Title: The Naval Postgraduate School (NPS) NEPTUNE Kickoff

http://nps.edu/energy/

Purdue University

December 2015

Agenda

- **What is the Naval Postgraduate School (NPS)?**
  - **Video**
  - **A few slides**
- **What is the NPS Energy Academic Group (EAG)?**
  - **A few slides**
- **NEPTUNE**
  - **1 summary slide**
  - **quad charts**

The Naval Postgraduate School mission: educating students

NPS MISSION – OPNAVINST 5450.210D

Programs: "Provide relevant and unique **advanced education and research programs** to increase the combat effectiveness of commissioned officers of the naval service to enhance the security of the United States."

Research and Faculty: "In support of the foregoing, and **to sustain academic excellence**, foster and encourage a program of **relevant and meritorious research** which both supports the needs of the Navy and Department of Defense (DOD) while **building the intellectual capital** of NPS faculty."

NPS fulfills the graduate education needs of the Department of the Navy, DOD, and U.S. Government.

- In-residence and Distance Learning (DL)
- Master's, Ph.D., Engineer, MBA, EMBA, more
    - Biennial program reviews by flag-level sponsors
- Subspecialty and professional education
- Professional certifications
- Joint Professional Military Education
- Civilian Instruction (CIVINS)

NPS has a long, rich history in the pursuit of innovative education in support of national security.

1909 – Founded at the U.S. Naval Academy

1951 – Moved to Monterey

1951 – Operations Research department

1956 – Systems Management department

1972 – National Security Affairs department and Warfighting curricula (anti-submarine warfare)

1996 – Information Warfare curriculum

1999 – Joint Professional Military Education campus

2003 – Homeland Security curriculum

2004 – Information Operations curriculum

2011 – Cyber Systems and Operations curriculum

2012 – Energy Specializations

NPS

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NPS was recently awarded a 10-year reaccreditation, the longest term achievable.

WASC   Western Association of Schools and Colleges

ABET   Accreditation Board for Engineering and Technology

AACSB   Association to Advance Collegiate Schools of Business

NASPAA   National Association of Schools of Public Affairs and Administration

NPS
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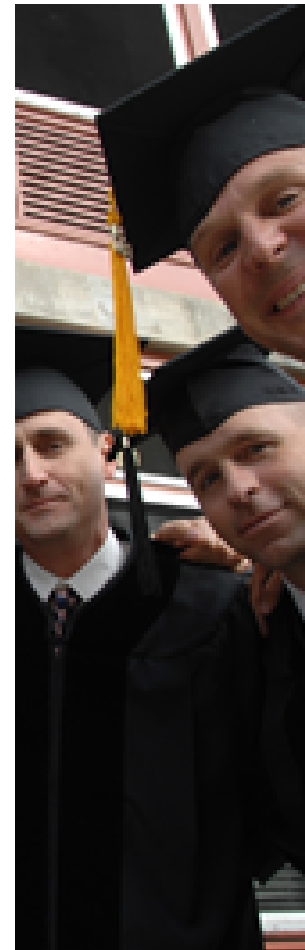
Resident Degree Students
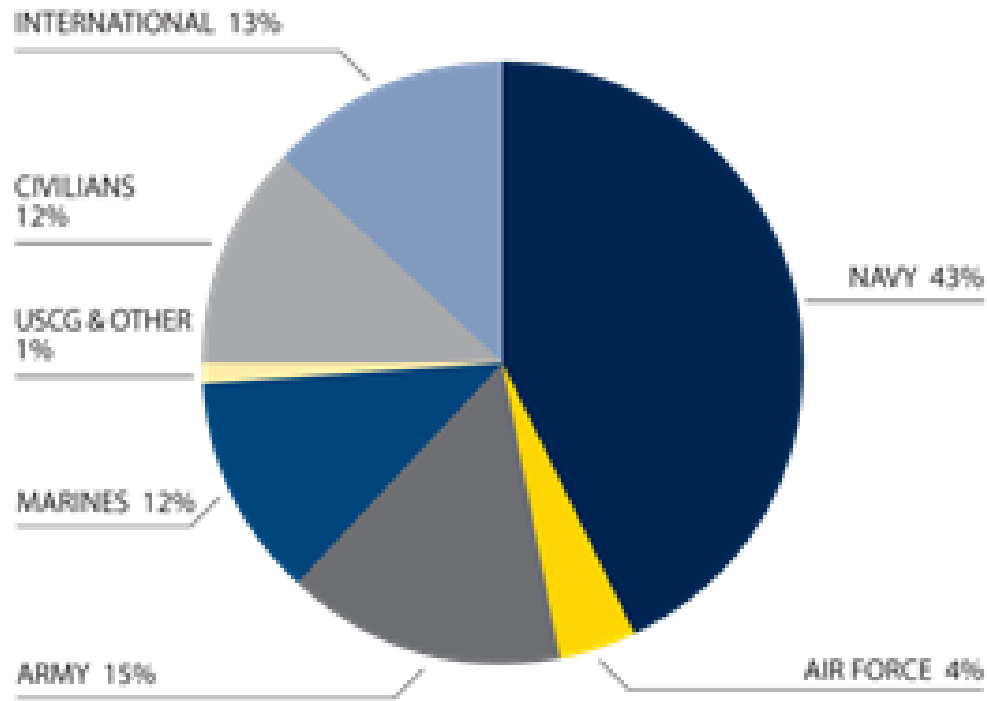
Average on Board
AY 2013

Total Resident: 1,636

75% U.S. uniformed services

13% International

12% Government Civilian

Resident Degree Student Enrollment
AY2013 · Average on Board 1,636

- INTERNATIONAL 13%
- CIVILIANS 12%
- USCG & OTHER 1%
- MARINES 12%
- ARMY 15%
- NAVY 43%
- AIR FORCE 4%

# Leading the cultural change necessary to achieve energy independence.

- Four specialized degree programs focused on energy science, technology, policy

- Active, student-driven research in all aspects of energy, focused on warfighting first

- Dedicated Energy Academic Group

- Senior leader continuing education programs, campus lecture series, more

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Energy Academic Group

www.nps.edu/energy
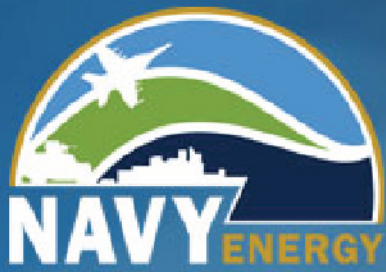
BLUF

*The Energy Academic Group (EAG, **http://nps.edu/energy** has made measurable progress in*

Curriculum Development and Delivery
- Masters -- 13 graduates, 21 currently enrolled
- Certificate -- 29 completed, 9 currently enrolled
- Seminars -- 100 Completed
- Executive Education -- 2 classes completed; 35 Flags/SES attended; Program formally embedded in Naval Flags curriculum; VERY strong support from ASN and OpNav senior leadership

• Research
   100+theses, 60+ faculty research projects

• Outreach
   US Government (defense and nondefense),commercial firms, academic institutions

and has specific plans for FY 16

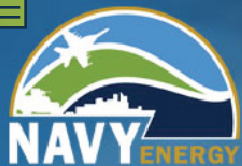| Dr. Daniel A. Nussbaum	Mr. Alan Howard	Mr. Kevin Maher
Energy Academic Group	Dep. Chair, EAG	Program Officer, EAG
danussba@nps.edu	arhoward@nps.edu	kjmaher@nps.edu
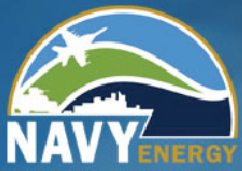
EAG charter May 2013

EAG mission *The overall objective for the EAG is to develop and maintain NPS as a Navy Center of Excellence for Energy Graduate Education and Research. The EAG will also actively explore educational and research partnerships across the full spectrum of Department of Defense (DOD) related organizations, Department of Energy (DOE), as well as other universities, industry, and non-profit sectors.*

- Energy Security
  - NATO School
  - Indonesian Defense University
  - Technology for Information Operation
- Critical Energy Infrastructure Protection
- Energy Efficiency in Expeditionary Operations (E3O)
- University of Hawaii (Workforce Development: Energy, Cost and Cost-Benefit Analysis)

	2010	2011	2012	2013	2014	2015
Student theses	49	14	43	43	84	35
Faculty Research	21	40	53	88	116	26

- Supporters and funding sources of for NPS Energy Research
  - DoN (Naval Research program, Acquisition Research Program, ONR)
  - USMC (Expeditionary Energy Office, Thesis Research Working Group)
  - IMET, OSD (AT&L)
- Examples of high payoff current energy research
  - Replenishment at Sea Planner (RASP)
  - USMC Attitudes and Behaviors-- Energy Consumption and Conservation
  - Gen Military Training--Energy (GMT)
  - Reduction Of Aviation Fuel Consumption Through Slot Management
  - Energy Management Systems to Reduce Electrical Energy Consumption- Hardware
  - CVN Speed of Advance and Removal of PIM Restraints
  - Energy Systems Technology Evaluation Program (ESTEP)
  - PACOM Refinery Capacity Analysis: Final Report
  - NEPTUNE---To Be!
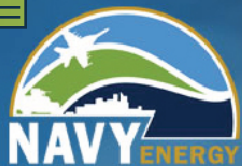
Outreach

EAG has built relationships to provide…

- Enhancement of NPS's core mission
    - *Graduate Education* of Naval officers
    - *Faculty Research* to support that mission
    - *Non-degree Education* programs to support that mission
- Awareness of NPS's capabilities
- Opportunities to work collaboratively

- DoD—all Services
- DoE—Sandia, PNNL, LLNL,..
- Academic Institutions
- Research Laboratories/Institutions
- International--
    - Indonesian Defense University
   - NATO Energy Security Center of Excellence

Outreach: Defense Seminar Series

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MacKinnon`	Chu	Temple	Gurminder	Phillips	
					Designing and Operating Self-Organizing Micro-grids for Civilian and Military Applications
X					Remote Sensing for Smart Renewable Power
X					CyCIT-WS: Cyber Critical Infrastructure Threat Warning Stream
			X		Energy Leadership Informatics Institute
			X		Resilience Processes in Positive Case Studies
	X				Underwater Optical Communications on a Real-Time Sensor Mooring Deployed in Tempe Town Lake
					Heterogeneous surface wettability for manipulation of dryout hydrodynamics and bubble departure during high-heat-flux boiling processes
					Low cost catalyst for portable hydrogen generation and on-demand power
X					Fundamental studies on composition/performance correlations for aviation fuels
					Towards vetted sensing and control system firmware and software
					GaN interface engineering for naval RF power electronics applications via atomic layer epitaxy
					Unlocking the chemistry of the amine-thiol universal solvent system for solution processed, flexible electronic devices
					Combat Power Monitor: Non-invasive Load Monitoring (NILM) of shipboard power systems.
					Higher energy density Lithium-ion batteries.: Exploiting Oxygen Anion Redox for High-energy Rechargeable Lithium Batteries
X					Thermal Management Technologies for Low-Temperature Undersea Dive Persistence: a Novel Arctic Diving Suit: Passive (materials with improved insulating properties) and active (energy harvesting from environment) approaches to allow longer operating times during cold-water dives.
				X	Determination of the Impact of Chemical Composition on Measured and Predicted Fuel Properties and on Combustion in Military Diesel Engines
		X			Plug in Electric Vehicle Decision Making Data Based Tools
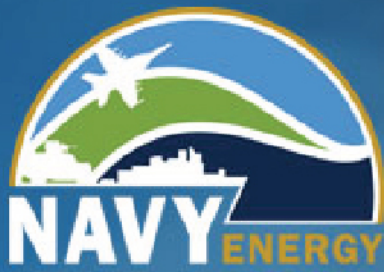
Non-tactical Fleet Energy Data Mining and Research

Project Objects: Leveraging Lexical Link Analysis (LLA), advanced Big Data and Deep Learning tools to address the challenges of Fleet energy usage

Researchers: Zhao, MacKinnon, and Gallup Information Sciences Department
Naval Postgraduate School

Required Budget: $40K

Performance Period: 4 weeks

LLA Outputs and Visualizations

Why LLA?

- Performs heterogeneous data fusion
- Ingests and analyzes mixed structured and unstructured data
- Performs Big Data and Deep Learning analysis
- Performs pattern recognition and anomaly detection
- Ranks and sorts information based on authority and expertise
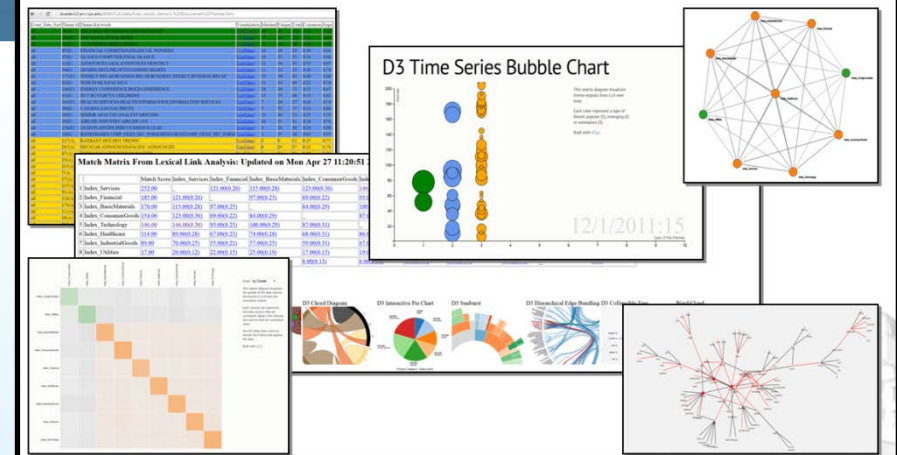
Project Tasks

Task 1: Work with the Navy sponsors or UC Davis to extract sample data that might address fleet energy usage, for example, sample data in <u>ONE</u> of the areas blow:
- Remote sensing for smart renewable power options
- Threat warning stream for critical cyber infrastructure and combat power monitoring
- Composition/performance correlation for aviation fuels
- Thermal/energy management and active energy harvesting from the environment

Task 2: Apply LLA and other selected Big Data and Deep Learning tools

Task 3: Meet with domain experts and sponsors to review outputs to discover previously unknown insights

Background:

NPS has been involved in developing ocean optical propagation models for underwater optical communication and detection.

Naval Oceanographic Office has conducted long term in-situ measurements from ships and autonomous measurements from gliders of optical and hydrographic properties.
Thesis students: **LCDR Brian Breshears, LCDR Alec Cullen, and LT Ross Hammerer**
Advisor: **Professor Peter Chu**
Second Reader: **Dr. Tetyana Margolina**

Scope of Research:

This study will analyze/assimilate the NAVO optical dataset with the Navy's Electro-Optic DEtection and Simulation model (EODES) to investigate the salinity effect on underwater optical communication and detection

Underwater Light Propagation

Optical Communication and detection
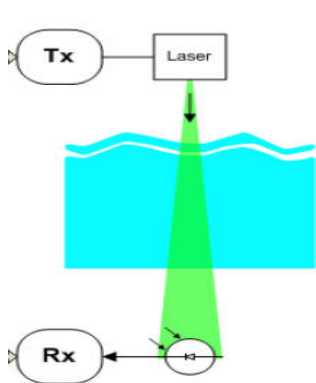
Objectives:

Assess the transmission loss of optical signals during the underwater propagation.

Provide a new approach to identify mines or mine-like obstacles and in turn enhance the warfare capability.

Identify the salinity effect on the underwater optical propagation.

Plug in Electric Vehicle Decision Making Data Based Tools

Background:

Plug in Electric Vehicle usage is expected to have a major impact on (1) energy sources, (2) grid loads, (3) energy security, (4) local emissions, and (5) greenhouse gas emissions by substituting gasoline driven miles with electric vehicle miles traveled (eVMT).

The first direct impact of both battery electric vehicles (BEVs) and plug in electric vehicles (PHEVs) is electric charging loads. The spatial and temporal patterns of the grid loads are an outcome of the PEV fleet and PEV usage.

Scope of Research:

This analysis is expected to help make important planning decisions related to charging infrastructure, fleet and grid management including vehicle-grid integration (VGI) for a growing PEV fleet. Special emphasis is on modeling potential rollout of PEVs using available internal combustion engine (ICE) vehicle fleet travel behavior datasets, charger usage datasets and plugin vehicle (PEV) datasets to develop tools for planners, policy makers and decision makers.

These modeling tools would specifically help the Navy design an optimum PEV fleet vehicle and charging infrastructure strategy.

Simulated Statewide Charging Demand Based on Current Vehicle Locations and Ranges.
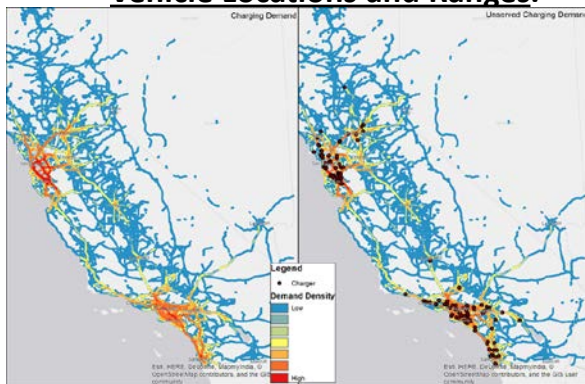
- Left figure shows potential scaled demand from current vehicles
- Right figure shows how much demand is met by current chargers

Objectives:

Help the Navy design an optimum non-tactical PEV fleet and charging infrastructure strategy based on current travel patterns, future PEVs in the market and charging infrastructure scenarios.
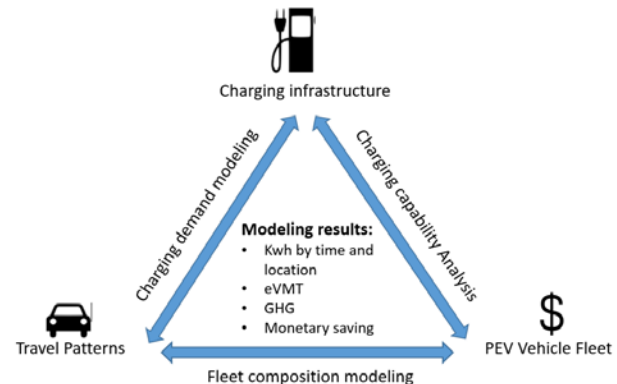
Charging infrastructure

Charging demand modeling

Charging capability Analysis

Modeling results:
- Kwh by time and location
- eVMT
- GHG
- Monetary saving

Travel Patterns

Fleet composition modeling

PEV Vehicle Fleet

ITS UCDAVIS INSTITUTE OF TRANSPORTATION STUDIES

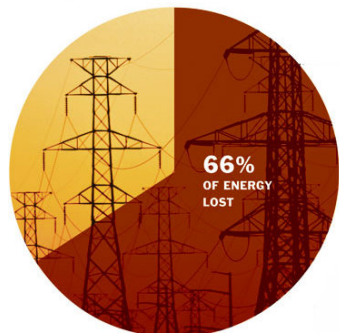**NAVAL POSTGRADUATE SCHOOL**
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Background:

Most military installations can be made more energy efficient by preventing wastage of energy. In the current practice at most installations, information about such energy wastage events is collected manually and reported using phone calls or emails. Being manual, this process is fraught with numerous problems including high-effort involved in reporting events, incomplete and inconsistent descriptions, and little accountability for the responsible agency. These lead to low motivation on the part of users to report such events. This project will design a system to alleviate these problems.

Scope of Research:

We propose to design a system which will alleviate problems with manual reporting by focusing on the following:

- Capturing and reporting of energy wastage events with minimal effort - use advanced capabilities of COTS handheld devices
- Fail-safe operation – enable the user to continue operation under DIL network conditions
- Drive user engagement - create a tight feedback and reward system
- Audit system for the responsible departments to address the reported events

Objectives:

To design a software system to enable users to easily and rapidly capture, report and track energy wastage events at military installations using COTS (Commercial Off The Shelf) handheld devices.

Deliverables:

A report describing the detailed design of the system including screen layouts, information flow and network diagrams.

Contact:

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66% OF ENERGY LOST

STOP ENERGY WASTE
Turn off the lights when leaving the room

Plasma Generated Nano Na-Sn Anodes

P.I.s-Jonathan Phillips, jphillip@nps.edu
And Claudia Luhrs, ccluhrs@nps.edu

Ultimate OBJECTIVE: Develop high performance Na-ion alternative to Li-ion battery

- Plasma generate Sn Core/Carbon-shell nano-particles for anode
- Characterize with TEM and SEM
- Electrochemical test anode of battery working with partners at Purdue University (Prof. V. G. Pol, 110 papers, 15 US Patents filed)

Preliminary RESULTS:
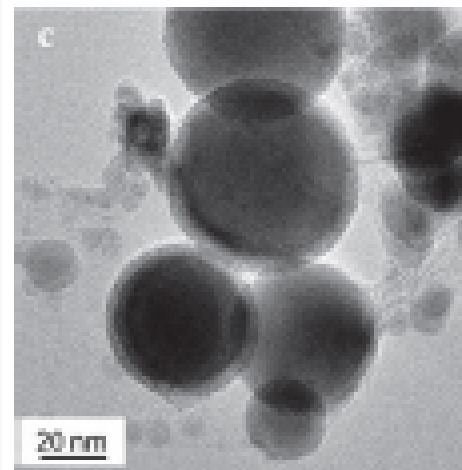
In earlier studies PIs showed A-T-P could create core metal/ shell carbon nanoparticles

Stephen Wakeland, Yuehua Cui, Angela Krapp, Monique Richard, Jonathan Phillips and Claudia Luhrs, 'Multilayered Nanoparticles Generated by Plasma Methods for Energy Storage Applications' Nanoscience and Nanotechnology Letters 4, 816-822 (2012).

BACKGROUND: Na-ion : Possible low cost alternative to Li-ion battery.

Hypothesis: Proper design of Na-anode nano-structure will bring Na-ion battery to a more competitive performance level.

Na-Sn: Preferred high energy density anode chemistry

PIs invented and developed Aerosol-Through-Plasma (A-T-P) technique: Fourteen issued US A-T-P Patents. Fully equipped for plasma work and characterization.

PROGRAM:

1. Produce 2nd Generation Nano Sn Core/Carbon Shell particles using A-T-P process.
2. Partially remove Sn to accommodate Na expansion (~450%).
3. Characterize using Transmission and Scanning Electron Microscopy studies
4. Work with Purdue team to test Na charge/ discharge, energy density and lifetime behavior.
5. File patents on new sodium ion battery technology and publish

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Back Up

Outreach: Defense Seminar Series

Academic Institutions	Research Laboratories/Institutions
• NPS, Stanford • CalTech • UC-Berkeley • UCLA • Idaho State • Massachusetts Institute of Technology • Colorado School of Mines • Colorado State • *Georgia Tech* • *University of Texas, Austin*	• Idaho National Labs • Lawrence Livermore • Sandia Labs • Pacific Northwest National Labs • Monterey Bay Aquarium Research Institute • Electric Power Institute • California Institute for Energy and Environment, University of California • Navy Renewable Energy Lab • Center for Naval Analyses
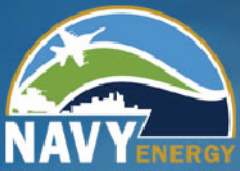
Outreach: Defense Seminar Series (con't)

Industry / Private Sector	Government
• Rocky Mountain Institute • IBM Senior Research Division • Babcock & Wilcox • Tesla Motors • Yardney Technical Products • Pathfinder Partners • Aera Energy LLC • American Public Power Association • Pacific International Center for High Technology Research	• Director for Operational Energy, DOE • Director, Navy Energy Coordination Office (OPNAV N45E) • State Department • Secretary of Defense • Defense Logistics Agency • HQ USMC • Naval Surface Warfare Center, Crane • NDW Command Information Officer (N6) • Center for Naval Analyses • NASA Ames Research Center