



SURGE



ENERGY ACADEMIC GROUP QUARTERLY NEWSLETTER FALL 2023

Highlights

DOD OPERATIONAL ENERGY STRATEGY
NAVY DECARBONIZATION
CLIMATE CHANGE AND NAVAL OPERATIONS
E-CIRCUIT MOTORS



ENERGY EDUCATION

Operational Energy Courses for Warfighters Underway

By Michael A. Davis, Faculty Associate—Research (Curriculum Development), Energy Academic Group

Annually, the DoD consumes circa 90 million barrels of liquid petroleum.

However, when we consider the overall fiscal and operational costs of fuel demand (contracts, delivery, security, force protection, etc.) the entire DoD requirement is even larger. As our Navy exercises Distributed Maritime Operations (DMO) and assesses the increased energy requirements for both directed energy and unmanned systems, our reliance on these fuels is increasingly evident. Consequently, the Department of the Navy Operational Energy Goals memo requires Naval and Marine leaders to, “foster and guide an energy culture in our Sailors and Marines through policy, training, and education.”

The EAG is answering the call—educating U.S. naval leaders, as well as our allies and partners, to achieve Operational Energy (OE) dominance. In conjunction with a wide array of

stakeholders and subject matter experts across the joint force, the EAG is developing two, unique 1-week courses to enhance workforce knowledge of the challenges and opportunities related to OE. The Operational Energy I course focuses on warfighters from O-1 to O-3 and E-4 to E-6, while Operational Energy II is tailored for O-4 to O-6 and E-7 to E-9.

Sponsored by Deputy Assistant Secretary of the Navy for Research Development Test and Evaluation, the first of these two courses, OE I, is piloting at locations across the Navy and Marine Corps in 2023 and 2024. Developed for a broad audience that includes all Naval and Marine Corps’ specialties, OE I will ensure dissemination of critical OE knowledge across the operational force. OE I will focus on key themes such as mobility, lethality, operational resilience, command and control, and distributed/expeditionary operations,

all centered on four main competencies: fuels, power generation and distribution, energy storage solutions, and energy management.

The OE I Course is being developed in coordination with the Massachusetts Institute of Technology’s Lincoln Laboratory (LL). Collectively, EAG and LL are constructing realistic practical exercises that demonstrate operational choices for OE in the battlespace. If your unit or organization is interested in hosting a pilot of OE I in 2023 or 2024, please contact the author to coordinate hosting an EAG mobile training team at your location.

LEARN MORE

Email Michael Davis at michael.a.davis@nps.edu for more information about this program.



From the Director's Chair

Alan Howard, Associate Chair of the Energy Academic Group

On the Naval Postgraduate School (NPS) campus, something electric is happening, and it is not just the buzz of enthusiastic minds at work. It is the hum of groundbreaking energy research and the promise of educational programs set to transform our defense capabilities. As the Associate Chair of the Energy Academic Group (EAG), I have witnessed firsthand the surge of innovation emanating from our classrooms and labs, and I am excited to share a glimpse into our current efforts and what lies on the horizon.

With our ever-evolving defense needs, it is clear that the energy landscape must adapt swiftly and intelligently. NPS has taken up this challenge with enthusiasm. Our researchers are delving deep into topics that hold immense potential for our military's future. The application of unmanned and autonomous systems, the intricacies of contested logistics, and breakthroughs in directed energy, are but just a few. These are not just abstract concepts; they are central to addressing the Navy and DoD's

pressing challenges.

Our commitment is not confined to research alone. We are equally passionate about equipping the next generation of leaders with the knowledge and tools they will need. To that end, I am pleased to announce that our new Master's in Operational Energy is on track for a Winter Quarter launch. This comprehensive program is meticulously designed to intersect with the real-world challenges and strategies highlighted in the latest DoD Operational Energy Strategy. It promises to offer not only theoretical insights but hands-on application of critical energy concepts.

But that is not all. Starting January 8, 2024, we are launching the brand-new Directed Energy Certificate program. This 4-course asynchronous online offering, spread across four quarters, will provide an in-depth understanding of directed energy's vast potential, and challenges. Recognizing the diversity of our defense community, we have opened this program to all federal civilian employees and qualified uniformed (U.S.) officers and are taking applications from interested students now. It is an unparalleled

opportunity to gain insights into one of the most promising fields in defense energy, and I encourage you to be one of our first students in the program.

Being part of EAG, I have seen the dedication, passion, and brilliance that our faculty and students bring to the table every day. The fusion of cutting-edge research with innovative educational offerings positions NPS as a beacon in the realm of operational energy.

I invite you all to join us on this electrifying journey. Whether you are a prospective student, a passionate researcher, or an interested observer, there is no better time to be involved in the energy domain at NPS. Together, we will not only keep pace with the rapid transformations in defense energy, but set the course for a resilient, efficient, energized, and secure future.

Alan Howard
Associate Chair,



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Join the Energy Team

EAG is looking for motivated people to join our Curriculum Development team in Monterey, CA to work on the battery workforce challenges affecting the US and national security. We are seeking researchers from entry level to senior level experience—minimum education is a Bachelor's degree. Areas of interest include workforce development, talent management, instructional design/development, battery technology, supply chain/logistics, operational energy, engineering, and policy/geopolitics of energy.



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To explore the short and long-term opportunities available, contact Mary Sims at mjsims@nps.edu or go to HERC at <https://main.hercjobs.org/jobs/19210083#expand>.



OPERATIONAL ENERGY

Department of Defense Operational Energy Strategy

By Alan Howard,
Associate Chair,
Energy Academic Group

In May 2023, the Department of Defense (DoD) unveiled an updated Operational Energy (OE) Strategy, laying down a visionary roadmap for energy use within the defense community. As global energy dynamics evolve, this strategy provides not only an operational blueprint but also highlights the growing value and importance of energy education for the leaders of tomorrow, especially for those at the Naval Postgraduate School (NPS).

For students at NPS, particularly U.S. officers from all branches of service, this new strategy is of paramount importance. It encapsulates the future direction of military operations, emphasizing the critical role of energy in ensuring mission success, security, and resilience. The strategic outlook outlined by the DoD underscores several areas that will shape the curriculum and research focus of the Energy Academic Group (EAG).

Why is the Strategy Important?

Holistic Approach to Energy:

The 2023 strategy goes beyond just a focus on supply; it delves into the intricacies of demand, diversification, supply chain resilience, and real-time energy visibility. Such a comprehensive approach reinforces the need for our officers to understand the full energy spectrum—from procurement to tactical deployment.

Operational Excellence and Contested Environments: The strategy emphasizes reducing energy demand and ensuring forces can operate effectively in contested environments. This reflects a shift towards a more agile, resilient force that can respond swiftly to emerging threats. For NPS students, this underscores the importance of integrating energy considerations into their tactical and strategic planning.

Supply Chain Resilience: Given the increasing complexities of global geopolitics, the emphasis on supply chain resilience is timely. The DoD's focus on minimizing reliance on potentially hostile or unstable foreign energy sources necessitates that our students understand the geopolitics of energy and the intricacies of effective supply chain management.

Implications for NPS's EAG:

Curriculum Development: The EAG, in its mission to provide a top-tier energy-focused curriculum, will need to integrate the strategic objectives of the 2023 plan. This involves exploring topics like energy storage technologies, the geopolitics of energy supply chains, and the tactical implications of energy use in contested scenarios.

Research Opportunities: The strategy's emphasis on diversifying energy sources, exploring lithium battery technologies, and enhancing energy visibility opens avenues for cutting-edge research. Students and faculty

can delve into these areas, contributing to the broader defense community's knowledge and capabilities.

Operational Training: With the strategy's focus on real-world operational readiness, the EAG can spearhead training modules and simulations that put theory into practice. Such hands-on experiences will prepare our students for the energy challenges they will face in their respective military branches.

In conclusion, the DoD's 2023 Operational Energy Strategy isn't just a document—it is a call to action and a guiding light for the future leaders being molded at the Naval Postgraduate School. As the defense landscape evolves, the importance of energy as a strategic and operational resource only magnifies. EAG, with its commitment to excellence in both education and research, is perfectly poised to ensure that our warfighters are not only well-versed in the intricacies of energy but also ready to lead the charge in this new era of defense operations.

LEARN MORE

The full report can be viewed here: <https://www.acq.osd.mil/eie/Downloads/OE/2023%20Operational%20Energy%20Strategy.pdf>

Contact [Alan Howard](mailto:arhoward@nps.edu) at arhoward@nps.edu for more information.

CLIMATE STRATEGY

Setting Direction: Research Roadmap for Navy Decarbonization

By Bill Muras,
Faculty Associate-Research,
Energy Academic Group
and Kristen Fletcher,
Faculty Associate-Research,
Energy Academic Group

With the Office of Naval Research, the Energy Academic Group has developed a Research Roadmap for Navy Decarbonization through the Navy Decarbonization Research Consortium, a public-private collaboration that advances interdisciplinary research to help the Navy meet the complex challenges of platform decarbonization, with a focus on ships and aircraft.

The Navy's Climate Strategy, *Climate Action 2030*, sets the Department of the Navy (DoN) on a path to achieve net-zero emissions by 2050, while becoming a more capable, climate-resilient and lethal fighting force. Emissions reduction from operations is especially challenging for the Navy, as the vast bulk of emissions are from fossil fuel use in ships and aircraft, platforms that are difficult to decarbonize, especially in the military context.

To help address these challenges, the Consortium team assessed and identified research focus areas for the highest potential to enable ship decarbonization, developed the Roadmap to guide research and lay the foundation for future efforts, and identified key next steps required to

advance the research agenda and develop potential technology transition pathways.

The Roadmap's key findings include:

- Decarbonizing Navy ships requires research and development to enable integration of lower carbon fuels, alternative propulsion systems, efficiency technologies, and carbon capture.
- Continued emphasis on demand reduction and efficiency technologies are key to early emission reduction efforts.
- The Navy will pursue decarbonization measures that maintain or enhance warfighting capability and mission effectiveness.
- Collaboration and partnering will be a key component to the success of these decarbonization initiatives.

The importance of collaboration to decarbonization success cannot be overstated. The Roadmap suggests a whole-of-government approach, with a focus on increasing collaboration between the Navy, the Department of Energy and the Department of Transportation. The DoN must also expand collaboration to the rest of DoD, private sector and international partners while setting realistic decarbonization targets for identified thrust areas. Finally, the DoN must be prepared to identify policies that constrain adoption of promising technologies and offer appropriate policy changes to enable adoption of key technology.

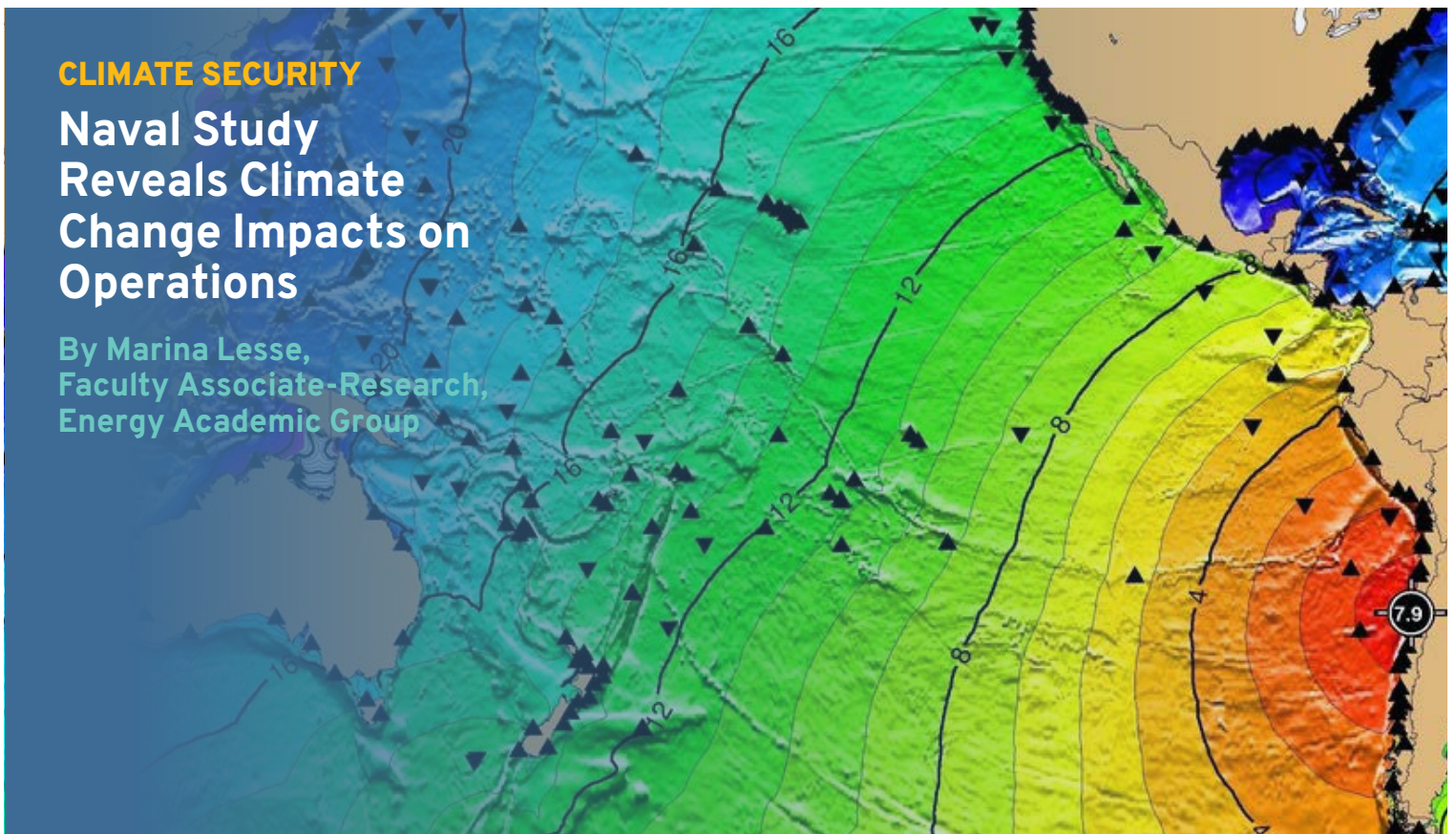
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Contact Bill Muras at william.j.muras.ctr@navy.mil or william.muras@nps.edu or Kristen Fletcher at kristen.fletcher@nps.edu.

CLIMATE SECURITY

Naval Study Reveals Climate Change Impacts on Operations

By Marina Lesse,
Faculty Associate-Research,
Energy Academic Group



Researchers at the Naval Postgraduate School recently completed the *Impact of Climate Change on Naval & Marine Corps Operations* project, funded by NAVAIR. The project was led by the Energy Academic Group's Marina Lesse, Kristen Fletcher and Cayle Bradley, with support from Bill Muras, Rabia Khan (Systems Engineering) and Lieutenant Commander Ted Jacobs (Meteorology and Oceanography).

Identifying and understanding the true impact of climate change on Naval and Marine Corps operations is a persistent challenge. However, this has been infrequently studied. Understanding, projecting, and predicting the impacts are especially important for strategic, operational and tactical planning. The goal of this research is to help the Department of the Navy better understand how to meet its operational mission in a changing climate and environment.

The work focused on a meteorological approach. Much of the meteorological analysis was conducted by NPS Nimitz

Research Group Scholar and Meteorology and Oceanography (METOC) officer, LCDR Ted Jacobs. The Nimitz Research Group was established in 2022 to leverage NPS' educational and research capabilities for the Indo-Pacific Area of Responsibility. Feedback received from INDOPACOM identified the First Island Chain as the ideal case study for vulnerabilities to climate change.

LCDR Jacobs created a framework that captures climatological projections for the region while analyzing the set of priority platforms frequently used in the area. The capabilities and limitations of these platforms were then compared to the predicted environmental factors, generating a tool to serve as guiding functions for decision makers on the feasibility of those operations.

Researchers partnered with the Center for Naval Analysis (CNA) which conducted a parallel study entitled *Climate Change Implications for Navy Operations, Platforms, and Systems: Setting a Research Agenda*. This collaboration helped guide a well-rounded approach which was to study climate impacts by focusing on the physics couplings

on sensors and platforms influenced by climatic environmental drivers while also conducting a research gap analysis. Other strategic partners for this research offered feedback garnered via workshops and consultations. These strategic partners include the Center for Excellence in Disaster Management & Humanitarian Assistance (CFE-DMHA) Climate Change Impacts INDOPACOM program, the Joint Typhoon Warning Center, the U.S. Pacific Fleet (PACFLT) Commander, and the INDOPACOM METOC community.

LEARN MORE

An unclassified version of this report is available at: <https://tinyurl.com/uda2vmn4>. For a classified version, please contact POC Marina Lesse, marina.i.lesse.civ@mail.smil.mil.

ENERGY RESEARCH

JIFX Operational Energy Enterprises

By Brandon Naylor, Faculty Associate-Research, Energy Academic Group; and EAG Interns Jorge Rodrigues and Tim Duran

This past May and August, technology demonstrators and experimenters gathered for the Joint Interagency Field Experimentation (JIFX) and Thunderstorm events hosted by NPS at Camp Roberts. JIFX and Thunderstorm allow technology developers to bring their systems to a permissive representational operating environment where they can conduct experiments that would otherwise require special permits or permissions, and to get feedback from key military stakeholders. Examples of experiments conducted at JIFX included autonomous resupply missions using large-scale UAVs and ground vehicles, remote networking applications, and tactical energy generation and storage among others.

Academic and private industry technology developers were invited to JIFX and Thunderstorm because their

technologies show promise in addressing near-term key capability gaps. Among the invited experiments, several showcased key operational energy aspects that hold significant promise.

Other examples included a demonstration of Airrow's "Sustained Autonomous Overwatch" where Dronehub was presented, a computer vision-driven robotic drone station capable of swift battery swaps and payload exchanges, enabling autonomous operations for tasks like supply drops, munition reloads and overwatch security. Bluespace, AI's "Motion First Perception" technology stood out by harnessing 4D emerging technologies, eliminating the need for training data or maps, using perception systems in real-time. Bluespace can provide great benefits for operations in austere environments, especially where there may be IED threats. Stucan Solutions Corporation's "QuickBlock" demonstrated a reusable structure solution, being an alternative to sandbag protection, utilizing renewable materials such as polyethylene to procure blocks which can be built into walls to protect any equipment or troops in hostile environments. These blocks, each with a 3.6 ton payload, can prevent armor-piercing rounds from penetration, as well as withstand mortar blasts.

JIFX and Thunderstorm not only highlighted these operational energy innovations but also offered a vital



opportunity to observe and evaluate the operational energy dynamics of promising technologies. This platform fosters ongoing experimentation, creating a comprehensive understanding of operational energy performance measures across various showcased technologies. The Energy Academic Group (EAG) plays a pivotal role as a cross-cutting organization, seamlessly integrating faculty, students, and interns into the realm of longitudinal operational energy field experimentation. By engaging these diverse perspectives, EAG enriches the understanding of operational energy measures of performance for the technologies being demonstrated.

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The full report is available at:
<https://nps.edu/web/eag/intern-research>

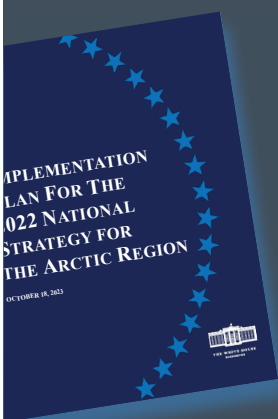
NPS Contact: Brandon Naylor at
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U.S. Releases Implementation Plan for the 2022 Arctic Strategy

In October 2023, the U.S. released the *Implementation Plan for the 2022 National Strategy for the Arctic Region*, which sets forth the methodology, process, and approach for implementing the National Strategy for the Arctic Region (NSAR). It follows the four pillars of the NSAR: Security, Climate Change and Environmental Protection, Sustainable Economic Development, and International Cooperation and Governance. In addition, it tracks the NSAR five guiding principles which are: Consult, Coordinate, and Co-Manage with Alaska Native Tribes and Communities; Deepen Relationships with Allies and Partners; Plan for Long-Lead Time Investments; Cultivate Cross-Sectoral Coalitions and Innovative Ideas; and, Commit to a Whole of Government, Evidence-Based Approach. The plan includes actions toward development of clean energy and supporting the energy transition in the region. Federal agencies will report on progress made on these actions through an annual report to the Arctic Executive Steering Committee.

REPORT AVAILABLE AT

<https://www.whitehouse.gov/wp-content/uploads/2023/10/NSAR-Implementation-Plan.pdf>



ENERGY OUTREACH

Preparing for the Unexpected: Supporting the ERRE TTX at Naval Station Rota

By Eric Hahn,
Associate Faculty-Research,
Energy Academic Group

The Energy Academic Group recently supported the Energy Resilience and Readiness Exercise (ERRE) Tabletop Exercise (TTX) at Naval Station Rota.

The exercise brought together tenant command representatives and other key stakeholders to discuss issues and challenges and develop strategies for collaboratively enhancing energy resilience and readiness in the face of a potential disruption.

The ERRE TTX was a valuable opportunity for participants to share their respective responsibilities, capabilities, and needs during a disruption. The exercise focused on response and recovery during a 72-hour base-wide outage caused by a lightning strike on the base power distribution feeders. Participants engaged in a series



Naval Station Rota

of guided discussions in syndicates to evaluate risks, constraints, and capabilities after a central power loss, and develop recommendations for mitigation.

One key takeaway from the exercise was the importance of collaboration and coordination. Participants emphasized the need for effective communication and information sharing to ensure common awareness of potential risks and foster teamwork to address them. For example, fuel was discussed as a common limiting factor with a corresponding need for effective tracking and prioritization of refueling for backup generators.

The ERRE TTX was a valuable opportunity for participants to learn

from each other and develop strategies for enhancing energy resilience and readiness. The exercise highlighted the critical role that energy plays in supporting military operations and the need for continued investment in energy infrastructure and technology. As the military continues to face evolving threats and challenges, exercises like the ERRE TTX are essential for ensuring preparedness and resilience.

LEARN MORE

Email Mr. Eric Hahn at ehahn1@nps.edu for more information.



Unmanned Systems Persistence Certificate Course

The Naval Postgraduate School's (NPS) Energy Academic Group (EAG) is pleased to launch the Operational Energy Certificate: Unmanned Systems Persistence as part of EAG's Operational Energy Certificates program. Three stackable graduate level certificates have been developed for this program to educate students on the technical, operational, and security aspects of DoD's energy need.

The Unmanned Systems Persistence Certificate, curriculum number 117, opened for enrollment October 15, 2023 for the AY24 Winter Quarter 2023, commencing January 8, 2024.

LEARN MORE

For all program information and course requirements, please visit <https://nps.edu/web/eag/operational-energy-certificate> or email the program manager, Dr. Colleen McHenry, at colleen.mchenry@nps.edu.

ENERGY RESEARCH

E-Circuit Motors

By Brandon Naylor
Faculty Associate-Research,
Energy Academic Group



ECM propulsion motor for underwater vehicle

designers are not limited to the form factor and performance specifications of a pre-existing motor, and efficiency gains can be seen in some applications by rightsizing a motor with custom stators to specific applications. PCB motor production also lends itself to a more versatile and resilient supply chain, as any PCB manufacturer can produce the copper and fiberglass composite structure that makes up the stators of a PCB motor. In the Navy, PCB motors are currently being used in unmanned vehicles to drive propellers and gimbals that house mission-critical sensors. The design tools offered by companies such as E-Circuit Motors will hopefully allow further proliferation and ease of design of unmanned systems as designers are given more flexibility in design and manufacture of these key components.

On August 24 NPS had the honor of welcoming Steve Shaw of E-Circuit Motors to give a presentation on his company's advancements in the field of printed circuit board (PCB) motors. Printed circuit board motors are not a new concept, but E-Circuit Motors has developed a suite of software tools that improve on the state of the art in allowing users to easily design

custom motors and generate standard drawings that can be sent to any PCB manufacturer for rapid production. Compared to traditional motor manufacturing methods, the PCB motor manufacturing process allows users to design and produce motors optimized to their specific applications rather than picking a "best fit" motor out of a catalogue. This can simplify the design process for complex systems because

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Contact Brandon Naylor at blnaylor@nps.edu for more information



Enrollment Open for Defense Energy Certificate Program

The Naval Postgraduate School's (NPS) Energy Academic Group is pleased to announce our Defense Energy Certificate program. This certificate is a distance learning asynchronous program. This offering begins in March 2024. The certificate program is free to all students. Applications must be submitted with transcripts received by January 8, 2024.

FOR MORE INFORMATION OR TO APPLY

Email Colleen McHenry at colleen.mchenry@nps.edu or call 813-508-0764. Detailed instructions are posted on the EAG website at <https://nps.edu/web/eag/defense-energy-certificate-program>

EAG INTERN RESEARCH HIGHLIGHTS

Classification of Maritime Unmanned Systems by FVEY Countries



By MIDN Theresa Milio,
EAG Intern,
U.S. Naval Academy

As unmanned systems permeate the maritime environment, it becomes increasingly evident that policy lags far behind technological advances. Created in 1982 by the International Maritime Organization (IMO), the most commonly accepted regulatory policy on the high seas is the United Nations Convention on the Law of the Sea (UNCLOS). Regulations in UNCLOS imply that ships and vessels (terms used interchangeably in the agreement) must be crewed. Since UNCLOS fails to define either of these terms, it is unclear whether its regulations apply to maritime maritime unmanned systems (UxS). This summer, EAG undertook research that:

- Explored the ways the various Five Eyes Alliance (FVEY) countries define the terms “ship” and “vessel”;
- If and how an unmanned system fits into these definitions;
- The precedents being set by how the regulatory bodies of these countries define and treat unmanned systems;
- The implications these classifications will have for the maritime environment.

Observing the definitions provided in FVEY countries, there were two main requirements to be considered a vessel- that it (1) be in or on the water and that it (2) be used for transportation or navigation. The requirements of navigation or transportation led to further definitional challenges, since many UxS do not navigate in traditional

manners or do not transport traditional loads. Despite remaining questions about the definitions of “ship” and “vessel,” all FVEY countries have either promulgated policy or set precedents that unmanned systems can be considered as such, indicating that they are regulated by UNCLOS. While this finding affirms that being crewed is not a prerequisite for being considered a ship or vessel, many questions remain about how widely these classifications will apply. New unmanned systems contain novel technology and do not have an obvious crewed counterpart. As UxS develops and becomes more prevalent, policy will need to remain flexible to keep up with changing technology.

The full report by Midshipman Milio will be made available on the EAG website this year.

LEARN MORE

Contact Marina Lesse at marina.lesse@nps.edu for more information about this research.

To learn more about EAG Intern Research visit: <https://nps.edu/web/eag/intern-research>



Photo by Moraima Johnston, Office of Naval Research



Courtesy Photo from U.S. Sixth Fleet Research

ENERGY SECURITY

A New Black Sea Natural Gas Project Could be a Game Changer for the Region—and a Challenge for Putin

By Arnie Dupuy, PhD
Faculty Associate-Research
Energy Academic Group

Last month, energy companies **Petrom and Romgaz announced plans to develop Romania's Neptun Deep offshore gas field.** The development of the field is a good sign for the wider Black Sea's energy security—and has the potential to impact the region geopolitically and economically, notably by providing an alternative to Russian gas, thereby weakening Moscow's influence.

Much of the Black Sea has been off limits for oil and gas production mostly because of geopolitical tensions, the sea's exceptional depths, and environmental and worker safety concerns. Prior to 2014, sizeable natural gas fields existed in Ukraine's Black Sea exclusive economic zone (EEZ); however, when Russia annexed Crimea, it appropriated Ukraine's gas deposits, effectively removing these assets and potential revenues for the foreseeable future.

In recent years, Turkey and Romania have emerged as players in the region's gas projects. For example, in August 2020, the state-owned Turkish Petroleum Corporation discovered the Sakarya gas field, the largest in the western Black Sea. Estimates indicate that Sakarya holds 540 billion cubic meters (bcm) of gas reserves, and it will meet roughly 30 percent of Turkey's

natural gas demand. The first deliveries of gas are anticipated in 2023.

Romania has also discovered significant offshore gas reserves in its EEZ and plans to exploit about 200 bcm. Romania started doing so in 2023, producing 1 bcm from the Ana platform, a field developed by Black Sea Oil & Gas. However, the largest field in the Romanian sector is Neptun Deep, estimated at 100 bcm, in water depths between 100–1,700 meters.

OMV Petrom (a Romanian oil and gas company owned by Austria's OMV) and Romgaz (a Romanian state-owned gas company) will lead the development of the project. Infrastructure development will start in 2024, and first production is expected in early 2027. According to George Scutaru, director of the New Strategy Center (a Romanian think tank) and former national security advisor to the Romanian president, Neptun Deep will produce between 7 bcm and 8 bcm per year, with potential revenues of over twenty-five billion dollars—the equivalent of three and a half years of Bucharest's current defense expenditures.

READ THE FULL ARTICLE

This article is a reprint from the Atlantic Council website. To read the full article, go to <https://www.atlanticcouncil.org/blogs/turkeysource/a-new-black-sea-natural-gas-project-could-be-a-game-changer-for-the-region-and-a-challenge-for-putin/>

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Email Dr. Arnie Dupuy at arnold.dupuy@nps.edu for more information about this article.

⚡ STUDENT ENERGY RESEARCH SPOTLIGHT

Modeling, Simulation, and Experimental Validation of an Energy Management System on a Tactical Microgrid Built With Commercial Off The Shelf Components

By Capt Joshua Ashley, U.S. Marine Corps

The Department of Defense (DoD) continues to explore the implementation of microgrid technology to reduce dependence on the utility grids aboard military installations and to alleviate the logistical burden of hauling fossil fuels for forward operations. To this end the research being conducted seeks to develop a physics-based model to simulate the performance of a microgrid under different load conditions and geographic scenarios. It also presents a methodology for processing historical solar irradiance data to estimate future power contribution from a photovoltaic array for a specific geographical location.

The model implements an energy management system that controls the microgrid based on monitored values of the components. Validating this model is a series of experiments conducted on a hardware microgrid and measuring performance characteristics to compare the model output.

The model focuses on capturing the power contributions from each energy source while supporting a specific load profile drawing power from the system. Having the capability to change the size and specifications of equipment used allows the designer to observe the performance of the system over time. This capability gives a better understanding of how increasing battery energy storage systems or renewable energy sources will reduce the dependence on generator and utility grid power. By including a model for energy management systems, it replicates a



control system that governs the mode in which a microgrid operates. A unique approach in simulating the microgrid functionality is the photovoltaic (PV) array output power model. Historical irradiance data gathered by the National Renewable Energy Laboratory for a chosen geographic locations is averaged for a specific month and processed with the PV panel characteristics to calculate the PV array power contribution to the microgrid.

The validation of the simulation consists of conducting a three-day trial of the NPS microgrid under a DC electronic load. Two trials have been conducted, each with a different load profile to compare with the functionality of the simulation. Data logging of the power drawn from the load is input to the simulation to best fit the conditions under which the experiment is conducted. The results from these experiments reported promising results, depicting similar trends in performance specifically focusing on the amount of time the support generator is active and the state of charge of the battery energy storage system.

This research continues the effort to develop a design tool that predicts accurate performance results of a proposed microgrid. As a result, the DoD will be in a better position to make informed decisions on the future implementation of microgrids in military operations.



ABOUT THE AUTHOR

Capt Ashley graduated from the Naval Postgraduate School in September 2023 with a Master of Science in Systems Engineering. Contact Prof. Giovanna Oriti at goriti@nps.edu for more information about this research.



Calendar of Events and Important Dates

OCTOBER

October 23–27, 2023

Critical Energy Infrastructure Protection and Resilience Course
Lublin, Poland

NOVEMBER

**October 23–
November 3, 2023**

Building Resilience to Hybrid Threats Residence Course
Monterey

November 13–17, 2023

Coherent Resilience (CORE) Tabletop Exercise
Riga, Latvia

November 17, 2023

Application deadline for the Defense Energy Certificate and the Unmanned Systems Persistence Certificate for the Winter 2024 Quarter.

DECEMBER

December 1, 2023

Accepting applications for Refuel Logistics Certificate for the Spring 2024 Quarter

December 11–15, 2023

Energy Security Strategic Awareness Course
Oberammergau, Germany

December TBD, 2023

Information Resilience Workshop
Africa

UPCOMING

2023 Defense Energy Seminar Series

EAG is pleased to have resumed in-person presentations for its Defense Energy Seminar lecture series. Watch for upcoming dates and full event details as they become available on the EAG website at nps.edu/web/eag/seminars.



ENERGY ACADEMIC GROUP
NAVAL POSTGRADUATE SCHOOL



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 lkhazard@nps.edu.

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The views and perspectives herein do not necessarily reflect the official views of the U.S. government, the Department of Defense or the U.S. Navy (or Marine Corps).

Connect with the Energy Academic Group

The Energy Academic Group is located in Room 101A, Spanangel 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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