ENERGY ACADEMIC GROUP
NAVAL POSTGRADUATE SCHOOL

SURGE

ENERGY ACADEMIC GROUP QUARTERLY NEWSLETTER FALL / WINTER 2018

Highlights

Captain Fuller (far right) briefs Soldiers from the 1-106th Infantry Battalion, CA ARNG on a 120W Vehicle Solar Kit.

NPS Students Team with the National Guard to Field Test Vehicle Solar Kits

Naval Postgraduate Student (NPS) Major Genevieve Studer (USMC) and, now NPS graduate, Captain Sherifa Fuller (USMC) conducted a field experiment of two 120W Vehicle Solar Power Augmentation Kits during the 1-160th Infantry Battalion's California National Army Guard (CA ARNG) training exercise at the Pohakuloa Training Area in Hawaii. The experiment was coordinated by the NPS Energy Academic Group and the Center for Civil-Military Relations (CCMR) as a part of the NEPTUNE project with sponsorship from the Office of Naval Research.

The vehicle solar kits are designed to lower vehicle fuel consumption, preserve battery life, and decrease the aural and heat signatures of vehicles in order to increase operational capability, enhance force protection, and reduce a unit's logistical footprint. The solar kit enables the vehicle to provide power and operate its electronics equipment without running the vehicle's engine. The field test confirmed that the 120W charging system was convenient, portable, user friendly, and rugged. It also produced enough power to keep the vehicle battery trickle-charged when exposed to full direct sunlight.

A 1-160th Infantry Battalion communications officer noted that during peak power, the power drawn from the radio is greater than the power produced from the solar panel. Additionally, the range of the communications was insufficient for longer retrans missions. One potential solution is to upgrade the vehicle with a Lithium Ferrous Phosphate 6T battery, which could compensate for peak hours and for periods when there is a lack of sunlight.

LEARN MORE

Email Lawrence Walzer at **lmwalzer1@nps.edu** or call 831.656.3777

Principal's Thoughts

Dan Nussbaum, Principal, Energy Academic Group

I've been reading/re-reading a number of energy geopolitical texts, such as *Windfall, Energy Politics, The Absent Superpower, The Prize*, and so forth, and I want to leverage these into a discussion of "what are the BIG issues?" In other words, what questions should we to be thinking about for the next 3–5+ years regarding energy? My purpose is to get people thinking about some of these big energy issues and engender a conversation and perhaps a research roadmap based upon the discussion. My thanks to Professors Bob Looney and Emily Meierding in NPS's National Security Affairs Department for contributing their ideas and helping me to kick off this discussion.

Supply

What are the implications of the supply from the U.S. shale boom, including its ability to act as a "swing supply"? Do we distance ourselves from the Mideast and therefore, be less inclined to commit military forces to the region? Can we enhance both U.S. hard and soft power around the world (e.g., increasing U.S. pressure on Iran), and what forms might these pressures take?

Demand

Some might describe this as "Peak Oil", but I am not talking oil supply here, which was rumored about in the past. Rather, I am referring to peak oil demand. This is particularly interesting during a period where things like conservation, renewables, and electric transportation bite into aggregate oil demand. Do lower oil prices (further) destabilize, say, Venezuela, Iran, or Russia? What happens to social cohesiveness in, say, Saudi Arabia?

Energy diversification

What are the implications for Russia and Europe if the U.S. becomes a serious liquified natural gas supplier to Europe? Similarly, what are the strategic implications for Jordan and Egypt for buying Israeli natural gas via pipelines? How quickly, and with what consequences, do wind and solar penetrate the aggregate energy market, and in which geographies is it most impactful?

What are your thoughts? How do we leverage these ideas, including yours, into NPS student theses, research projects, or symposium panels? I would very much like to hear from you!

CONTACT
DAN NUSSBAUM
Email danussba@nps.edu
or call 831-656-2387

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 Seminars Series is 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 in this issue of *Surge* or visit **nps.edu/web/eag/seminars** for upcoming and archived seminars.

STUDENT ENERGY RESEARCH SPOTLIGHT

Marine Corps NPS Students Seek to Capture the Energy of Braking

By Major Tyrone Barrion and Major Dianna Zempel

Besides the foot patrols our infantry and special forces conduct, you would be hard pressed to find an operation or training exercise in which tactical vehicles are not employed. Subsequently, it is an obvious understatement to say that fuel is central to Marine Corps mission accomplishment, both in garrison and deployed. Imagine then, if our logistic vehicles' range were doubled. How much more lethal could the Marine Corps be if vehicles did not have to be idled to maintain communications capabilities? Can this lethality be quantified and if so, how much should be invested to realize this tactical advantage?

This is our goal. By researching the application of current technology employed in the commercial and private sectors, we hope to find ways in which the DoD can retrofit tactical vehicles with energy recovery systems. While most energy recovery systems today utilize the recovered energy for the propulsion of the vehicle (think Prius), our goal is to divert this energy to power the on-board auxiliary systems, such as communications equipment. Such a concept is not new; however, it has yet to be integrated into tactical vehicles.

The focus of Majors Tyrone Barrion and Dianna Zempel's research is to find ways in which the DoD can retrofit tactical vehicles with energy recovery systems.

In response to questions by the Armed Services Committee, Secretary of Defense Mattis called for efforts to reduce our reliance on fuel and reduce the limitations imposed on our forces. Through our research, we will provide decision-makers feasible and economical solutions to achieve this reality. One of the benefits of this approach is increased range of tactical vehicles through improved fuel economy. With fuel costs nearing $600 per gallon during combat operations in Afghanistan, there is a clear and present need for adaptations to achieve cost savings. In addition to savings, there are also operational impacts, such as: smaller convoys, less fuel runs, smaller heat signature, and the ability for more covert ops. We are hopeful that through our research, the Marine Corps will see the benefit of energy capture through regenerative braking and engender conversations around the implementation of current and emerging technologies.

Major Tyrone Barrion

Major Dianna Zempel

About the authors

Both Majors Tyrone Barrion and Dianna Zempel are engineer officers in the U.S. Marine Corps. They are currently enrolled in the Defense Systems Analysis curriculum at the Naval Postgraduate School. Both have served in deployed environments numerous times and have experienced firsthand the "tether of fuel."

Contact the EAG team at **nps.edu/energy** for more information about this research.

Power Electronics-Based Energy Management System Research

By Giovanna Oriti, ECE, GSEAS

Distributed energy resources (DERs), including local electrical energy sources and energy storage resources, are increasingly being utilized by the Department of Defense (DoD) in many facilities, remote military camps, and on ships, with the goal to increase energy efficiency and reduce fossil fuel consumption. Examples of DER sources are photovoltaic (PV) panels, gas and diesel generators, wind turbines, and fuel cells which are located near the user, unlike the traditional electric power plants which are remotely located.

associate professor in the Electrical and Computer Engineering Department at the Naval Postgraduate School, has led the development of a power electronics-based energy management system (EMS) platform, with funding provided by the ONR Energy Systems Technology and Evaluation Program. An EMS controls various DERs so that they form a microgrid with respect to the main electric power grid as shown in Figure 1. The EMS operates a microgrid in either grid-connected mode or islanding mode when electrical power from the main grid is not available. Thus an EMS increases the microgrid reliability so that critical loads are independent

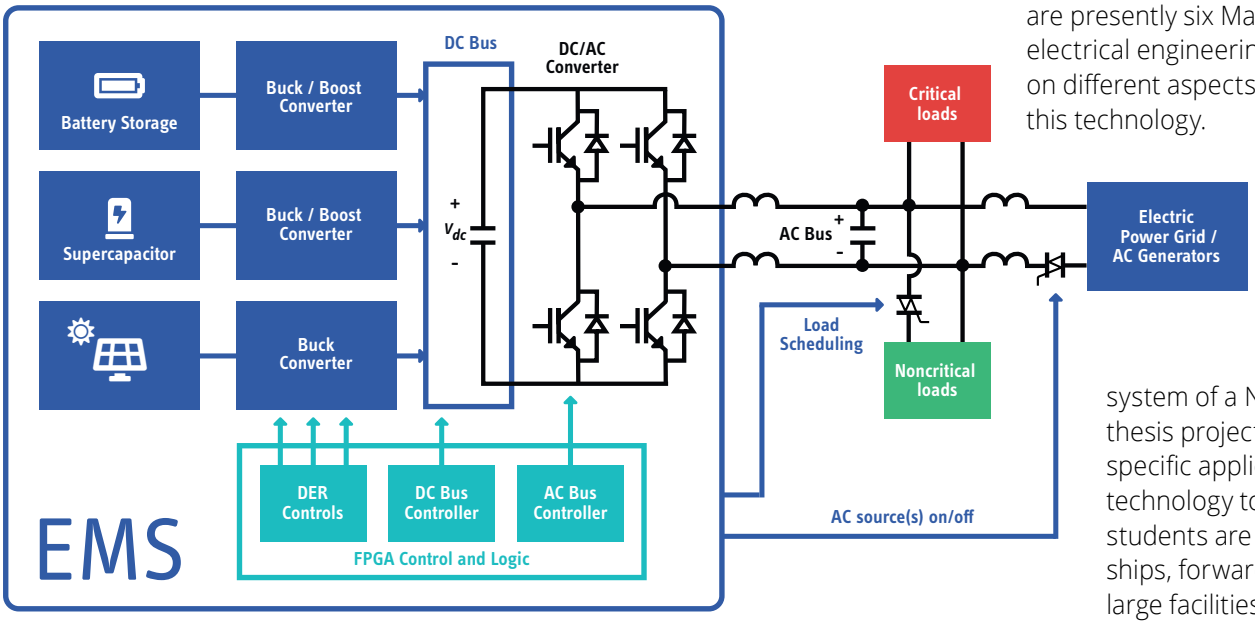


Figure 1: An EMS interfaces with the local DERs and loads forming a microgrid with respect to the main electrical power grid.

Energy storage resources include batteries, flywheels, and supercapacitors as well as thermal and other non-electrical energy storage modules. Power electronic converters are necessary interfaces to connect DERs to a local power system or microgrid because they convert the electrical energy from the format required by the DERs to the format demanded by the loads.

For the past six years Dr. Giovanna Oriti, a power electronics specialist and

from any alternating current grid malfunctions.

The schematic in Figure 1 illustrates how EMS interfaces with local loads, DERs, and the main electric power grid. Loads can be critical if they are necessary to the successful operation of the facility or military mission; alternatively they are labeled as "non-critical", and they can be shed if an emergency occurs and the amount of electrical power available to the microgrid is limited. In forward operating bases diesel generators are used instead of the electric power grid, which is not available in remote locations. Note that the DERs connected to the direct current bus require power converters to condition and regulate the power flow.

Since 2012, several electrical engineering (EE) students have contributed to the development of the EMS platform, including active and reactive power flow control, load management and shedding, power converter control and topologies, energy storage interface and control, and modeling and analysis of the various components of the EMS. The first two theses, in 2013, led to as many peer-reviewed journal papers as well as conference presentations. After that, the interest in EMS-related theses projects has grown, and there are presently six Master of Science in electrical engineering students working on different aspects and applications of this technology.

Increased energy efficiency and energy security result from embedding an EMS into the electrical power system of a Navy facility. Ongoing thesis projects are focusing on specific applications of the EMS technology to scenarios that the students are interested in: hybrid ships, forward operating bases, large facilities, buildings, etc.. Each case has a specific power system whose requirements and challenges are addressed using engineering methodology and ingenuity in order to successfully increase its energy efficiency and energy security. Students utilize physics-based modeling to analyze and develop power converter topologies and control strategies for the different applications of the EMS technology. They also verify their analytical results with laboratory experiments on a platform that has been developed over the years by faculty and students in the EE power laboratory.

ENERGY RESEARCH

Marine NPS Students Assess Potential Uses for Power Transmission Over Laser (PTROL) Technology

Capt Dullnig-Abercrombie (far left) and Capt Cybulski (far right) at PowerLight Technologies in Seattle, WA with laser powered RC helicopter showcase.

Marine Captains Christine Dullnig-Abercrombie and Michael Cybulski, both Naval Postgraduate School (NPS) students in the Information Warfare Systems Engineering Program, recently completed a "use case" study on Power Transmission over Laser (PTROL) technology and its applicability to Marine Expeditionary Units (MEUs). Through the Neptune program with the Office of Naval Research sponsorship, the NPS Energy Academic Group coordinated the study in support of U.S. Pacific Command's Transformative Reductions in Operational Energy Consumption (TROPEC) office, which is looking closely at the potential to conduct remote power resupply in order to increase operational capability, enhance force protection, and save costs.

PTROL technology conducts remote power resupply by converting electrical energy into a laser, beaming it to a receiver on equipment requiring power, and then converting the laser back into electricity for use by the receiving equipment. The capability is envisioned to conduct point-to-point resupply of static/dynamic ground systems and even mobile air assets such as Unmanned Aerial Systems in order to maintain continuous intelligence, surveillance, and reconnaissance.

The assessment focused on likely potential use cases and ideal power capacity of PTROL for MEUs. While the assessment identified some risks to be mitigated, the team identified several benefits for conducting power resupply via PTROL technology during ship-to-shore operations, for retransmission sites, and for perimeter sensors. The study will help enable TROPEC to focus development on the right level of wattage for transmission at the desired ranges most applicable to operations.

LEARN MORE
Email Lawrence Walzer at **lmwalzer1@nps.edu** or call 831.656.3777

U.S. and international military personnel engage in wargaming and operations planning. (U.S. Air Force/Nathan Allen)

Air Force Helps Incorporate Operational Energy Into Wargaming

By Dominick Wright, PhD, Air Force Operational Energy (SAF/IEN)

Assertions that energy logistics are an important feature of major combat operations are not new. Henri Berenger made his observation during the inter-war period when great powers were determining how to prevent the next global war, and how to win it if deterrence failed. While planning for combat operations against Imperial Japan in the Pacific during the Second World War, the United States military embarked on a series of wargames, and in doing so, discovered operational shortfalls that presented significant logistical challenges. As a result, the U.S. military identified game changing logistical advances, such as the advent of underway replenishment for fuel and resources, leading to the acquisition of required capabilities including liquid and dry bulk transport ships. These developments remain a critical enabler of operational reach today.

Despite the relevance of operational energy throughout history, military planning and execution over the last few decades has often assumed fuel and associated logistical resources to be readily available. Wargaming has not been much different. Prior to 2017, simulated planning and execution in the Air Force Title 10 wargame campaign, Global Engagement, largely ignored fuel flows needed to sustain base operations. At present, Air Force Operational Energy is working with a host of defense and industry partners, such as the Naval Postgraduate School, Air Force Petroleum Office, Defense Logistics Agency – Energy, and others to incorporate energy logistics into Global Engagement.

Energy logistics, as a system of activities for fossil fuel-burning platforms, includes the extracting and refining of crude oil, the bulk shipping of refined products, the operational storage of refined products, and the tactical distribution of refined products to combat or support platforms. Air Force Operational Energy's goal is to facilitate better understanding of the logistical challenges that come with this system across the enterprise and to drive energy-informed leadership decisions in wargaming—and ultimately in basing strategy and investment priorities.

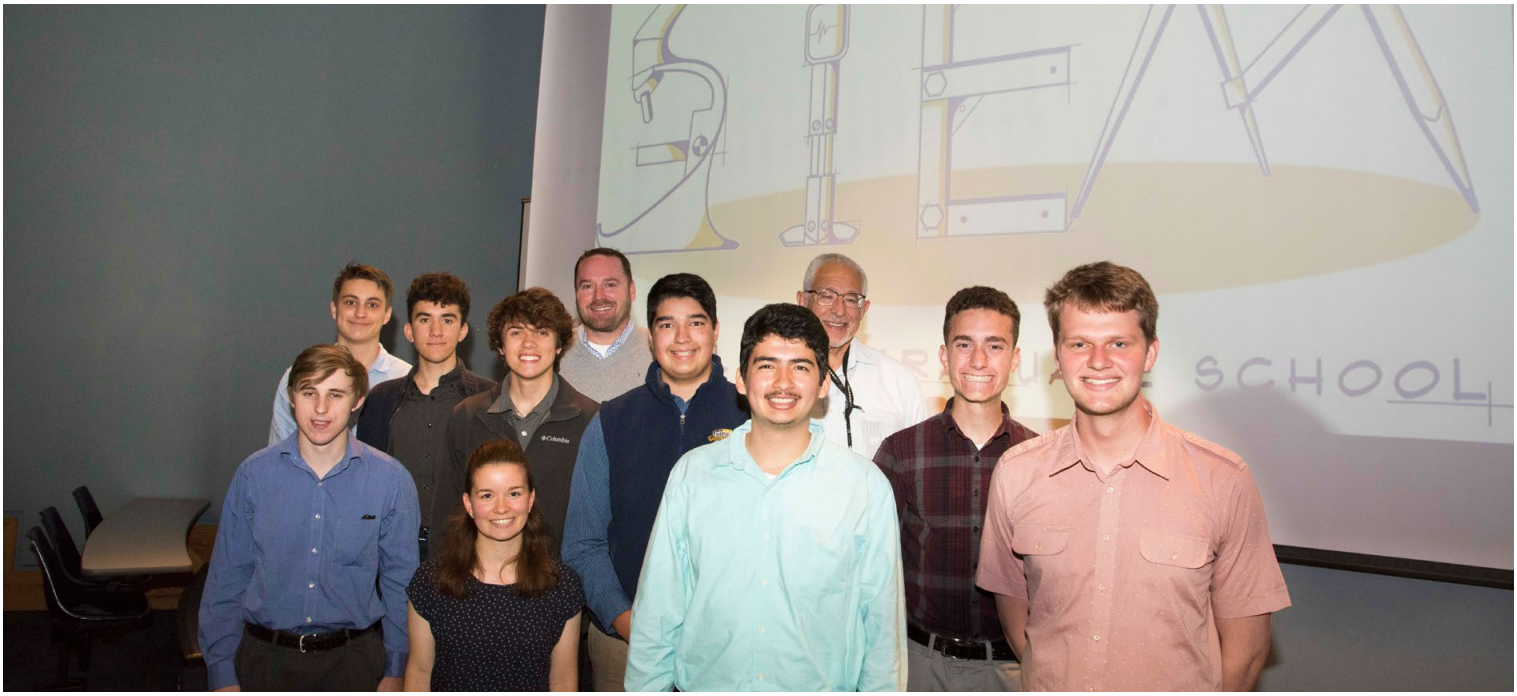
Some insights drawn from the fast paced, short duration Global Engagement 2018 Capstone Event, which took place at Schofield Barracks in July, are likely to have near-term, tactical-level impacts that may improve the Air Force's airbase resiliency efforts. Following its completion, Air Force Operational Energy turned its attention to incorporating energy needed to run installations and contingency locations into wargaming, developing capabilities to integrate logistics-related modeling and simulation tools into gameplay, and—most importantly—continuing to build and leverage partnerships throughout the defense logistics community.

LEARN MORE

For more information and news on Air Force Operational Energy visit: **www.safie.hq.af.mil/OpEnergy/**, **twitter.com/AFEnergy**, and **facebook.com/AirForceEnergy**

ENERGY RESEARCH

Summer Interns Advance Ship-to-Shore Fuel Studies



EAG worked with interns on an ongoing Naval Research Program study. Interns included one Air Force cadet, three college students, and six high school students.

The Energy Academic Group brought on ten interns to assist in an ongoing Naval Research Program study on the challenges associated with ship-to-shore transfer of bulk fuels. These interns consisted of one Air Force cadet, three college students, and six high school students. They were divided into three teams to tackle different aspects of the problem.

The first team focused on issues related to fuel demand of a distributed expeditionary base model for Marines in the Pacific area of responsibility. Their work established estimates for bulk fuel demand at these bases and a system for estimating degradation of operational capabilities if those fuel needs are not fully met. Their biggest accomplishment was the creation of a simple excel tool that could be used to compare different bases' resiliency towards disruptions in fuel supplies.

The second team created a wargame to explore how limited ability to transport fuel can hinder ground operations. This wargame is played on Android tablets and is adapted from an earlier EAG table-top excercise intended to improve understanding of logistical constraints when planning combat operations. The new Android-based wargame is designed with the flexibility to be used in both research modeling and educational roles with minor adjustments.

The last team created a computer model to help understand how different mechanisms of ship-to-shore bulk fuel transfer impact naval operations and logistics. Their program includes combat ships, logistics ships, and various shore bases with scheduled fuel demands. The model determines if the ships are able to meet the fuel demands for their missions while supporting the ground forces with different ship-to-shore transfer mechanisms.

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

Announcing the Resilience Corner

By Dan Eisenberg, PhD, Department of Operations Research, Naval Postgraduate School

Resilience is a "new" term creeping into Energy Academic Group discussions and research, but what does it mean? Starting in the next issue of *Surge*, I will present short explanations of unclear concepts like risk, resilience, and robustness to help readers apply them in their own work. I invite feedback and recommendations for content for the upcoming Resilience Corner.

ENERGY EDUCATION

NATO Energy Efficiency in Military Operations Course in Vilnius, Lithuania

NATO's 2018 Energy Efficiency in Military Operations Course Participants and Instructors

The Energy Academic Group at the Naval Postgraduate School and the NATO Energy Security Center of Excellence (ENSEC COE) co-sponsored the NATO Energy Efficiency in Military Operations Course (EEMOC) in Vilnius, Lithuania from 11–15 June 2018. The purpose of the course was to raise awareness on the importance of energy efficiency in the military domain, as well as enhance participants' understanding of energy efficiency implications during military operations.

The course brought together 19 participants from Canada, Denmark, Estonia, France, Great Britain, Latvia, Lithuania, Poland, Spain, and the United States (U.S.). Participants enjoyed the opportunity to attend such an event with energy security stakeholders from other agencies and countries. Lecturers from across NATO and subject matter experts from the ENSEC COE, NPS EAG, NATO Headquarters, U.S. Army Engineer R&D Center, Germany, the UK Royal Marines, and industry specialists presented topics during the course.

The EAG faculty assisted with course facilitation, presented briefings on energy security, and conducted an energy efficiency table-top exercise (TTX) for participants. The energy efficiency TTX was presented and facilitated by EAG Faculty Associate Mr. Lawrence Walzer and recent NPS graduate, Captain Geoffrey Melvin (USMC). The TTX focused on best practices, emerging technologies, and alternative energy solutions related to camp energy generators. The exercise operationalized the course content and allowed the students to test and develop solutions, through scenarios and problems, in order to compete for the most fuel-efficient operational planning.

The next EEMOC will also be in Vilnius, Lithuania in May 2019.

LEARN MORE

Email Lawrence Walzer at **lmwalzer1@nps.edu** or call 831.656.3777

ENERGY SECURITY

EAG and NATO Energy Security Center of Excellence Hold Regional Energy Security Symposium in Baku, Azerbaijan

U.S. Chargé d'Affaires to the Republic of Azerbaijan, Mr. William Gill, provided a keynote speech to symposium participants

The Energy Academic Group co-sponsored the Regional Energy Security Symposium in Baku, Azerbaijan from 16–20 July, 2018 with the NATO Energy Security Center of Excellence, which was hosted by ADA University. Participants included government and industry representatives from Turkey, Georgia, and Azerbaijan. Lecturers included academics, government officials, and oil executives from British Pretroleum (BP) and the State Oil Company of the Azerbaijan Republic (SOCAR).

The objective of the symposium was to further energy security and resiliency through increased awareness, information sharing, interagency collaboration, and regional cooperation. The week included several discussions to include topics on energy security, geopolitics, threats to energy infrastructure, and breakout groups focused on energy crises—such as cyberattacks, terrorism, and hybrid warfare.

Participants enjoyed the opportunity to attend the symposium which included energy security stakeholders from other agencies and countries. They particularly appreciated the high-level participation by government officials and oil executives. The Azerbaijan Minister of Energy, H.E. Parviz Shahbazov, and the U.S. Chargé d'Affaires, Mr. William Gill, both were keynote speakers during the week. Additionally, BP and SOCAR executives provided briefs on industry perspectives focused on regional energy security and public-private cooperation on critical energy infrastructure protection (CEIP).

EAG faculty provided briefings on CEIP and resiliency, threats to energy infrastructure, and facilitated daily breakout groups.

LEARN MORE
Email Lawrence Walzer at **lmwalzer1@nps.edu** or call 831.656.3777

Calendar of Events

SAVE THE DATE!

TWITTER CHAT with @AFEnergy | October 30, 2–3PM EST | #ProtectThePower

Learn about USAF energy initiatives that increase combat capability.

OCT

October 12, 2018

Defense Energy Seminar Series: Topic to be determined

NPS ME Lecture Hall
1300–1430

October 19, 2018

Defense Energy Seminar Series: Data and Analyses in Support of Energy Efficient Base Camp Design

NPS ME Lecture Hall
1300–1430

October 26, 2018

Defense Energy Seminar Series: Energy Security Curriculum at United States Naval Academy

NPS ME Lecture Hall
1300–1430

NOV

November 2, 2018

Defense Energy Seminar Series: Navy Power and Energy

NPS ME Lecture Hall
1300–1430

November 16, 2018

Defense Energy Seminar Series: Operational Models for Critical Energy Infrastructure Resilience

NPS ME Lecture Hall
1300–1430

DEC

December 14, 2018

Fall Quarter Graduation Ceremony

NPS King Hall
1000

Upcoming

December 17, 2018 – January 2, 2019

Winter Break

January 3, 2018

First day of Winter Quarter

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:

Alan Howard
arhoward@nps.edu
831.656.3855

Jack Templeton
jctemple1@nps.edu
919.696.1398

Lawrence M. Walzer
lmwalzer1@nps.edu
831.656.3777

Brandon Naylor
blnaylor@nps.edu
831.656.1986

Kevin Maher
kjmaher@nps.edu
831.656.2691

Contribute to *Surge*

If you would like to contribute or have your research/work published in the SURGE newsletter, please contact Jack Templeton via email at jctemple1@nps.edu or phone 919.696.1398.

Surge is published quarterly by the Energy Academic Group at the Naval Postgraduate School.
Jack Templeton, Editor-in-Chief • Lois Hazard, Lead Editor • Frank Chezem, Art Direction / Design