



SURGE



ENERGY ACADEMIC GROUP QUARTERLY NEWSLETTER FALL 2021

Highlights

CLIMATE AND ENERGY
CARBON NEUTRAL MILITARY
DOD ENERGY STRATEGY
CYBER ANALYTICS
HYBRID MICROGRIDS
EAG INTERN RESEARCH

NPS Launches Center on Combating Hybrid Threats to Address Hybrid Warfare

By Matthew Schehl,
Naval Postgraduate School
Office of University Communications

On November 25, 2018, a Russian commercial cargo ship suddenly parked itself across the narrow Kerch Strait on the Crimea, blocking three Ukrainian Navy vessels sailing in international waters from reaching the port of Mariupol on the Sea of Azov. When they tried to turn back, the ships were rammed and fired on by Russian military forces, then boarded and seized. The event sparked international outrage at the time, but the deed was done: through obfuscation and brute force, Russia had asserted de facto dominance over the strategic passage into the Black Sea and beyond.

The incident has since been seen as a textbook example of a new generation of hybrid warfare, blurring the lines between military and unconventional conflict. Operating just below the threshold of war, state and non-state actors are increasingly employing hybrid methods to attain their objectives. Their intentional use of disinformation,

Operating just below the threshold of war, state and non-state actors are increasingly employing hybrid methods to attain their objectives.

prevarication, cyberattacks, economic pressure and the deployment of irregular armed groups presents a critical challenge to the world's democracies.

It's a challenge that the Naval Postgraduate School (NPS) is taking on directly.

The university's new Center on Combating Hybrid Threats (CCHT), officially formed in early 2021 to meet this growing threat, is part of an international effort to detect, deny, disrupt, degrade, defeat and ultimately deter the use of hybrid threats by our adversaries. Drawing on NPS' immense intellectual capital, the CCHT serves as a locus for interdisciplinary research, education programs and outreach for partners near and far.

"The CCHT is an opportunity for us to tackle the problem of hybrid threats from a comprehensive, 'whole-of-discipline' approach in order to better confront these challenges in the future," explained Larry Walzer, CCHT's deputy director. "We work both domestically and with allies and partner nations as a forum to exchange ideas to better confront these challenges together. Certainly, a more comprehensive approach is required if we're going to get to a position where we can actually deter our adversaries."



CONTINUED ONLINE

Read the full article at:
nps.edu/-/nps-launches-center-for-combating-hybrid-threats-to-address-hybrid-warfare



FROM THE CHAIR

Dan Nussbaum, Chair of the Energy Academic Group

There is much going on, as always! Therefore, in this article I want to highlight some of the current activities by faculty members within the Naval Postgraduate School (NPS).

- In an article published in Foreign Policy, "Hidden Dangers of a Carbon-Neutral Military", Alan Howard and Brenda Shaffer, both in the Energy Academic Group, address a provocative issue: "If the U.S. military goes electric, it could be good for the planet—and bad for national security." Their line of questioning is not tendentious, but rather is in line with good research, as it addresses the argument: "Transferring from a diversified U.S. energy mix to one concentrated on electricity will create many new threats to the United States, including its military. This is especially important to consider in the context of competition with China, which will have an immense advantage in this new energy era. These new threats warrant a wider public discussion before the Pentagon flips the switch."
- Preetha Thulasiraman of the Electrical and Computer Engineering department provides insights into "Cyber Analytics for Energy Infrastructure Networks."
- Giovanna Oriti of the Electrical and Computer Engineering department and Daniel Reich of the Graduate School of Defense Management contribute an important article entitled "Rightsizing the Design of a Hybrid Microgrid."

- ENS Joo W. Lee, USN, gets this edition's student spotlight with his thesis "Optimizing Fuel Efficiency on Isolated Microgrid with Energy Storage System under Varying Loads."

Continuing a focus on the critical issue of educating naval officers in the issue of energy, and, in particular, operational energy, three initiatives deserve mention:

- Alan Howard, Brenda Shaffer, and Daniel Nussbaum of NPS' Energy Academic Group, sponsored by RuthAnne Darling of OSD (Energy Innovation), are developing a textbook on operational energy. The book is 65% finished (all authors reading this know the challenges associated with writing a textbook!) and will include many case studies, which are useful for teaching the material in the textbook and for sparking new thinking on operational energy among the students.
- EAG's Naval Enterprise Energy Education & Training (NE3T) Workshop, held in late July under the leadership of Daniel Temple, also from EAG, continues the effort to address the DoN energy problem through education. The workshop hosted experts in multiple fields to explore opportunities to use education to advance the DoN's operational energy issues and to discover ways to include operational energy curricula in the Navy's undergraduate and graduate programs. You can see more [here](#).
- Dan Nussbaum, Alan Howard, and Arnold Dupuy, all from EAG, proposed

to ASN (RDA) the creation of a new energy educational program for naval officers. The proposal proceeded from the assertions that energy is the base of the kill chain; that the naval Services are not ready for the future; and that we need energy-aware, technically-proficient officers who are versed in operations and warfare exercises, and able to respond with innovative solutions to continue to dominate in rapidly-evolving future warfare environments.

If you're interested in any of these topics, please do not hesitate to reach out to me.

The work in all aspects of the energy domain continues, and I am honored to work with outstanding colleagues at EAG and throughout NPS.



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CLIMATE AND ENERGY

The Intersection of Climate and Energy

By Kristen Fletcher
Faculty Associate-Research,
Energy Academic Group

Solar panels form part of the Renewable Hydrogen Fueling and Production Station on Joint Base Pearl Harbor-Hickam. It is the only hydrogen station in Hawaii and about 30 hydrogen-powered vehicles use the JBPHH station. (U.S. Navy Photograph by Mass Communication Specialist 2nd Class Daniel Barker)

Both climate and energy are interwoven in national security and military operations.

Our use and production of energy have an impact on climate, and climate change can alter our energy generation potential and energy needs. Operationally, environmental change puts stress on energy infrastructure and reliability of energy sources, especially in extreme temperatures or extreme weather.

The Navy's approach to addressing the intersection of climate and energy is practical: it recognizes its vulnerabilities including coastal infrastructure and supply chains that furnish energy and materials to its bases and fleet, all of which are essential to mission readiness. Increasing energy efficiency reduces risk to infrastructure and lives, while transitioning to renewable energy at bases can help protect from cyberattacks on traditional electric grids.

Executive Order (EO) 14008, "Tackling the Climate Crisis at Home and Abroad," includes a U.S. goal of net-zero emissions by mid-century and makes this goal an essential element of U.S. national security. In 2019, DoD energy consumption accounted for up to 77% of federal government energy use. To meet the goals of EO 14008, the DoD and DoN must move from a focus on high-level goals to identifying achievable pathways that can lead to net-zero emissions.

NPS research is contributing to the Navy's role in this effort. NPS students have undertaken a capstone project on the cost-benefit analysis of green fuels this fall while EAG will lead a 2021-2022 project, funded by the Naval Research Program, entitled *Analysis*

of Pathways to Reach Net-Zero Naval Operations by 2050. The project will be interdisciplinary to understand DoN energy needs and evaluate solution pathways.

LEARN MORE

NPS Climate and Security Network: nps.edu/climate

EAG Energy, Climate & Environmental Security: nps.edu/web/eag/energy-climate

Email Kristen Fletcher at kristen.fletcher@nps.edu



Interested in Energy-related Thesis Research?

Since 2013, NPS and the EAG supported a plethora of student thesis research in the area of energy. Publicly viewable student theses can be searched from the Resources page of the EAG website at nps.edu/web/eag/resources. 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 STRATEGY

The Hidden Dangers of a Carbon-Neutral Military

By Alan Howard, Associate Chair, Energy Academic Group and Brenda Shaffer, PhD, Faculty Associate – Research, Energy Academic Group

Washington has encouraged the electrification of wide swathes of the U.S. economy as a way to encourage greater use of renewable energy and reduce carbon emissions. The U.S. Defense Department, the largest consumer of energy in the U.S. federal government, is now considering pursuing its own wide-scale electrification. Such a step would have profound strategic effects that should cause policymakers to proceed far more cautiously.

In recent months, the Pentagon has launched studies to examine increased use of electricity by the military, including in battle for vehicles, tanks, ships, and planes. The Pentagon has even studied the deployment of small nuclear reactors in the battle space to provide power. NATO is also promoting increased electrification of its allied militaries. According to NATO Secretary-General Jens Stoltenberg, “it makes little sense to have more and more electric vehicles on our streets while our armed forces still rely only on fossil fuels.”

What Stoltenberg said sounds intuitive but may not be true. Each time a military makes a major change to its energy system, it inevitably has immense geopolitical implications. When former British Prime Minister

Winston Churchill made the decision to transfer the main source of fuel for the British Royal Navy from coal to oil, he understood the decision had significant strategic implications. Fueled by oil, the British Royal Navy could cover larger distances without refueling and at quicker speed. Yet, through this decision, London would be dependent largely on foreign-produced oil versus homegrown coal.

Today, the United States’ energy mix is well diversified: oil, natural gas, coal, nuclear, hydropower, biofuels, wind energy, and solar energy. Diversification is a key element of any energy security policy and a cornerstone of a system’s resilience. By relying more heavily on electricity and by regulating electricity generation in ways that phase out fossil fuels, the number of major energy sources widely consumed in the United States will inevitably shrink to a less diversified mix.

It will also make the United States more reliant on foreign actors. The bulk of energy supplies currently consumed in the United States are homegrown. The United States can supply all its oil, natural gas, and coal needs as well as uranium for nuclear power. The policy to rely more on electricity means the United States will need to import

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minerals necessary for electricity systems. The bulk of these minerals are found in China and countries where China is the dominant player in their economies and infrastructure. Fossil fuels, by contrast, are ample and found in diverse places around the globe. There no longer is a geopolitical race to put flags on oil or gas fields since there is enough for all.

The broader renewable energy economy’s dependence on limited rare earths and other minerals is likely to unleash a great game for minerals that is already requiring the U.S. government’s attention. To reduce dependency on imported minerals, Washington is

considering granting incentives for domestic mining of these needed materials. Thus, the United States may soon go from mining coal to mining lithium, substituting one environmental threat with another.

The U.S. energy system's increasing concentration on electricity production also drastically raises the likelihood of cyberattacks. The more interconnected an energy system is, the more vulnerable it is to severe cyberthreats. Moreover, hydroelectric and nuclear power plants—though emitting little to no carbon—have potentially catastrophic cyber vulnerabilities that entail not only the loss of power production but also plant exploitation, which could lead to massive flooding or radioactive exposure.

The United States should be strategizing about ways to combat these vulnerabilities. For it to jump headlong into contributing to those vulnerabilities by de-diversifying its own energy mix would be a disastrous folly.

And this is before even considering the specific vulnerabilities posed by an electrified military battlefield. The more the U.S. military's equipment, infrastructure, and personnel depend on electricity, the more vulnerable it will be to cyberattacks from foreign militaries. The United States' adversaries have substantial proven capabilities in cyberspace, some superior to the United States' abilities. Greater use of electricity in the battlefield will also increase U.S. troops' exposure to foreign surveillance.



CONTINUED ONLINE

Read the full article at:
nps.edu/web/eag/news-2021

LEARN MORE

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Enrollment Open for Defense Energy Certificate Program



The Naval Postgraduate School's (NPS) Energy Academic Group is pleased to announce the fifth offering of its Defense Energy Certificate program. This offering (cohort) will begin 28 March 2022. The certificate program is free to all students, but applications must be submitted, transcripts received, and a Participation Agreement signed before NPS can process the application.

Applications are due NLT 7 January 2022.

The DL Defense Energy Certificate program is a graduate-level and accredited certificate program. It consists of four courses, offered one course (online) per quarter for four consecutive quarters. The program is open to all federal civilian employees who are U.S. citizens and qualified uniformed enlisted and officers. The Energy Certificate is designed to support the Office of the Secretary of Defense and the Secretary of the Navy's energy goals. The DL Energy Certificate provides those working military and civilian employees of the Department of Defense the opportunity to understand the complex issues facing the Operational and Installation Energy segments of DoD and how they impact Operational Capability issues as well as military requirements. This certificate program is designed to expose students to the technical, operational, and security aspects of DoD's energy needs. Students who successfully complete the program will earn an accredited Certificate in Defense Energy. The Western Association of Schools and Colleges (WASC) confers accreditation.



FOR MORE INFORMATION OR TO APPLY

Email Kevin Maher at or call 831-656-2691. Detailed instructions are also posted on the EAG website at <https://nps.edu/web/eag/defense-energy-certificate-program>

OPERATIONAL ENERGY

Energy Academic Group's NE3T Workshop Tackles DOD Energy Problem With Education

By MC2 James Norket,
Naval Postgraduate School
Office of University Communications



NPS Faculty Associate for Research Daniel Temple speaks to participants of the NE3T Workshop held at the Naval Postgraduate School on July 30, 2021. (U.S. Navy photo by MC2 James Norket)

The Energy Academic Group (EAG) at the Naval Postgraduate School (NPS) hosted experts in multiple fields to explore opportunities to utilize education to advance the DODs operational energy issues during the Naval Enterprise Energy Education & Training (NE3T) Workshop, July 27–30.

The EAG is an interdisciplinary group of highly diverse faculty that provides energy-focused graduate education, research and outreach. Dr. Daniel Nussbaum, NPS professor and chair of the EAG, said that the workshop was held to discover ways to include operational energy curricula in the Navy's undergraduate and graduate programs.

"This is a multi-year project," he said. "Ultimately, we would like to create new courses and maybe build in some energy-related topics to already existing programs."

Daniel Temple, a Faculty Associate for Research with the EAG, coordinated and facilitated the workshop.

"The goal of the workshop was to figure out the operational energy learning objectives that officers in the Navy and Marine Corps need to know at certain points in their careers," said Temple.

Operational energy is defined, simply, as "the energy, electricity or gas that is needed to complete a mission," Temple added.

Although NPS has several people who are considered subject-matter experts in all things energy, Temple went above and beyond to get the most out of the workshop.

"We didn't just want to hear from our own people," he said. "We wanted to hear from experts in training and education, community research, and acquisition specialists. We wanted to have multiple facets represented during the workshop."

Temple believes the workshop was a great success and said that multiple ideas were generated during the four-day event.

"A ton of ideas were brought up that we had never thought of," Temple said. "We have some really good examples and plans that we can now present to senior leadership in the DOD to get everyone to fully buy in."

Nussbaum also gave the workshop an "A+" and admitted that he was a hard grader. Interdisciplinary problems call for jointly integrated solutions, Nussbaum said, making NPS the ideal location for this event.

"[NPS] has brilliant academics just like they have at other top-tier universities," said Temple. "But NPS academics are solely focused on DOD applications. I don't think you could find a civilian university to solve these problems. You'd be hard pressed to find another school that can do the research, and develop the academic material that NPS can."



LEARN MORE

Email Dan Temple at daniel.temple@nps.edu

Join the Energy Team

EAG is looking for smart, motivated people to join our team to work on the energy challenges affecting the U.S. military and national security. We are looking for varying levels of experience and education—minimum requirement is a Bachelor's degree. Areas of interest include cyber/energy nexus, supply chain/logistics, critical infrastructure protection/resilience, engineering, policy/geopolitics of energy, environment/climate. Military experience is desired but not required.



LEARN MORE

Contact Alan Howard arhoward@nps.edu to learn more.

SMART GRIDS

Cyber Analytics for Energy Infrastructure Networks

By Preetha Thulasiraman,
PhD, Associate Professor
Electrical and Computer
Engineering, NPS

In 2019, the Naval Facilities Engineering Systems Command (NAVFAC), deployed the Navy Smart Grid enterprise energy management solution. With Smart Grid, an operator in a central command location can monitor energy data in near-real time, deploying technicians to efficiently manage emergencies, outages and repairs. The Department of Navy (DoN) plans to deploy Smart Grid across the shore enterprise over the next several years to enhance resiliency on its installations. However, in order for the Navy to ensure resiliency of the smart grid network, effective countermeasures against security threats must be addressed using techniques that adapt to the massive data that is collected by smart sensors and meters.

The goal of our research is to develop cost-effective, cyber threat detection techniques to secure energy infrastructure that is critical to the Navy. Our research is focused on the use of cyber analytics to continually define and mitigate evolving threat vectors for the Navy smart grid as well as other energy infrastructure networks.

Traditionally, cyber security is managed with reactive solutions that respond to incidents once they have occurred. Cyber analytics is a proactive approach to cyber defense, in which future attack strategies are anticipated and insights are incorporated into the response management of active attacks in real time. Supervised and unsupervised machine learning approaches, including

artificial neural networks and statistical data analysis are key to developing cyber analytic tools that will allow the accurate classification/identification of adversarial and malicious network activity.

Over the last year, this project has investigated the use of supervised learning techniques to build predictive cyber defense systems for the Navy smart grid. We began with supervised learning due to its simplicity and to show cyber analytics can be feasible in the context of the Navy smart grid. Specifically, we built a simple Intrusion Detection System (IDS) that is located at the data concentrators of the smart grid. These concentrators receive the data from the wireless

depending on the type of attack and the combination of attacks for each experiment. We proved that different attacks can be grouped together based on objectives, and that machine learning using a weighted KNN algorithm can be used to segregate the various classes of attack traffic from benign traffic.

The past year of research has been foundational. Our current research efforts are focused on unsupervised learning with an emphasis on neural network autoencoders and predictive optimization. We are training our algorithms on NAVFAC provided data sets that include current, voltage levels, and energy consumption from various smart

Our research is focused on the use of cyber analytics to continually define and mitigate evolving threat vectors for the Navy smart grid as well as other energy infrastructure networks.

networks before pushing it to the local control center. The IDS is a combination of classifier, to quickly detect known attacks, and an anomaly detector to detect new threats. We used a weighted K-Nearest Neighbor (KNN) approach along with Bayesian classification to implement this IDS. Attacks that were studied included Denial of Service (DoS), port probing, and web attacks. The probability of detection and the false positive rate were statistics of significance. We found that our threat detection rate ranged from 93% to 98%,

meters within the smart grid architecture. Preliminary results show a 96% detection rate of irregular data values. As we continue to build our IDS and integrate sophisticated yet optimal multi-layer learning techniques, our ability to predict complicated threats on DoN energy asset networks will improve.



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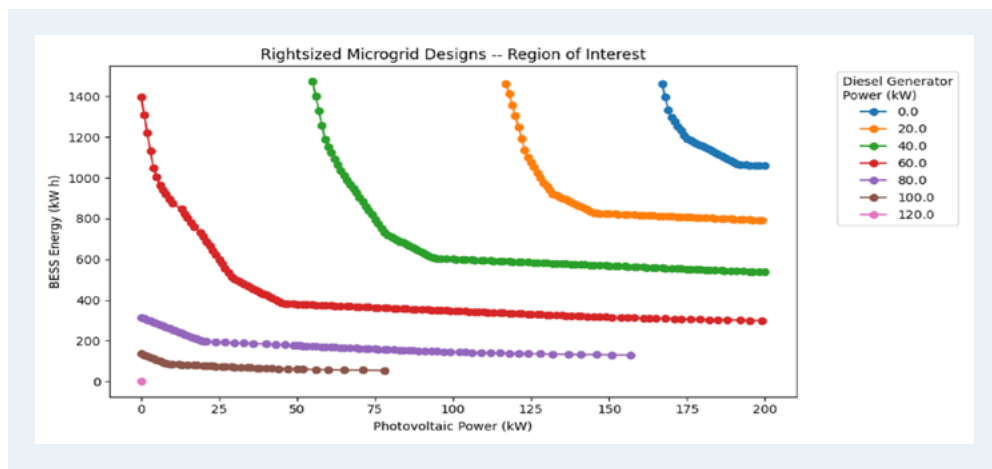
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MICROGRID DESIGN

Rightsizing the Design of a Hybrid Microgrid

By Daniel Reich, PhD (Graduate School of Defense Management) and Giovanna Oriti, PhD (Electrical and Computer Engineering Department)

Selecting the sizes of distributed energy resources is a central planning element when designing a microgrid. We propose a simulation-based nested binary search methodology for rightsizing the distributed energy resources (DERs) of a stand-alone microgrid, given the historical load profile of a facility or building, providing a variety of choices for the energy manager of a facility in which a microgrid is to be installed. Using this design space as a compass, decision makers will be able to select the design(s) most suited to their particular requirements, whether they have cost constraints, environmental specifications or seek to achieve operational resilience. Our method can be



Microgrid designs rightsized to meet power load requirements.

used to size DERs for AC or DC microgrids and also for hybrid AC/DC microgrids.

We decouple component-specific modeling assumptions, energy management system logic and objective measurements from our simulation-based nested binary search method for rightsizing to meet power loads. In doing so, we develop a flexible, customizable and extensible approach to microgrid design planning. Aspects which have traditionally been incorporated directly in optimization-centric frameworks, such as resilience and reliability, can be treated as complementary analyses in our decoupled approach. This enables

decision makers to gain exposure to a wide range of relevant information and actively participate in the microgrid design assessment process.

LEARN MORE

The full publication can be found at: <https://doi.org/10.3390/en14144273>

For more information, email Daniel Reich at daniel.reich@nps.edu and Giovanna Oriti at goriti@nps.edu

Postdoctoral Opportunity on Climate Resilience and Military Installations

The Naval Postgraduate School (NPS) Center for Infrastructure Defense (CID) and the Energy Academic Group (EAG) are leading efforts to assess and improve the resilience of U.S. military installations and surrounding communities to climate change related disasters. Currently, the CID and EAG are leading several projects in this area, such as conducting military installation resilience analysis, creating a climate resilience training platform, coordinating the Climate and Security Network (CSN), and delivering infrastructure resilience short courses to U.S. military and Allied partners. In support of these efforts, we are seeking one or more postdoctoral scholars to support research, publishing, and teaching activities. Applications are coordinated through the Oak Ridge Institute for Science and Education (ORISE) program. We are reviewing applicants, so please apply as soon as possible for full consideration.



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Apply at: <https://www.zintellect.com/Opportunity/Details/NPS-2021-0002>
Visit the following websites to learn more about our work at **CID**, **EAG**, and **CSN**

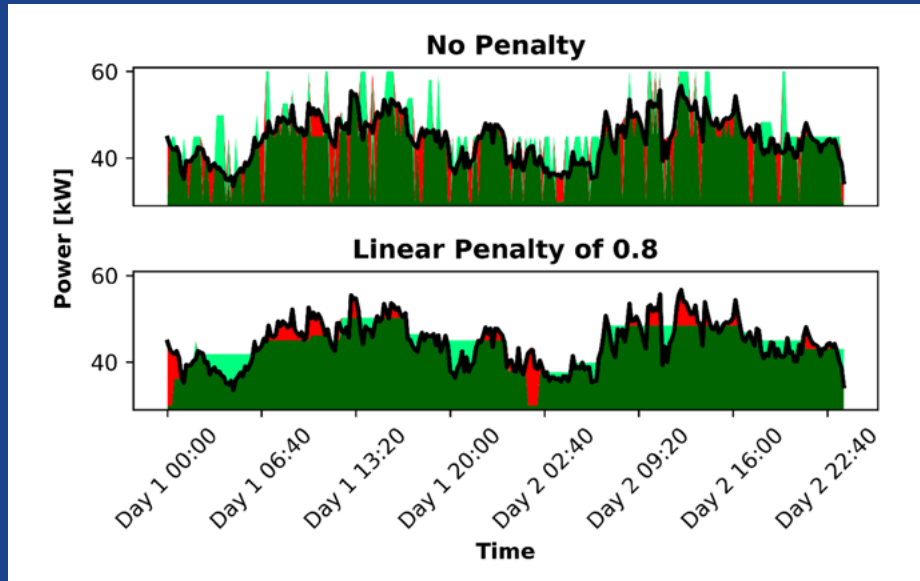
STUDENT ENERGY RESEARCH SPOTLIGHT

Optimizing Fuel Efficiency on Isolated Microgrid with Energy Storage System under Varying Loads

By ENS Joo W. Lee, USN

A major drawback of generating power in an isolated environment is the ability to withstand time-varying loads.

The time-varying demand characteristics introduce difficulty in successfully satisfying the power demands due to generator ramping limits. To help analyze the impact of time-varying loads on optimal generator operation and fuel consumption, we formulate a mixed-integer optimization model to plan generator and energy storage system (ESS) operation to satisfy known time-varying demands using minimal fuel. In the optimization model, we introduce an additive penalty to the existing generator fuel consumption calculation to reduce rapid power fluctuation. Our results show that the change in fuel efficiency between scenarios with the integration of ESS is minimal regardless of the imposed penalty placed on the generator. However, without the assistance of the ESS, the fuel consumption increases dramatically as the penalty imposed on the generator becomes greater. The integration of ESS



The generator (dark green) produces and ESS (red) discharges power to satisfy the demand (black). The additional generator output (lime green) charges the ESS. Generator and ESS power output over time-varying demand where the top graph depicts no penalty imposed on the generator, and the bottom graph depicts a 0.8 slope linear penalty imposed on the generator. The power fluctuation decreases dramatically with an imposed penalty on the generator.

shows a drastic improvement in fuel consumption, where the ESS allows the generator to minimize power output fluctuation to maximize fuel efficiency. The insignificance of penalty type and weight imposed on the generator provides potentially useful insight for future studies in

developing a real-time controller. The exploration of a microgrid controller to save fuel consumption will contribute to minimizing the Department of Defense's operational costs in the future.



ENS Joo W. Lee,
USN

About the Author

ENS Joo W. Lee, USN is a student of the Operations Research department at the Naval Postgraduate School. Contact Dr. Emily Craparo at emcrapar@nps.edu or Dr. Giovanna Oriti at goriti@nps.edu for more information about this research.

EAG INTERN RESEARCH

Moving Toward an Environmental Security Framework



By Emily Zimmerman,
EAG Intern, Summer '21



An aerial view of U.S. Naval Base Guam shows several Navy vessels moored in Apra Harbor.

In an era of significant environmental change that is fueling food insecurity, water and land conflicts, and energy shortages, the links between environment and security are growing more powerful.

Environmental security encompasses environmental change, human security, and national security. A nation-state becomes environmentally insecure when an environmental change is destructive enough to weaken the economy, political stability, quality or quantity of natural resources, and the status of military installations. The Energy Academic Group (EAG) is undergoing research to determine the value of incorporating environmental security into existing

installation management processes.

Traditionally, national security focuses on visible, tangible threats. Today, these threats are exacerbated by global environmental changes from the effects of climate change, extreme weather, ocean acidification, coastal erosion, depletion of natural resources, and water crises. These are considered “actorless” challenges as there is no clear culprit, but they have the potential to multiply other threats. Naval bases are already experiencing environmental changes that can cause a greater risk to security and stability.

Executive Order 14008 directs the DoD to review the implications of climate change on national security, and to incorporate findings into future planning, modeling, simulations, documents, processes, and analyses. There is currently no existing environmental security framework or plan for naval

bases or installations. Research indicates that adding an environmental security framework to existing management of naval bases and installations would reveal vulnerabilities due to environmental change and empower a more proactive approach toward understanding the underpinnings of, preventing, and responding to future conflict.

LEARN MORE

Report available at
<https://nps.edu/web/eag/intern-research>

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Operational Energy Research Available on Calhoun

All NPS resident students write a thesis or capstone project report as part of their curricular requirements. Many theses are unclassified and accessible on Calhoun—the Naval Postgraduate School's digital repository for research materials and institutional publications created by the NPS community. To access theses which involve operational energy, please use the following link. New theses are added every quarter.



View operational energy theses available on Calhoun:
<https://calhoun.nps.edu/>

EAG INTERN RESEARCH

Autonomous Systems: Navigating in Today's Legal Atmosphere



By Philip DeCocco,
EAG Intern, Summer '21



A Seahawk medium displacement unmanned surface vessel participates in U.S. Pacific Fleet's Unmanned Systems Integrated Battle Problem (UxS IBP) 21 on April 21, 2021.

The Navy's capabilities and use of autonomous and unmanned systems are developing rapidly. As the technology and viability of these systems advance, it is vital that the Navy understand both the physical and legal environments in which it operates.

This year, the Energy Academic Group (EAG) is undertaking an analysis of U.S. and international laws of autonomous systems supported by the Consortium for Robotics and Unmanned Systems Education and Research (CRUSER). This summer, research focused on the legal requirements for these systems to operate in international waters and exclusive economic zones (EEZs). This project contributes to Navy and DoD calls

to ensure the legality of these systems.

Researchers utilized a fictional scenario involving a Navy autonomous underwater vehicle (AUV) called Luke that traveled through different maritime zones conducting military surveillance. As Luke progresses through U.S., international, and Canadian maritime zones, applicable laws and regulations were identified and analyzed. Luke's journey abruptly ended with its removal by a foreign nation, requiring further investigation of Luke's legality and rights.

The research includes several international conventions – including the United Nations Convention on the Law of the Sea (UNCLOS) – that apply to autonomous and unmanned systems in the maritime environment. Generally, the laws are significantly older than the advanced autonomous technology and were not written with these cutting-edge systems in mind. While this does not make them inherently incompatible, it

presents the reality that there is not a comprehensive legal approach to the challenges inherent in the design and use of these systems. EAG will continue its research this fall with a full report available in January.

LEARN MORE

Report available at
<https://nps.edu/web/eag/intern-research>

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Information about CRUSER at
nps.edu/web/cruser

ABOUT EAG's INTERNSHIP PROGRAM

Each year the EAG offers internship opportunities for motivated young people who share an interest in energy-related research and a possible future career strengthening the intellectual capital within the U.S. Government. During the summer months, we run a structured 8–10 week internship program, but also have opportunities throughout the year to craft a valuable and challenging experience, both for the intern and for the EAG. Our intern programs are always fast-paced, rigorous, and focused on energy-related challenges facing our nation's defense. If you are interested in learning more, please contact Alan Howard (arhoward@nps.edu) to see if an internship experience with EAG could be right for you.



Calendar of Events

2021

OCT

10 – 14 October

Critical Energy Infrastructure Protection (CEIP) Analysis Workshop
Kuwait City, Kuwait

25 – 29 Oct (tentative)

Energy Security in Hybrid Threat Environment Course
Bucharest, Romania

2021

NOV

15 – 19 November

Energy Efficiency in Military Operations Course
Vilnius, Lithuania

2021

DEC

29 November – 3 December

Energy Security Awareness Course
Ankara, Turkey

2022

MAR

14 – 18 March

Operational Level Energy Security Course

Tartu, Estonia

Learn more at: Baltic Defence College - Operational Level Energy Security Course (baltdefcol.org)



ENERGY ACADEMIC GROUP
NAVAL POSTGRADUATE SCHOOL



Connect with the Energy Academic Group

The Energy Academic Group is located in Room 101A, Spanagel Hall 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, please contact one of the principal EAG faculty members:

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Contribute to an issue of Surge

If you would like to contribute an article or have your research/work published in the *Surge* newsletter, please contact Lois Hazard via email at lhazard@nps.edu.

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