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ENERGY ACADEMIC GROUP QUARTERLY NEWSLETTER SUMMER / FALL 2018

Highlights

USS Spruance (DDG 111) does a high speed run during Super Trials. In April, the Energy Academic Group at NPS sent a student thesis team to Naval Base San Diego to gather data relating to recent transits by the USS Spruance and USS Stockdale (DDG 106). The data will help form the basis of a more detailed analysis of OTTER's expected fuel savings and the factors that impact transit fuel consumption. Photo courtesy U.S. Navy.

OTTER Sea Trials Promising, But Require Further Analysis

Last fall, the Energy Academic Group conducted testing of the Optimized Transit Tool & Easy Reference (OTTER) on the USS Wasp (LHD-1) as it transited from San Diego to Sasebo, Japan. OTTER is an Excel-based tool designed to help surface ships reduce their transit fuel consumption by suggesting efficient combinations of transit speeds and engine configurations. During this testing, OTTER was used by the Wasp's Navigator to compare the ships actual transit practices and fuel use against OTTER's predictions. Although operational and maintenance considerations on the WASP didn't allow for full testing of OTTER's optimized transit planning capabilities, the testing demonstrated OTTER's ease of use, ability to adapt to engine mode constraints, and ability to create reasonable fuel consumption estimates. The test also highlighted several important considerations for future trials. Depending on ship type, mission requirements, transit requirements, or engine constraints, the potential savings from OTTER may be overshadowed by variations in electric generator fuel use or ocean conditions. In these cases, more data will be needed to get an accurate assessment of OTTER's actual fuel savings.

This April, the Energy Academic Group at NPS sent a student thesis team to Naval Base San Diego to gather data in support of OTTER. The team collected data relating to recent transits by the USS Stockdale (DDG-106) and USS Spruance (DDG-111) that will help form the basis of a more detailed analysis of OTTER's expected fuel savings and the factors that impact transit fuel consumption. The work of this thesis team will help determine exactly what data is needed to determine fuel savings attributable to OTTER and what data is readily accessible from ships' logs.

LEARN MORE
Email Brandon Naylor at **bnaylor@nps.edu** or call 831.656.1986

Principal's Thoughts

Dan Nussbaum, Principal, Energy Academic Group

From the beginning, we built EAG on three pillars—Curriculum, Research, and Outreach. While a previous Assistant Secretary of the Navy called these pillars "Education, Technology, and Relationships", this article focuses on the third pillar, Outreach (or Relationships), including EAG's vision, current activities, and future plans.

Our vision is to create an energy community of interest (COI) to assist NPS in building professional and operational alliances supporting not only the Navy but the Department of Defense in pursuit of the national security objectives of the United States. EAG pursues this vision through the activities described below:

Pillars of the Energy Academic Group.

Current Activities

NPS's Defense Energy Seminar series provides students and faculty a broad palette of seminars, addressing both energy technology issues and policy perspectives.

Speakers from the NPS faculty as well as government, commercial firms, and not-for-profit activities provide expertise across a range of energy topics. All this is masterfully curated by Kevin Maher (CDR, USN, ret.).

You can view archived seminars and see planned speakers at http://www.nps.edu/web/eag/seminars

Also, EAG provides the unique opportunity for non-resident US students, International Allies, and Partner Nations to learn about Energy topics.

Since NPS faculty and their students regularly participate in these offerings, these courses support their research objectives and thesis projects.

Examples of offerings are:

- NATO Energy Security Centre of Excellence: Energy, an Operational and Strategic Level focus
- Tbilisi, Georgia: Energy Security
- Lithuania: Energy Efficiency in Military Operations
- NATO School, Oberammergau: Energy Security Awareness
- Kuwait: Critical Energy Infrastructure Protection/Resilience

Conferences, where I introduce various audiences to NPS and the work of colleagues in both EAG and the wider NPS community.

Examples include:

- Innovative Energy Solutions for Military Applications. This conference enables information exchange on best practices and technologies for advancing energy efficiency in the military, and helps accelerate the transfer of innovative energy technologies from the civilian to the military sector. I will lead a discussion panel on multinational NATO achievements in enhancing energy efficiency in military operations
- Military Operations Research Society (MORS) MORS. Held last month at NPS where I provided a keynote presentation

All of these professional organizations provide platforms for EAG to explain to the larger defense and security world who NPS is, describe the unique aspects NPS brings to graduate-level defense and security education, and discuss the work of the EAG. These venues also permit us opportunities to advance our vision of creating communities of interests.

I look forward to hearing your ideas on developing and sustaining the Energy COI.

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UPDATE REPORT

EAG/CID Team visits the U.S. Virgin Islands

Left: Hurricane Maria home damage (6 months post storm). Fredriksted, St. Croix.

Center: Marine Capt John Dommert standing in front of a destroyed 0.5MW solar farm, St. Croix.

Right: WAPA Contractors replacing an underground transformer; power outage to parts of downtown Christiansted lasted greater than 24 hours in this case.

During this past quarter, NPS's Center for Infrastructure Defense (CID) and the Energy Academic Group (EAG), along with two NPS students traveled to St. Croix, Virgin Islands to meet with local utility companies and government representatives to preliminarily assess the recovery and resiliency effort of the USVI infrastructure system. Specifically, the team met with local and government representatives from FEMA, DoE, NREL, the Virgin Islands Water and Power Authority (VIWAPA), Wastewater Treatment, Public Works, Limetree Bay Terminals, the VI Energy Office, and the St. Croix Foundation. CID and EAG's support to FEMA includes broad efforts to manage coordination, training, and convening activities with local utilities and government representatives, and manage the modeling and analysis on the identification, analysis, and development of a proposed energy infrastructure recovery and priorities in the US Virgin Islands. The first of these efforts includes a technical preliminary assessment report on the interdependent infrastructure resilience in the USVI. This technical report not only serves as the technical foundation for LCDR Brendan Bunn's Operations Research master's thesis, but also provides FEMA an operational overview of the USVI infrastructure system, awareness of current infrastructure system resilience/efforts, and identifies opportunities for future research contributions to the USVI recovery. From a Naval perspective, this project offers NPS a unique opportunity to assess island infrastructure resiliency/capacity building lessons learned for potential application in the Navy/Marine Corps Expeditionary Advanced Base Operations Concept.

LEARN MORE
Email Alan Howard at **arhoward@nps.edu** or call 831.656.3855

Defense Energy Seminar Series

NPS's academic programs in Defense Energy are supplemented by a seminar series which provides a forum for leading voices within the field, practitioners, and other Defense Energy influencers. These professionals give presentations, engage in brown bag discussions, and facilitate informal gatherings that encourage Defense Energy faculty and students to discourse over current issues in Defense Energy, supplementing classroom teaching with practical, professional experiences. The Defense Energy Speakers' Seminars are a permanent part of NPS's Defense Energy program, and a key to its real-world relevance.

LEARN MORE
Please see the Calendar of Events or visit **nps.edu/web/eag/seminars** for upcoming and archived seminars.

Mega-Trash to Mega-Watts: Estimating the Feasibility of Waste-to-Energy Technologies for Navy Installations

By Gary Parker

How does a decision maker evaluate whether investing in Waste-to-Energy (WTE) technology makes economic sense for a given project?

Thanks to a recent NPS systems engineering (SE) graduate student, the Commander, Navy Installation Command (CNIC)'s Energy Return on Investment (eROI) decision support tool may soon have an additional module that produces estimates for three WTE technologies (incinerators, plasma gasification, and anaerobic digesters) that previously had not been considered in eROI calculations.

Navy Lieutenant Adam Haag's December 2016 master's degree thesis, "Developing a Decision Support Tool for Energy Return on Investment (eROI) Waste-to-Energy (WTE) Calculations", details his application of a disciplined systems engineering approach to helping answer two questions posed by N46, namely: 1) How do we determine which facilities have the resources to implement WTE technology? and 2) What type of technology should we implement? Haag's investigation of the CNIC eROI tool capabilities revealed a gap when it came to WTE calculations, from which he developed his thesis problem statement. Hypothesizing that the eROI tool would need some sort of additional software module that would evaluate the viability of using WTE technology, Haag employed a SE methodology to determine and analyze project stakeholders, develop module requirements, conduct a functional analysis, and then allocate the functions the new module must perform to the module's requirements.

"Energy is a crucial consideration in our planning for both future operational systems and sustainable shore installations Navy-wide."

—ALEJANDRO HERNANDEZ, NPS SYSTEMS ENGINEERING DEPARTMENT

When it came time to develop a proof-of-concept module for demonstration to N46, Haag decided to use an Excel spreadsheet due to Excel's widespread availability and user familiarity within the DOD. Using Excel also simplified future integration of the module with the existing eROI tool. Multiple civil engineering sources, papers, and reports were used to develop spreadsheet calculations for each of three current WTE technologies: waste incineration, plasma gasification, and anaerobic digestion. Based on project-specific user input, the module produced an "eROI number" for each WTE technology that represents a benefit-to-cost (or "B/C") ratio familiar to users of the current eROI tool. A B/C ratio greater than 1.0 would suggest that the benefits outweigh the costs of an approach. Comparing all three eROI numbers side-by-side could suggest which might represent a more advantageous technology for further investigation.

The proof-of-concept module was demonstrated to the sponsor and accepted for additional refinement. While further work and testing remains before final acceptance of the module for integration into the eROI tool, Haag's research opens a door for further inquiry by future SE students interested in DOD energy sustainability. Haag's thesis advisor, Associate Professor Alejandro Hernandez of the NPS SE Department said of Haag's thesis, "This thesis is an exemplar of excellent systems engineering. The Navy can leverage the capabilities and talent of our NPS graduate students towards solving complex problems. Energy is a crucial consideration in our planning for both future operational systems and sustainable shore installations Navy-wide. Haag's final product is a concrete value-added capability that will assist leaders in making better-informed decisions regarding the potential use of WTE technologies. His thesis demonstrates how NPS graduate education can make real-world contributions to increasing the energy sustainability of the Navy and the Department of Defense."

CONNECT

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STUDENT ENERGY RESEARCH SPOTLIGHT

Realizing Energy Security on a DOD Installation Using Photovoltaics and Battery Energy Storage System

By LCDR Cody Keesee

Navy leaders have made it clear that progressing towards energy security on naval installations is of great importance. The difference between being energy secure versus net-zero is quite different. Energy security is having the ability to operate independent of the commercial grid for an indefinite period of time.

In order to have energy security on an installation in the most basic sense, two elements must be present. This research uses photovoltaic (PV) panels for generation and batteries for electrical energy storage with the goal of achieving energy security using Naval Support Activity Monterey (NSAM) as a test platform.

The design requires three inputs, the AC load required to be supported, peak-sun hours, and the days of usable storage required. All available rooftops on non-historic buildings were considered as candidates for a potential PV installation as well as carports in most parking lots. The largest available sites for new PV panels are Root Hall and eleven PV carports in the staff and student lots on campus. The total new installation area is calculated at 14,274 square meters. An additional 5,540 PV modules can be added to the campus with an estimated power delivery of 2,141,300 Watt-hours (Wh) per day. For perspective, Spanagel Hall consumes an average of 4.75 MWh per day, the proposed installation does not deliver enough to power even half of the building.

Aerial photo of Naval Support Activity Monterey (NSAM) in Monterey, California. Photo by Javier Chagoya.

Monterey's climate does not provide adequate peak-sun hours to justify large scale solar installations for energy security purposes. By taking advantage of all available NSAM areas suitable for PV installation, the proposed microgrid could provide energy security for some critical loads and the design could be used by decision makers if such a project were ever considered. Energy security is realizable to some extent using PV arrays; however, it is clear that NSAM is not a viable candidate for such a system.

LCDR Cody Keesee

About the author

LCDR Cody Keesee graduated in March 2018 with a Master of Science in Electrical Engineering from the Graduate School of Engineering and Applied Sciences at the Naval Postgraduate School. He is a Navy Civil Engineer Corps officer and former Surface Warfare officer. Contact the EAG team at **nps.edu/energy** for more information about this research.

Innovating compressor blade inspection

By Corrie Poland, Air Force Operational Energy

Deputy Assistant Secretary of the Air Force for Operational Energy, Roberto Guerrero (right), watches demonstration of Sonic Infrared inspection by Florida Turbine Technologies, Inc., Jupiter, Fla., January 9, 2018. The technology is currently being tested and implemented by Air Force Research Laboratory as a more efficient way to inspect turbine engine compressor blades for cracks and defects. Air Force Operational Energy is looking to further implement the technology across the Air Force.

As part of its goal to increase combat capability, Air Force Operational Energy looks holistically at every aspect of aircraft operations and technology for opportunities to optimize energy consumption. For the majority of Air Force aircraft, the condition of compressor blades is a critical aspect of engine performance. However, normal engine wear-and-tear causes blade cracks and defects, which deteriorates engine efficiency over time, resulting in higher maintenance costs, and decreased aircraft availability.

Recent developments in compressor blade inspection technology drastically reduce time and cost, and are more effective at identifying defects than earlier methods, like Fluorescent Penetrant Inspection (FPI). Sonic Infrared Inspection (SIR) uses ultrasonic waves to gently vibrate the blade and create friction between crack surfaces. In turn, a small amount of heat is produced where cracks exist, which can then be detected using highly-sensitive infrared cameras. By looking at the image, operators can easily pinpoint the crack or defect and determine its severity.

"Prior to the development of the SIR system, Tinker had no cost effective way of inspecting and repairing engine compressor blades, and returning them back to service."

—MR. SIAMACK MAZDIYASNI, AIR FORCE RESEARCH LABORATORY MATERIALS ENGINEER

Air Force Research Laboratory (AFRL) tested SIR technology and processes, developed by Florida Turbine Technologies, Inc. (FTT), on compressor blades at the Oklahoma City Air Logistics Complex, Tinker Air Force Base. Project engineers saw many benefits of SIR technology including increased detection speed, increased accuracy (SIR has the potential to detect smaller cracks than FPI, and has a lower incidence of error), environmental factors (SIR does not use toxic chemicals like FPI), and increased cost savings (from not having to replace as many blades). SIR technology is currently being implemented at Tinker Air Force Base, and personnel are being trained and certified on its use.

"While the main purpose of SIR technology is not to reduce fuel consumption, we found it is an added benefit. Making it easier to identify defects in compressor blades also helps detect potential engine inefficiencies," said Roberto Guerrero, Deputy Assistant Secretary of the Air Force for Operational Energy. "In order for an engine to function at its best, the blades need to be in, and maintain optimal condition, and SIR better allows us to determine that."

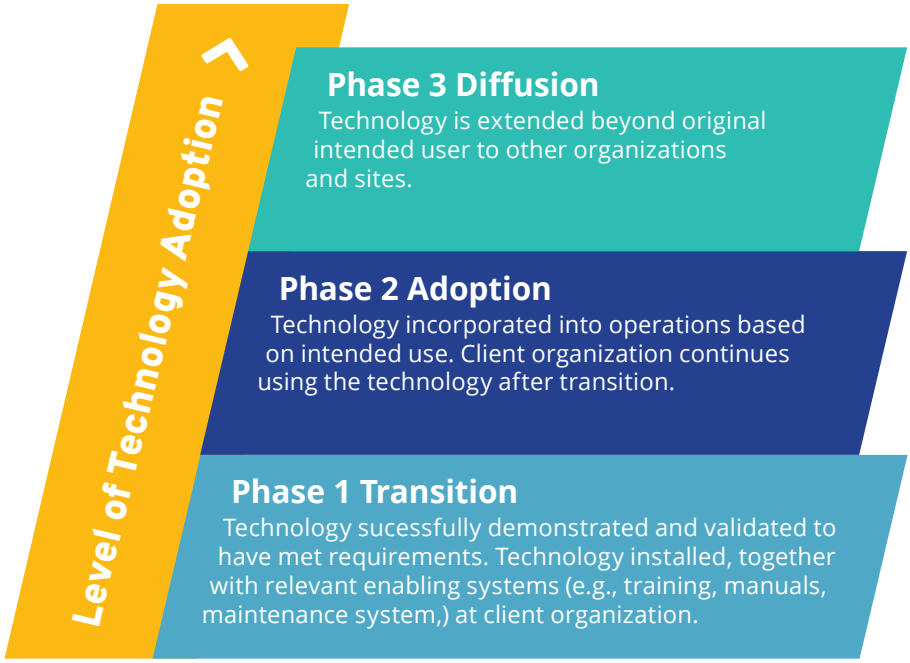
LEARN MORE
To read the full article, visit: **www.safie.hq.af.mil/OpEnergy**

STUDENT ENERGY RESEARCH SPOTLIGHT

Comparative Analysis of Integration Processes and Developing Measures of Effectiveness for Assessing and Predicting Technology Integration

By ME5 Lin Xinhong, Air Force Engineer (AFE), Republic of Singapore Air Force (RSAF) and MAJ Eugene Mok, Army Combat Engineer, Singapore Armed Forces (SAF)

One of the key objectives of the Navy Environmental Sustainability Development to Integration (NESDI) program is to maximize the number of developed technologies that are successfully integrated into the Fleet. However, the Naval Facilities and Expeditionary Warfare Center (NAVFAC EXWC) has faced challenges in doing so. Among the issues in determining successful integration are a subjective definition of integration and the lack of a set of measures of effectiveness (MOEs) that can be used to determine the level of technology integration. A result of these issues is the absence of a means to predict the successful integration of future technologies. The team has decomposed the definition of integration into three phases as shown in the figure. It will be this construct of integration that forms the basis of the team's work.



Three phases of Technology Integration

Proposed Definition of the Three Phases of Technology Integration:

There are two key deliverables for this effort. First, this research will develop an integration framework by performing a comparative analysis between the established systems engineering and diffusion processes on a selected NESDI project. This framework will serve to guide NESDI's in its future project development. Second, this research will develop a set of MOEs to determine the level of technology integration, and identify correlating characteristics of successful technologies that can serve as indicators to increase the likelihood of successful integration of future projects. To date the team has spoken with several key NAVFAC stakeholders to better understand their existing processes and challenges. The framework and MOEs developed in this study are envisaged to increase the likelihood of successful technology integration for future NESDI projects.

ME5 Lin Xinhong

MAJ Eugene Mok

About the authors

ME5 Lin Xinhong (left) and MAJ Eugene Mok (right) are students in the Master of System Engineering in the Graduate School of Engineering & Applied Sciences (GSEAS) at the Naval Postgraduate School. ME5 Lin is an Air Force Engineer (AFE) in the Republic of Singapore Air Force (RSAF) and MAJ Mok is an Army Combat Engineer Officer in the Singapore Armed Forces. Contact the EAG team at nps.edu/energy for more information about this research.

ENERGY RESEARCH

Hastily formed micro-grids

A road in the Roseau area, Dominica, is littered with debris, uprooted vegetation and felled poles and power lines from Hurricane Maria.

The Energy Academic Group at NPS is conducting a research effort to evaluate possible design and applications of constructing small, hastily-formed micro-grids using readily available commercial off-the-shelf (COTS) components. These micro-grids would consist of solar panels and deep cycle batteries to produce and store energy, an inverter to convert the battery power into usable AC power, and a controller to help regulate the batteries as they charge. This system would be small enough to fit into the back of a standard pickup truck, but would provide enough power to help meet the needs of small shelters.

The design of this micro-grid was inspired by the humanitarian crisis in Puerto Rico resulting from the 2017 hurricane season. The island's rugged terrain made it difficult to restore power and deliver supplies to communities outside the coastal population centers. These communities relied on portable generator power for months while the grid was undergoing repairs, which means they required a regular supply of fuel to meet their basic energy needs. This hastily formed micro-grids project is intended to help humanitarian efforts prepare for or respond to situations like this. By using readily available COTS components to provide a community with scalable renewable energy capabilities, relief workers could reduce the need to make regular fuel deliveries and reduce the strain on their logistics network.

CONNECT
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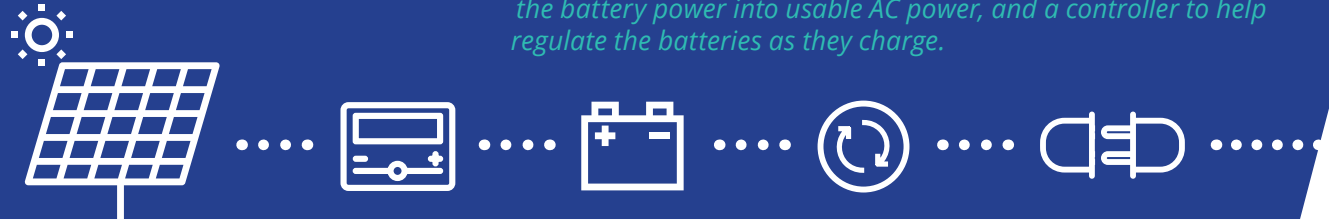
Micro-grid

The micro-grid design would consist of solar panels and deep cycle batteries to produce and store energy, an inverter to convert the battery power into usable AC power, and a controller to help regulate the batteries as they charge.



EAG Calendar of Events

JUL

July 2, 2018
Summer Quarter Begins

July 2, 2018
Second course of DL Defense Energy Certificate begins

July 13, 2018
Defense Energy Seminar Series
ME Lecture Hall
1300–1430

July 13–21, 2018
Energy Security: Regional Caucasus Course
Baku, Azerbaijan

July 20, 2018
Defense Energy Seminar Series
ME Lecture Hall
1300–1430

July 27, 2018
Defense Energy Seminar Series
ME Lecture Hall
1300–1430

AUG

August 3, 2018
Defense Energy Seminar Series
ME Lecture Hall
1300–1430

August 10, 2018
Defense Energy Seminar Series
ME Lecture Hall
1300–1430

August 17, 2018
Defense Energy Seminar Series
ME Lecture Hall
1300–1430

SEP

September 23–28, 2018
Energy Security Awareness Course
NATO School,
Oberammergau

Upcoming

WORKSHOP
July 12, 2018
Super Swarm Challenge – Problem Curation Workshop, Naval Undersea Warfare Center Rhode Island
Focused on potential problem owners and super swarm SMEs. Demonstration at NPS; date TBD.

Interested in Energy-Related Thesis Research?

Over the past five years, NPS and the EAG supported a plethora of student thesis research in the area of energy. A compilation of abstracts on student thesis and other research is available on the EAG website: **www.nps.edu/energy.** The EAG's extensive resources, intellectual capital, and connections with multi-disciplinary faculty and energy professionals provide students enhanced support for energy-related research. If interested in energy research, please reach out to the EAG team!

ENERGY ACADEMIC GROUP
NAVAL POSTGRADUATE SCHOOL

Connect with the Energy Academic Group

The Energy Academic Group is located in Quarters D, Bldg 281 on the NPS campus in Monterey, California. A wide range of NPS faculty are affiliated with the energy program, actively participate in energy graduate education, energy executive education, and energy research. For questions about the Energy Academic Group, please contact one of the principal EAG faculty members:

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