ENERGY
AND
THE DEPARTMENT OF AGRICULTURE

On 30 March 2011, President Barack Obama directed the Parties to work with private industry to create advanced drop-in biofuels that will power both the Department of Defense and private sector transportation throughout America.

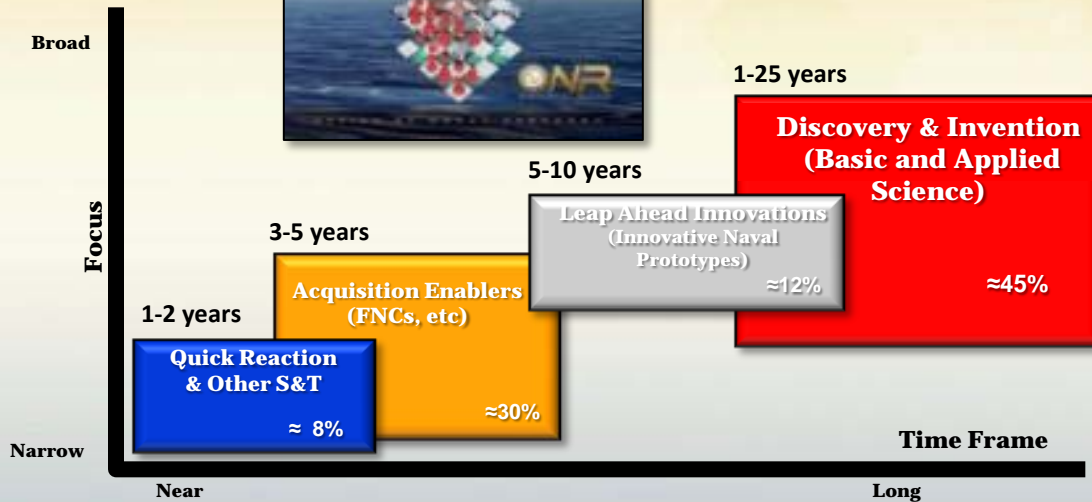
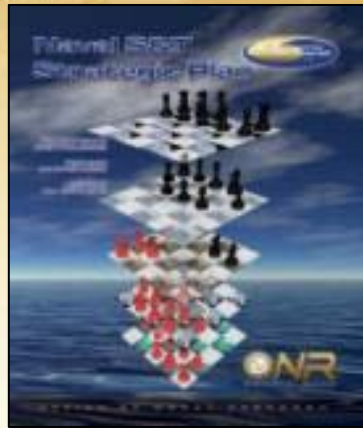
This Memorandum of Understanding (MOU) by and between the Department of the Navy (DON), Department of Energy (DOE), and the Department of Agriculture (USDA), hereinafter referred to as the Parties, is entered into to initiate a cooperative effort by the Parties to assist the development and support of a sustainable commercial biofuels industry and to foster mutual cooperation of the parties to achieve the goals and objectives further described herein.

4. Background
A robust advanced drop-in biofuels market is an essential element of our national energy security. Energy security for the Nation requires unrestricted, unconstrained access to affordable energy sources to power our economy and our military. Traditional fossil-fuel based petroleum is derived from crude oil that has increasingly challenging market and supply constraints. Chief among these is limited, unevenly distributed, and concentrated global sources of supply. America's growing dependence on foreign sources of crude oil undermines foreign policy objectives and poses at an ever increasing impact to the Nation's trade imbalance. In recent

June 2011

Navy, Energy & Agriculture

Naval Strategic Plan



Focus Areas:

- Assure Access to Maritime Battlespace
- Autonomy & Unmanned Systems
- Expeditionary & Irregular Warfare
- Information Dominance
- Platform Design & Survivability
- *Power & Energy*
- **Strike & Integrated Defense**
- Total Ownership Cost
- Warfighter Performance



Tech Solutions



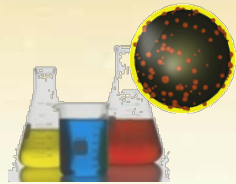
FNCs



INPs

Power & Energy Chain

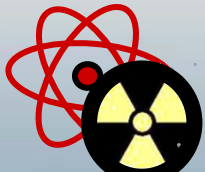
Fuel



Fuels Chemistry



Alternative Fuels



Nuclear
NAVSEA 08
Naval Reactors

Power Generation



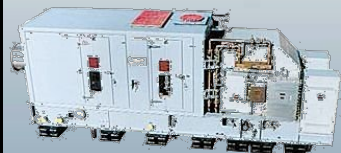
"Ion Tiger"
UAV Fuel Cell



Fuel Cells



Aircraft Engines

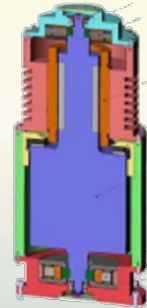


Gas Turbine Generators

Energy Storage



Batteries

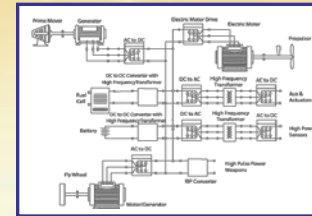


Flywheels

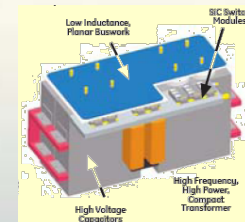


Capacitors

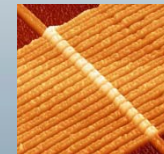
Distribution & Control



Electrical Architectures
& Pulse Forming
Networks



High Voltage Silicon
Carbide (SiC) Switches



Memristors

Power Loads



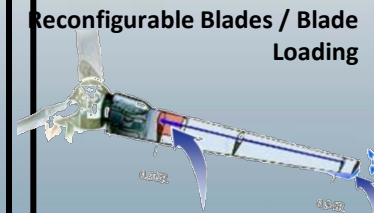
Electric
Weapons



Powering & Resistance

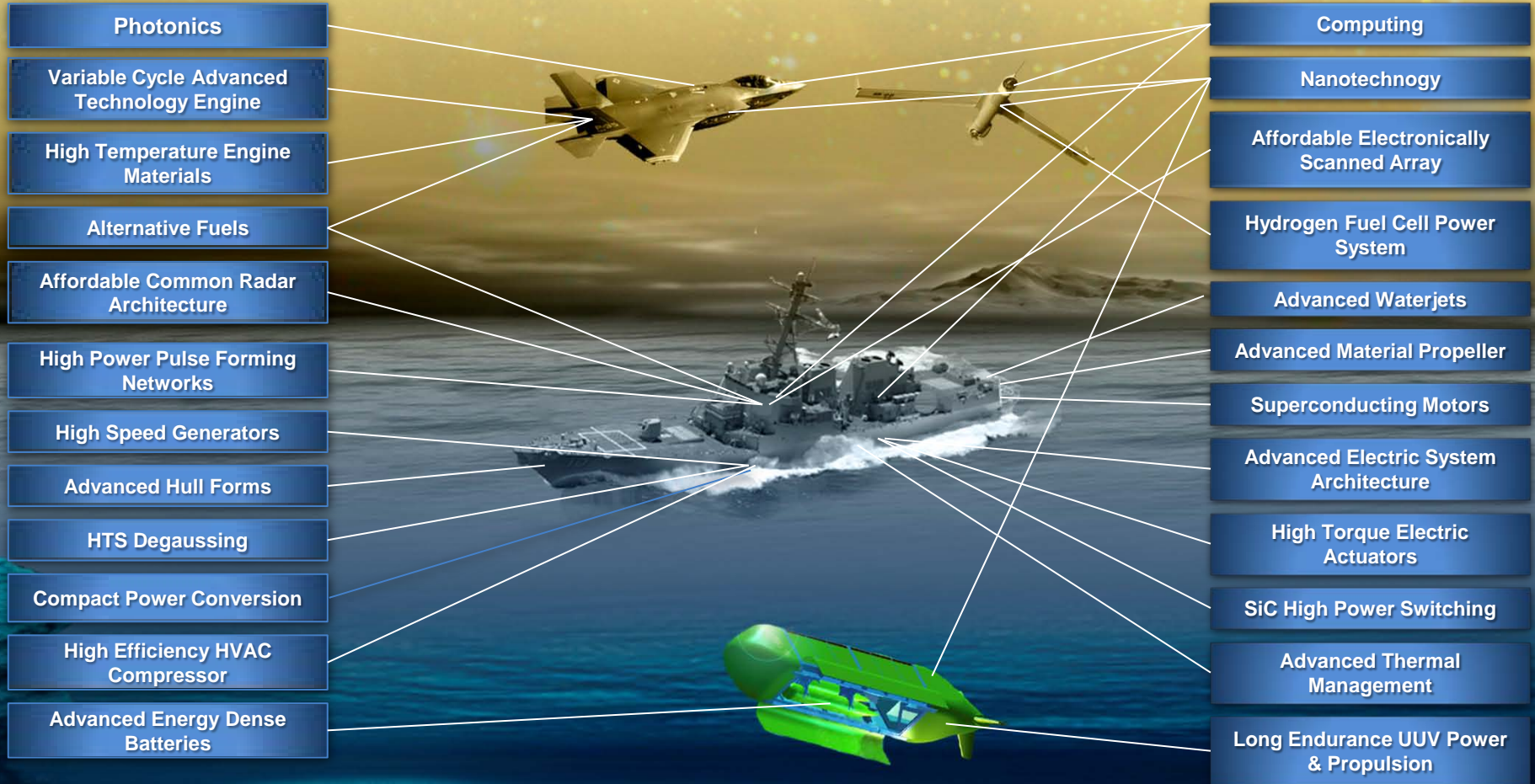


UV Sensor Loads

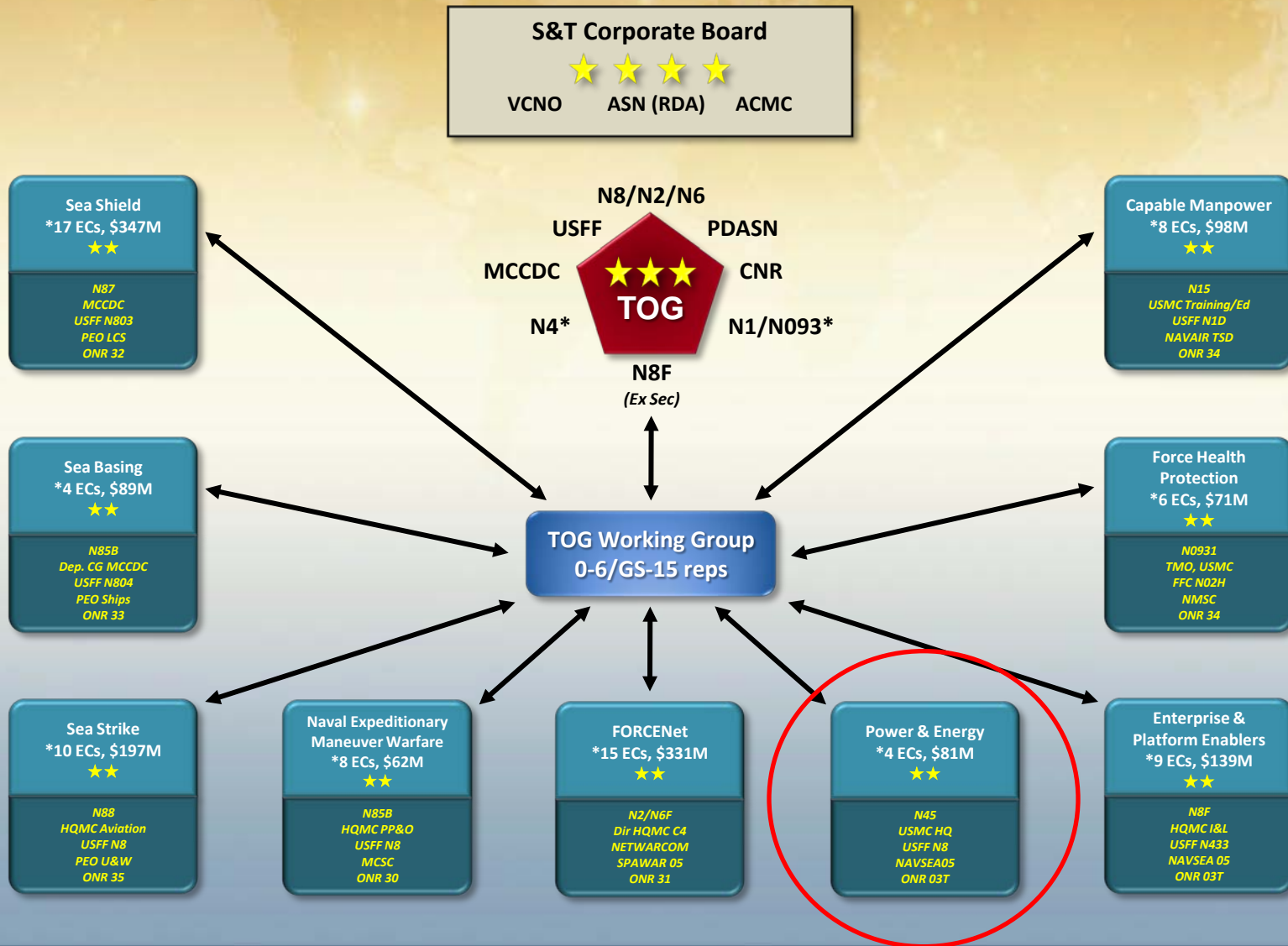


Reconfigurable Blades / Blade
Loading

Applications



Technology Oversight Group



* FY11-15

Future Naval Capabilities

FY11 and Prior

- Axial Flow Waterjet
- Compact Power Conversion
- Turbine Engines Reduced Cost of Operations – Materials
- Turbine Engines Reduced Cost of Operations – Engines
- Affordable Common Radar Architecture
- Advanced Material Propeller
- Affordable Electronically Scanned Array
- Advanced Power Generation
- Squad Electric Power Network
- Common Operating Picture Logistics Planning and Decision Support Tool

FY 12 New Starts

- ❖ P&E-FY12-01: Renewable-Sustainable Expeditionary Power
- ❖ P&E-FY12-03: Long Endurance Undersea Vehicle Propulsion
- ❖ P&E-FY12-04: Fuel Efficient Medium Tactical Vehicle Replacement (MTVR)



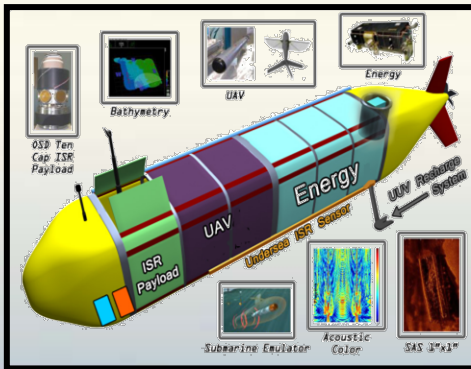
Advanced Engine Air Handling System



Unmanned Undersea Vehicles

Provide long-endurance power systems for unmanned undersea vehicles for extended range mission requirements

Large Displacement UUV FY12 INP
48" diameter, 60-90 Day endurance

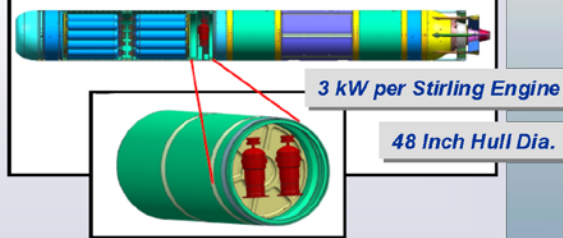


- Stirling Engine
- Fuel Cells
- Batteries
- AI Combustor



ONR Swampworks
48" diameter

Placement of Stirling Engines in Sea Lion Section

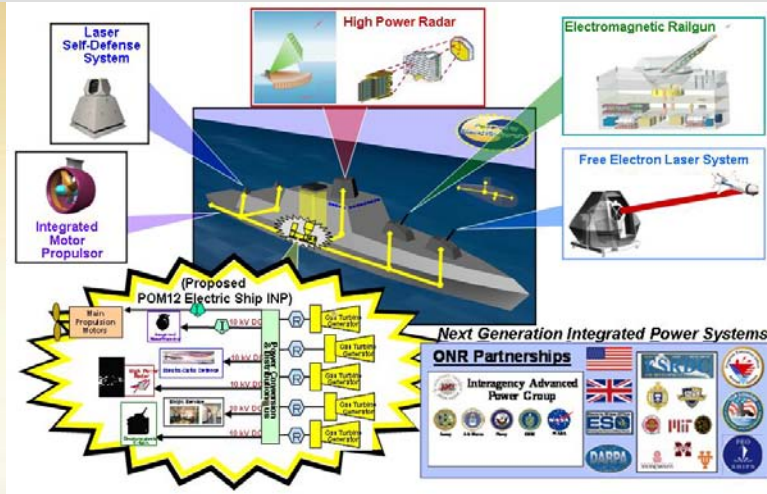


Long-Endurance UUV Propulsion FNC
21", 30 Hr endurance



Navy Ship Electric Power Systems

All Electric Ship

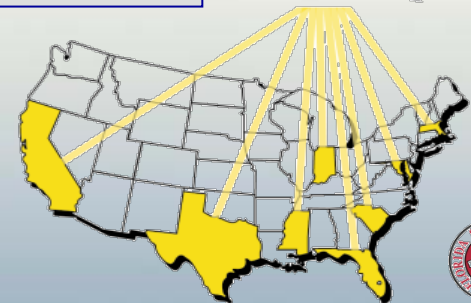


- Develop efficient power generation, energy distribution and control concepts to provide power for ship warfare, propulsion and support systems

Electric Ship Research and Development Consortium

- A consortium of virtually linked academic institutions with hardware-in-the-loop capability coupled with physics based models for system design, testing, and validation
- Develop advanced power concepts leading to increase performance, reliability, lower cost and lethality
- Develop new tools for electrical systems test and evaluation leading to reduced shipbuilding cost
- Develop EE power electronics S&T workforce with emphasis on naval applications

ELECTRIC SHIP RESEARCH
ESRDC
AND DEVELOPMENT CONSORTIUM



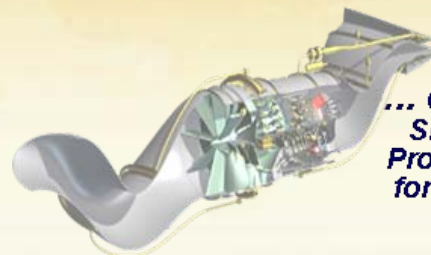
Variable Cycle Advanced Technology

Provide advanced aircraft propulsion technology for the next generation carrier-based aircraft

High Performance of a Military Engine...



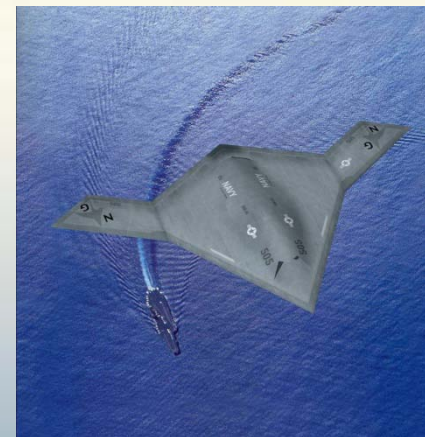
Fuel Efficiency of a Next-Gen Commercial Core...



*... Combined into a
Single Versatile
Propulsion System
for Naval Aviation*

Payoffs:

- Reduced fuel consumption
- Lower life cycle costs
- Higher performance and increased durability
- Improved environmental compliance



Non-tactical hydrogen-powered General Motors Fuel Cell Vehicles

- Evaluation ongoing at Camp Pendleton and Marine Corps Base Hawaii
- Coordinating with other Services and DoE



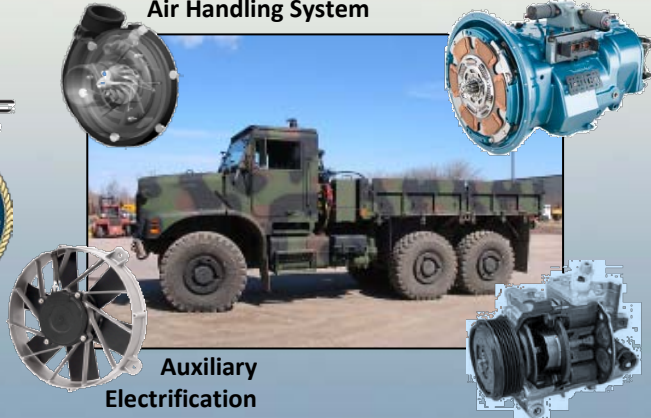
Marine Corps Base Camp Pendleton



MARFORPAC & Marine Corps Base Hawaii

Advanced Engine
Air Handling System

Hybrid Electric Transmission



Auxiliary Electrification

Auxiliary Power Unit

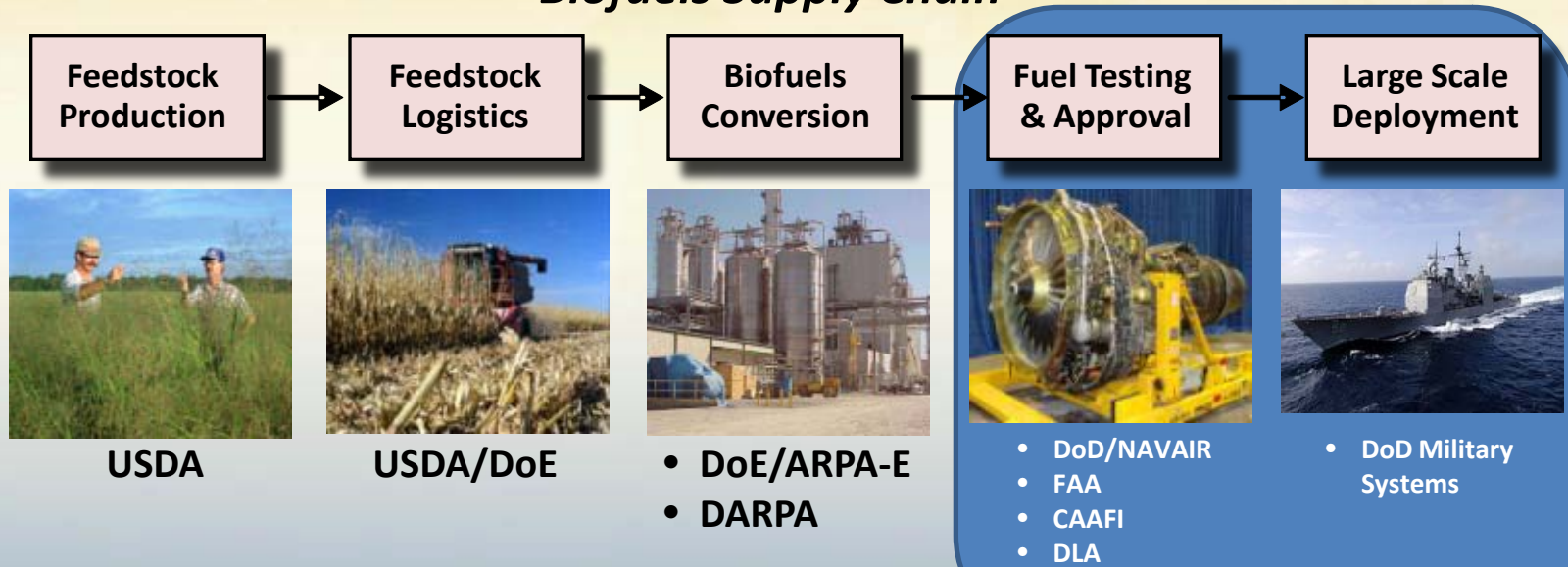
Fuel Efficiency Technologies for Tactical Vehicles

- Improve vehicle fuel efficiency
- Provide on-board electric power generation for hybrid drive, on-board mission systems and external power
- FY-12 FNC: “Fuel Efficient Medium Tactical Vehicle Replacement”

Biofuels Research

Accelerate the adoption of biofuels by supporting Navy certification process, and understand and mitigate the impact of emerging biofuels on naval power systems and operations

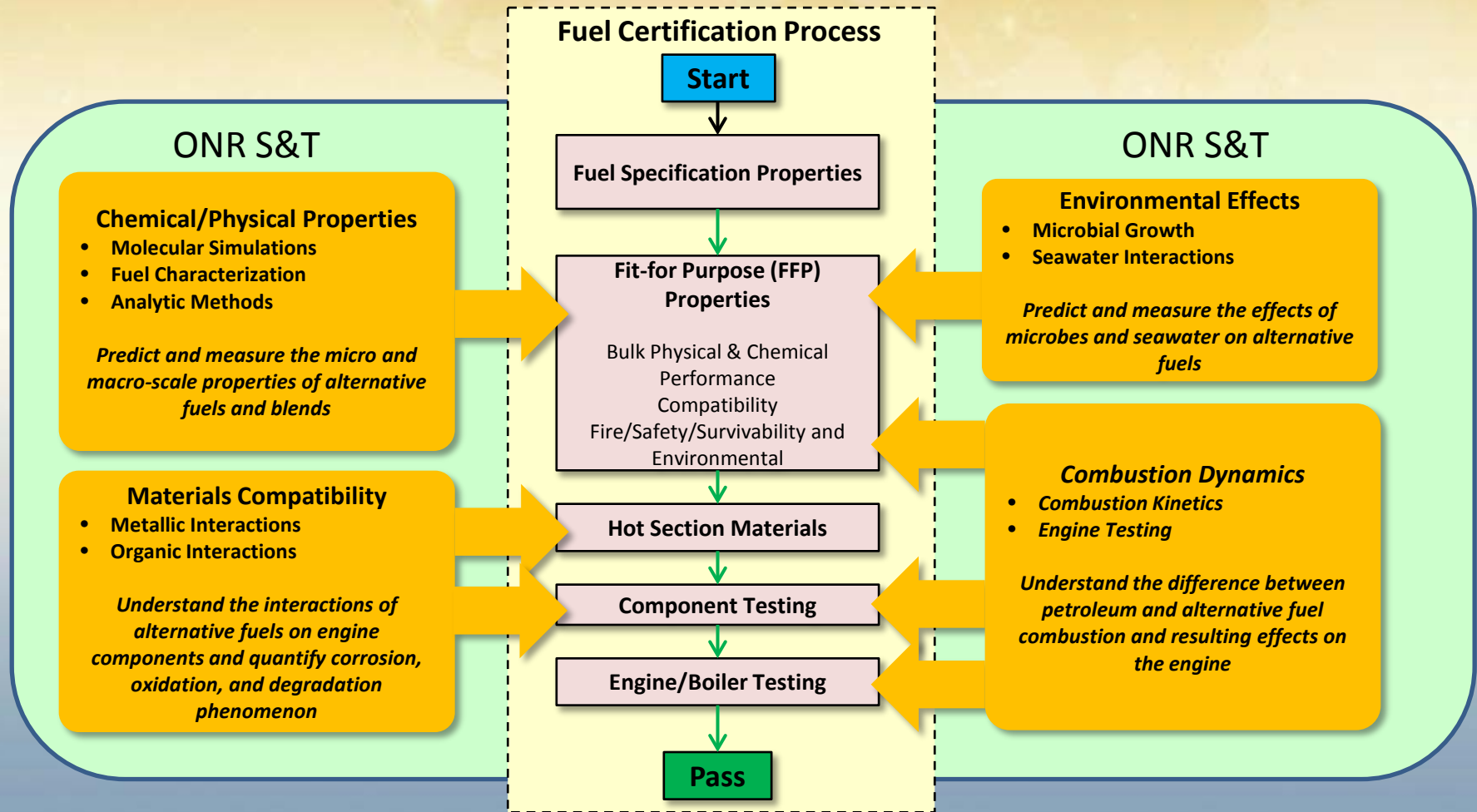
Biofuels Supply Chain



- ONR Alternative Fuels Focus**
- Engine & fuel cell performance
 - Materials compatibility
 - Fuel stability
 - Sustainable biofuels production

Program Thrusts

Alternative Fuels Program predicts and understands fuel properties to augment important steps/issues for testing and certification

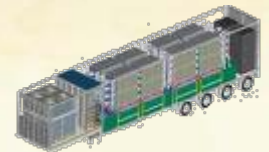


ARPA-E: Advanced Energy Storage Devices

FY11 FY12 FY13 FY14

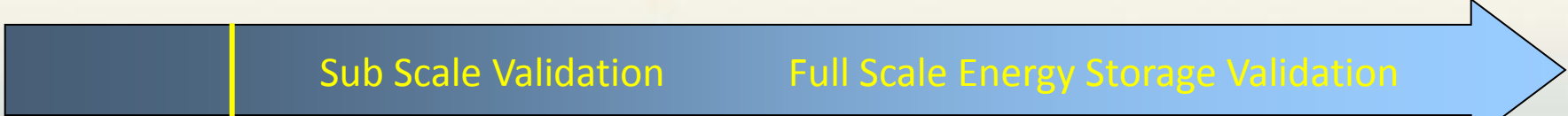


- Workshop
 - Threshold Req.
 - Joint BAA
- Advanced Flywheels
- Metal-air Battery

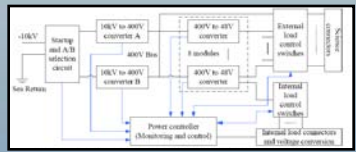


DoD: Hybrid Energy Storage System Level Development

FY11 FY12 FY13 FY14 FY15 FY16



- Workshop
 - Threshold Req.
 - Joint BAA
- Develop Control/Logic
 - Develop Fault Isolation
 - Power Converter Design
 - Advanced Thermal Mgt.
- Common Requirements Document
 - Full Scale System Fabrication
 - OEM Demonstration
 - In Field Demonstration





Silicon Carbide (SiC) Wide Band-Gap High Power Electronics



1MW, 10kV, 100 amp SiC Module



Single Phase AC-AC building block



Present PCM-4

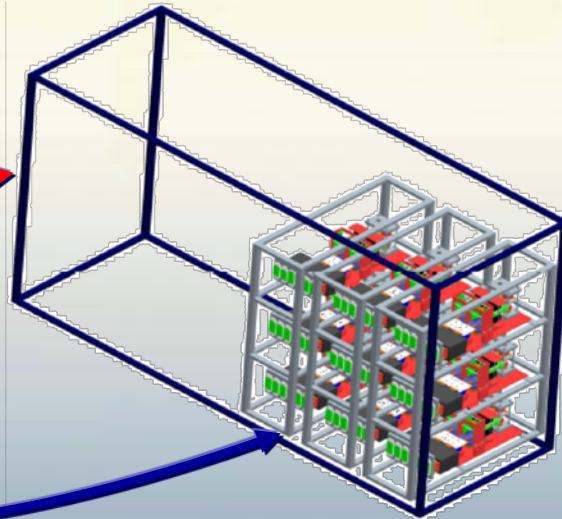
Weight: 35,000 lbs

Volume: 168" W x 60" D x 81" H

SiC PDM-4/1A

Weight: 3,500 lbs

Volume: 60" W x 60" D x 60" H



3 MW Application
SiC Ship Service Power System
70% Smaller & 89% Lighter

Increased efficiency
Reduced weight and volume
Improved thermal management

Smart Power Infrastructure Demonstration for Energy Reliability and Security (SPIDERS) JCTD

Reduce the “unacceptably high risk” of extended electric grid outages by developing the capability to island installations while maintaining operational surety, security & cyber defense

Approach

- Circuit level demo at Joint Base Pearl Harbor-Hickam using renewables with hydrogen storage & fuel cells
- Ft Carson microgrid including renewables, vehicle-to-grid storage, energy mgt, cyber defense
- Camp Smith, HI complete installation smart grid, islanding, battery storage, cyber defense

Joint Base Pearl Harbor-Hickam Renewable H₂ Production & Fueling Station



Deployable H₂ Modules (operating since Nov 2006)

- Hydrogen Fuel Processor (H₂FP) uses two electrolyzers and pressure management (H₂PM) produces up to 50kg/day @ 5,000 psi

146 kW Photovoltaic Array (operating since May 2009)

- Provides power to base grid when station is not operating.

Five 10 kW Vertical Axis Wind Turbines

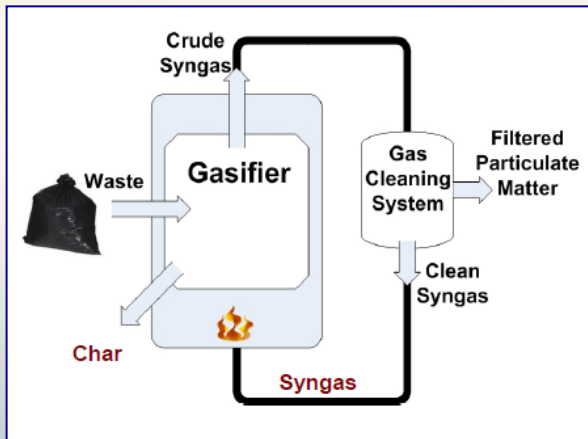
- Renewable energy for hydrogen station; power to base grid when station is not operating.



Micro Auto-Gasification System (MAGS)

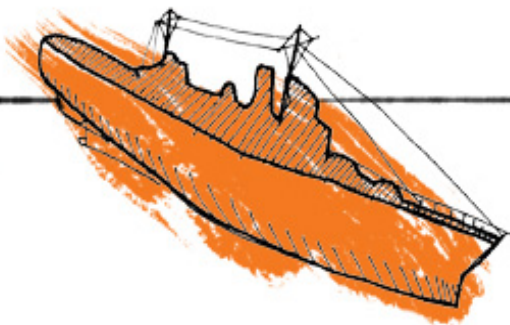


- Terragon Environmental Technologies, Inc gasification system
 - ❖ Treats organic waste, plastics, chemicals, wood products, and bio-hazardous waste
 - ❖ Processes 1,500 lbs daily [~1,000 Marines]
 - ❖ Waste heat available for other uses – hot water, space heating
 - ❖ Uses fuel source to start process – then self-sustaining
- ONR developed for expeditionary ops
- ONR-MARFORPAC is evaluating at Camp Smith in Hawaii





What if...you could get any resource you needed?



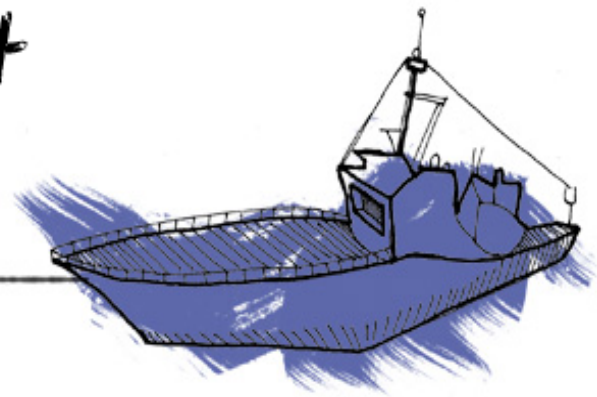
...remove any obstacle?

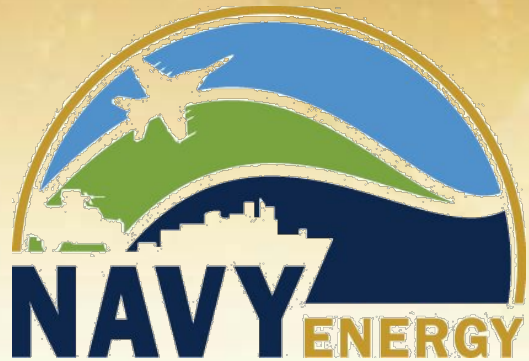


...change any practice?



How can the Navy best meet future energy demands?





mmo  gli

Coming in 2012

Pre-register at:

<http://www.onr.navy.mil/energymmowgli/>

And share early ideas with **#energyMMOWGLI**