



SURGE



ENERGY ACADEMIC GROUP QUARTERLY NEWSLETTER FALL 2024

Highlights

- Operational Energy Textbook
- DoD Releases Arctic Strategy
- Uncrewed Aerial Systems
- International Advisory Opinions on Climate Change
- DON Hydrogen Technical Planning
- Shore Energy Program



ENERGY EDUCATION

EAG Announces the Master of Operational Energy Degree

By Colleen McHenry, Faculty Associate-Research, Energy Academic Group

The Naval Postgraduate School's Energy Academic Group (EAG) is proud to announce the Master of Operational Energy. The Master of Operational Energy (OE) is an asynchronous distributed learning (DL) degree program that equips graduates with the skills and knowledge needed to operate in a contested logistics environment and which will ultimately enhance the graduates' effectiveness in the modern battlespace.

The OE master's degree combines a sequence of three stackable graduate level certificates under its OE Certificates Program: Directed Energy, Refuel Logistics, and Unmanned Systems Persistence. The certificates focus on areas related to operations research, operational energy analysis, war and

peacetime logistics, autonomous systems, and defense energy. The Program's flexible design allows sponsoring agencies and students to achieve specific professional education goals by selecting a tailored combination of certificates. The OE master's degree is sponsored by Deputy Assistance Secretary of the Navy, Operational Energy (DASN OE) and is open to qualified U.S. military personnel and U.S. Government civilians, as well as international students and defense contractors, who are eligible for entry to NPS certificate programs. The Master of Operational Energy program must be completed within 5 years.

This academic offering meets the Department of Navy's guidance on both the content and the structure of our offerings by providing high-quality

and relevant instruction to the Naval Enterprise. This degree will encourage potential students to explore additional content-focused topics and broaden their understanding during this critical time.

The operational energy objectives address challenges associated with operating in the contested environment specifically developing a strong foundation in OE principles into Navy training and education. This stackable approach to learning demonstrates the Navy's commitment to a modernized education program with obtainable learning objectives. Specifically, students will analyze gaps in the joint operational energy approach across all domains; conduct a formal assessment of energy

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From the Chair

Dan Nussbaum, Chair of the Energy Academic Group

I had thought to be provocative in the last edition of *Surge* by:

- pointing out that demand for energy is growing across most countries in the world, as standards of living rise and populations increase and the use of AI and data centers expand;
- asking, in the light of the observations above about energy-use drivers “Will we have enough energy in the future to meet our needs?”; and
- concluding that there’s a case to be made that the answer is “no”.

I conclude that I have not been provocative enough because I have not gotten responses from you, the *Surge* readership. What do you think about this evolving global situation?

I’m delighted that the Naval Postgraduate School has agreed to offer a “stackable” master’s degree in Operational Energy. This program is built upon several certificates that we currently offer, which may now, upon completion of these certificates, be “stacked” into a master’s degree. Kudos to Dr. Arnold Dupuy and Dr. Colleen McHenry and their team for their hard work, their patience, and for bringing this effort across the finish line. We anticipate that this program fills a gap in the training and education program across the DoD energy space.

The battery workforce consortium continues to work as part of the overall effort to reshore the battery value chain to the United States. Clearly, a viable workforce at all points along the value chain,

from mining to refining to designing and manufacturing to disposal, is a necessary condition to this reshoring effort. The team continues to support the DoE, and is currently investigating Battery Workforce Development in Europe as a case study for U.S. Battery Workforce Development.

The Decarbonization Consortium, led by EAG’s Kristen Fletcher and her team, supports the Office of Naval Research (ONR), seeking ways to decarbonize large naval platforms, with a current focus on aircraft and ships. They will be hosting the Navy Decarbonization Research Consortium meeting in Washington, D.C. They will also co-host a recently developed Climate Change and Security course at NPS with their NATO partners.

In the “it’s -finally- done” category, the book entitled *Operational Energy* has just been published by the De Gruyter press. This is the first text of its kind, and it provides military officers and students in defense studies with the knowledge and skills to effectively plan for the operational energy needs of their forces and missions. The authors are EAG faculty Alan Howard, Brenda Shaffer and I. Critical support was provided by many others as well, as the text explains.

EAG welcomed international students from the Universität der Bundeswehr-München, the Federal Armed Forces University in Munich. These students are part of an ongoing academic collaboration between the U.S. and Germany, and the collaboration allows these students (who specialize in computer science, aerospace, electronics, and information technology) to spend five months at NPS working on their master’s theses. During their stay, they will contribute to EAG projects,

integrating into our team, and supporting our mission.

Welcome to two new members of the EAG team, Rebecca (Bec) Grippo and LT Lennard Heidtmann. Bec will be working with Kristen Fletcher and her Climate Security team; LT Heidtmann is an international military student from the German Army and is visiting with us while he does his master’s research and thesis.

It’s always bittersweet when a valued member of the team takes a promotion in another organization, thereby validating their value. That’s the case with Cayle Bradley, who’s leaving NPS to take an important and visible position at the Department of Energy. Cayle will succeed John Jennings, whom I am sure many of you know. John has retired. Our best wishes for happiness and success go with Cayle as he moves to his new position.

There is much going on, and I encourage you to reach out to me. I would be happy to hear your ideas.



CONTACT DR. DAN NUSSBAUM

Email danussba@nps.edu
or call 831-324-3228.

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requirements and constraints; support staff with information and provide guidance in the basic technologies, concepts, laws and assumptions associated with the use of autonomous,

robotics, and unmanned systems; ensure that operationally employed logistics infrastructures satisfy the energy requirements of the supported systems; and analyze modeling solutions dedicated to risk reduction in contested environments.

LEARN MORE

EAG contact: Colleen McHenry at colleen.mchenry@nps.edu and visit <https://tinyurl.com/2p9jkxdy>

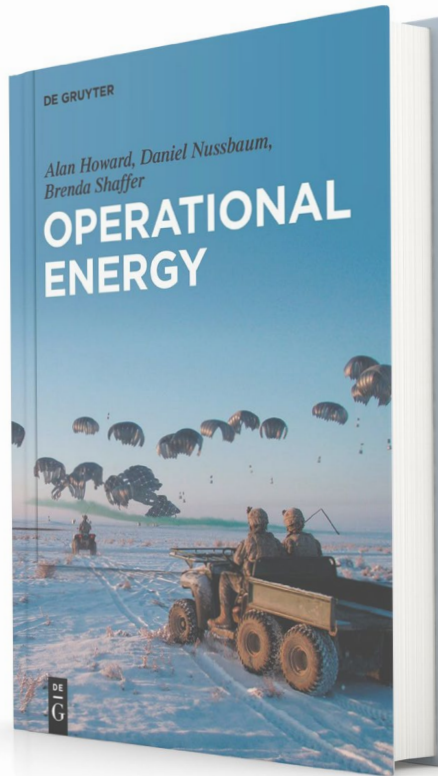
ENERGY PUBLICATIONS

EAG Announces Publication of Operational Energy Textbook

By Brenda Shaffer, Faculty Associate-Research, Energy Academic Group

EAG is pleased to announce the publication of *Operational Energy*, the first textbook to date on operational energy. *Operational Energy* provides military officers with knowledge and skills to plan effectively for the operational energy needs of their forces. Operational energy is the energy used to train, move, and sustain military forces and weapons platforms for military operations. In modern warfare, attaining energy superiority over one's adversaries is a critical condition for success on the battlefield. Operational energy planning is an integral part of all combat and regular operations.

Operational Energy is to date the only textbook on defense energy planning, analysis, and strategy. It examines in detail fuel types, geopolitical issues, energy supply risks, market economic factors, and technology, presenting topics for future research. It also includes chapter summaries, main points for study, and case studies. *Operational Energy* is available for purchase on Amazon, from De Gruyter Press, and most major book sales outlets. The book can be accessed through many university libraries as an



e-book and also the physical book.

Operational Energy is a valuable and extensive resource for students of U.S. Department of Defense courses in military universities, colleges, and academic training programs; scholars of geopolitics; and researchers on U.S. and global energy security.

Beginning a decade ago, the U.S. Department of Defense has devoted increasing attention to the U.S. military's energy strategies. Energy is an enabler of—and a constraint on—military power. Energy has always played a role in battlefield outcomes. Over the twentieth and early twenty-first centuries the importance of energy in warfighting has grown. Today, energy is a critical pillar of national defense and a major factor in military power.

Endorsements for *Operational Energy*

"This exceptional textbook shines a bright light on the too often unseen world of operational energy and provides richly detailed information every strategist and planner should know. This is the comprehensive reference we all needed for 21st century warfare."

SHARON BURKE, FORMER UNITED STATES ASSISTANT SECRETARY OF DEFENSE FOR OPERATIONAL ENERGY

"In an era where the homeland is no longer a sanctuary and all logistics, especially fuel, are contested, it is essential that military professionals of all grades and positions understand how to reduce, diversify, secure, and visualize energy flows across the battlespace. This textbook is vital as the US Department of Defense prepares for a future defined by complexity and competition."

RICHARD KIDD, FORMER DEPUTY ASSISTANT SECRETARY OF DEFENSE FOR ENERGY & ENVIRONMENT RESILIENCE

LEARN MORE

EAG Contact: Brenda Shaffer at brenda.shaffer@nps.edu

Operational Energy is publicly available at <https://tinyurl.com/nr9c5yvh>

The U.S. Navy guided-missile destroyer USS Gridley (DDG 101) is moored pierside in Tromso, Norway, during a brief stop for fuel. (U.S. Navy photo by Mass Communication Specialist 2nd Class Cameron Stoner)



CLIMATE SECURITY

DoD Releases Arctic Strategy in Midst of Changing Environment

By Kristen Fletcher
Faculty Associate-Research,
Energy Academic Group

In July, the Department of Defense (DoD) released its new Arctic Strategy, highlighting the significant changes in the physical and geopolitical environment in the region. To strengthen U.S. abilities and better manage risk in the region, the strategy calls for three E's: Enhance U.S. domain awareness and regional capabilities; Engage with allies, partners and stakeholders; and Exercise tailored presence.

There are eight Arctic nations: U.S., Canada, Denmark, Finland, Iceland, Norway, Sweden, and Russia. In addition, China is increasing its presence both through partnering with Arctic nations

and claiming itself as a "near Arctic state," even though that claim has no basis in international law. Nevertheless, China operates three icebreakers in the region and has conducted operations with the Russian Navy. This Russia-China partnership is a significant driver in the DoD Arctic Strategy.

Environmental changes in the region are affecting movement of state and private vessels and the drive to exploit natural resources. Research shows that from 1979-2021, major portions of the Arctic Ocean were warming at least four times as fast as the global average. As a result, sea ice coverage is less over time, permafrost is thawing, and coastal erosion is faster than anticipated. The strategy notes that the Arctic may experience its first ice-free summer within the next decade and "reduction in sea ice due to climate change means chokepoints such as the Bering Strait... are becoming more navigable and more economically and militarily significant."

The strategy lays out the U.S. approach of "monitor and respond" which requires maritime domain awareness, capabilities in Intelligence, Surveillance and Reconnaissance

(ISR), and cooperation with allies and partners; this will involve improved communications technology and data coverage. In addition, the U.S. will advance joint exercises to increase the Joint Force's ability to "respond rapidly and effectively to threats in the region." Awareness and focus on contested areas in the Arctic as well as an understanding of the different operating environments across the region will help prioritize partnerships and exercises.

As the strategy notes, it aligns with and nests under the 2022 National Security Strategy, 2022 National Defense Strategy, and 2022 National Strategy for the Arctic Region.

LEARN MORE

View the 2024 Department of Defense Arctic Strategy at <https://media.defense.gov/2024/Jul/22/2003507411-1/1/0/DOD-ARCTIC-STRATEGY-2024.PDF>

EAG Contact: Kristen Fletcher at kristen.fletcher@nps.edu



A launch of a Scan Eagle from a Coast Guard cutter. (Insitu Photo)

ENERGY POLICY

Legal Analysis of Ship-Based Uncrewed Aerial Systems (UAS) Operations in the Arctic

By Samuel Senseman, Intern, Summer '24 and Marina Lesse, Faculty Associate—Research

Ship-based Uncrewed Aerial Systems (UAS) are an effective tool for military operations in the Arctic. These autonomous systems have several potential advantages over conventionally crewed systems including having a potentially smaller environmental impact, easier deployment, wider range, more versatility, and the mitigation of human-exposure to environmental dangers. As the seasonal Arctic ice cover continues to decrease in size due to climate change, the increasing geopolitical and economic significance of the region will likely spur an increase

in the number of uncrewed systems in the region as well as crewed aircraft and vessels.

The United States Coast Guard (USCG) and the United States Navy (USN) are utilizing UAS capabilities in the Arctic for various mission sets including search and rescue (SAR) and intelligence, surveillance, and reconnaissance (ISR) operations. The 2024 DoD Arctic Strategy, released in July 2024, reaffirms the importance of integrating UAS into a broader strategy to enhance the coverage of Arctic air and maritime domains. UAS utilized in Intelligence, Surveillance, Reconnaissance (ISR) will also become part of an integrated information sharing system among key Arctic allies to improve the responsible use of air and maritime space in a region whose navigability is impeded by numerous climatic and terrain features.

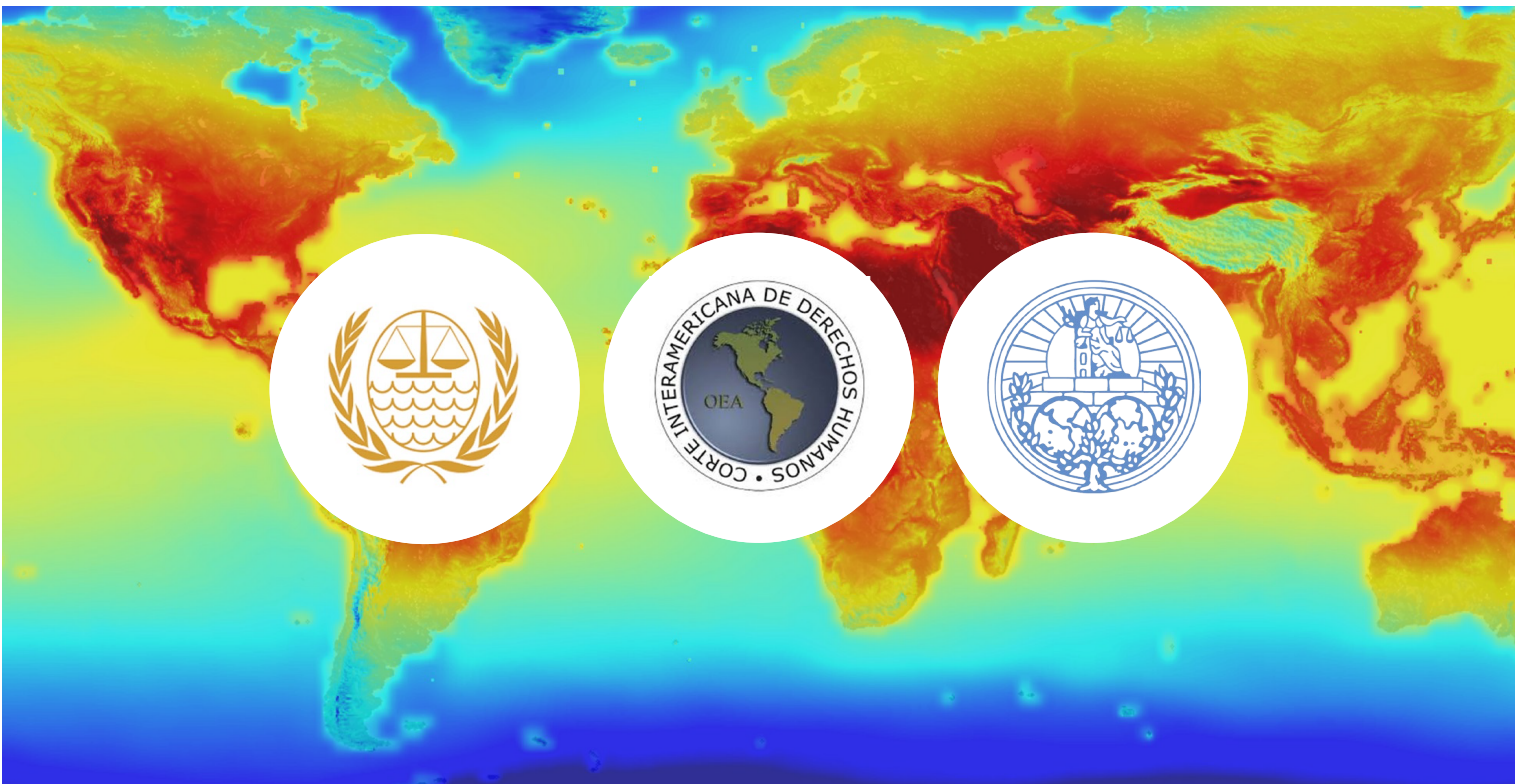
The integration of UAS into international, national, and regional airspaces is not, however, without its legal and regulatory difficulties. This report analyzes the laws, regulations, and policies relevant to operating ship-based UAS in the Arctic and finds that certain difficulties in operating UAS in the Arctic may be lessened through international and interagency

agreements. Most international agreements concerned with aviation are vague in how they might be applied to unmanned systems; this is especially true for aviation travel that crosses multiple countries. Within the Arctic Region there are eight sovereign airspaces, five territorial seas, eight Flight Information Regions, high seas and international airspace. The continued evolution of UAS regulations within international, national, and regional frameworks has made tracking what exactly is and is not allowed within those areas even more difficult. The Energy Academic Group's Climate Security Pillar will continue to analyze UAS law and policy to advance use of uncrewed systems by the U.S. and its allies.

LEARN MORE

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

EAG Contact: Marina Lesse at marina.lesse@nps.edu



CLIMATE CHANGE

Analysis of International Advisory Opinions on Climate Change

By Ella Nightengale-Luhan, Intern, Summer '24
Energy Academic Group

In May 2024, the International Tribunal for Law of the Sea (ITLOS) released the first advisory opinion on climate change from an international legal body. Currently, there are two other advisory opinions on climate change pending: one from the International Court of Justice (ICJ) brought under the United Nations Framework Convention on Climate Change (UNFCCC), and another from the Inter-American Court of Human Rights (IACtHR) under the American Convention on Human Rights. Both are expected to be issued in 2025 or 2026.

The ITLOS opinion held that greenhouse gases (GHGs) are marine pollutants; this finding is significant because it means countries that

are parties to the United Nations Convention for Law of the Sea (UNCLOS) must take steps to prevent, reduce and control greenhouse gas emissions under UNCLOS. The pending advisory opinions could reinforce the ITLOS decision and put pressure on the states that are parties to these various Conventions to take additional actions to address climate change.

While advisory opinions are non-legally binding judgements, they are written with the same rigor and attention to detail as decisions in contentious cases and are respected as valuable parts of the law. Consequently, they are sometimes used as supporting legal precedent in legally binding judgements. The ITLOS decision may be a significant source in the ICJ and IACtHR upcoming opinions.

The opinions are part of the larger body of international climate change law. The private sector considers these advisory opinions as relevant to its compliance with international law. For example, the advisory opinions may help shape standards set within the private sector such as the sustainability notations of the American Bureau of Shipping (ABS) which also track the United Nations Sustainable

Development Goals. As a result, ABS and its members are working together to seek low carbon fuel alternatives. Advisory opinions also lend themselves to the larger international conversation about climate change and security including among the parties at the UN Conference of Parties (COP 29) taking place in Baku, Azerbaijan in November 2024.

EAG's Climate Security Pillar will continue to analyze climate change cases, advisory opinions and how they affect security of the United States and its allies.

LEARN MORE

Report available at
nps.edu/web/eag/intern-research

EAG Contact: Kristen Fletcher at
kristen.fletcher@nps.edu



Regional Clean Hydrogen Hubs Sample Blueprint (Illustration by the United States Department of Energy)

ENERGY STRATEGY

DON Hydrogen Technical Planning Team Kicks Off

By Bill Muras
Faculty Associate-Research,
Energy Academic Group

Researchers from the Energy Academic Group are supporting the DASN Operational Energy Office in the organization and management of a Department of Navy (DON) Hydrogen Technical Planning Team (TPT), which officially kicked off in early July.

Contested operating environments and more distributed operational concepts present challenges to DON sustainment capabilities. Navy and Marine Corps installations face energy security challenges due to aging infrastructure, increasing threats from malicious activities, and extreme weather events exacerbated by climate change. Hydrogen is an energy solution with the potential to address both operational and installation energy challenges.

In recent years, government and commercial investment in hydrogen technologies, domestically and across

the globe, have increased significantly. The Department of the Navy has substantial efforts in hydrogen targeted at addressing expeditionary energy supply and contested logistics challenges, installation resilience, and energy security. In addition, the Department of Energy (DOE) has invested significant resources in maturing and driving down the costs of hydrogen technologies across the hydrogen value chain, to include publishing the U.S. National Clean Hydrogen Strategy and Roadmap, and launching the Hydrogen Earthshot Initiative, the Regional Clean Hydrogen Hubs Program, and the Hydrogen Interagency Taskforce (HIT). Appropriately leveraging these activities and investments will help the DON to increase the resilience of naval operating systems and improve the energy security posture of naval installations.

EAG is helping to undertake a holistic and systematic review of DON hydrogen activities, in order to 1) assess the role hydrogen can play in addressing Navy requirements; 2) align hydrogen activities across the DON where practical; 3) leverage a whole-of-government approach for the current investment portfolio; and 4) inform analyses and investments required to develop and integrate

hydrogen technologies to address DON requirements.

Expected products from this effort include a preliminary DON Hydrogen Roadmap, technology and capability evolution plans, and proposed demonstration plans with the goal to support rapid development, deployment and testing of hydrogen technologies for potential fleet acquisition.

LEARN MORE

Find the DOE Hydrogen Strategy and Roadmap at <https://www.hydrogen.energy.gov/library/roadmaps-vision/clean-hydrogen-strategy-roadmap/>

Find information on the DOE HIT at <https://www.hydrogen.energy.gov/interagency>

EAG Contact: Bill Muras at william.muras@nps.edu

ENERGY EDUCATION

Research, Training, and Education in Support of Commander, Navy Installations Command Shore Energy Program

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

The Assistant Secretary of the Navy for Energy Installations & Environment, Director of Shore Energy has directed the Energy Academic Group to develop an outline and roadmap for deploying a professional education offering for a one-year Shore Energy graduate-level professional certificate, and a four-day executive level course. This is a first step in the creation and deployment of a professional education program focused on shore energy education. Courses will be tailored to meet the needs of Naval Installation Energy Management and Public Works professionals working with the Navy's Installation Energy Program and will introduce and integrate



(Photo by Lisa Woodbury Rama)

innovative energy system concepts for secure and resilient naval installations.

Both engineering and institutional design aspects of Integrated Community Energy Systems (ICES) for defense communities such as Naval Installations and Ports will be covered in the curricula. ICES are an innovation in energy resilience and security that have been implemented in Europe, "ensuring self-provision of energy and providing system services to the larger energy system."¹ The Energy Academic Group and our Cooperative Research and Development Agreement (CRADA) partner, Pareto Energy, stand at a unique position

in this thought stream by improving energy resilience and security for critical infrastructure using the ICES model of management.

1. Koirala, BP., Koliou, E., Friege, J., Hakvoort, RA., & Herder, PM. (2016). Energetic communities for community energy: A review of key issues and trends shaping integrated community energy systems. *Renewable & Sustainable Energy Reviews*, 722-744. <https://doi.org/10.1016/j.rser.2015.11.08>

LEARN MORE

EAG Contact: Eric Hahn at ehahn1@nps.edu more information.

Refuel Logistics Certificate Course

The Naval Postgraduate School is pleased to announce the Operational Energy Certificate: Refuel Logistics beginning Spring Quarter AY2025. The Certificate is sponsored by OPNAV. The certificate program is an accredited graduate program that consists of four on-line courses, delivered one course per quarter for four quarters.

The Refuel (Contested) Logistics Certificate, curriculum number 121, commences Spring Quarter, Academic Year 2025. An application and participation agreement are required by December 13, 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 INNOVATION

Port Electrification is Possible with Solid State Substations

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

The Energy Academic Group and Pareto Energy are studying the design and implementation of a solid state substation enabled shore power solution for the Port of Hueneme as part of a Cooperative Research and Development Agreement, or CRADA. Resilient, high quality shore power is a common need at both Navy installations and commercial ports. The commercial Port of Hueneme faces a particularly acute need to replace a traditional electromechanical substation that was lost in a storm in December of 2023, so that ships in the port can rely once again on shore power of sufficient



(U.S. Navy photo by Dana Rene White)

quality, instead of ship power.

A solid state substation is an innovation using power electronics that uses only one-sixth of the physical footprint of an electromechanical substation. It conditions power on the load, or customer side of the meter, and avoids more expensive and less functional investments in electromechanical devices on the utility side of the meter. For example, in California a solid state substation costs \$0.80 per watt to install, within 18 months, while an average cost for an electromechanical substation on the utility side of the meter is more than \$2.40 per watt and can take four

years or more to install. A design and implementation study of an integrated energy system using a solid state substation at the Port of Hueneme could potentially save enough space for the port to install on-site power that will be more resilient than continuing to take power from the surrounding macrogrid.

LEARN MORE

EAG Contact: Eric Hahn at ehahn1@nps.edu

Energy Academic Group Welcomes New Team Members

Rebecca Grippo joins the Energy Academic Group (EAG) as a Faculty Associate-Research.

Grippo previously interned at NPS for two years while receiving her Juris Doctorate degree from Roger Williams University School of Law. As a legal intern, her research focused on how the growing area of international law and policy impacts environmental and climate security. She has led reports on the evolving climate litigation cases, climate-induced migration, and the financial considerations of climate change. She also has experience analyzing Arctic governance over autonomous systems. Her undergraduate degree is from Michigan State University in Supply Chain Management with a minor in Economics, and she looks forward to applying her financial background to future projects. In this new role, Grippo will work in the Climate Security Pillar, contributing to climate security curriculum and research and working with NPS faculty and students. Feel free to contact Rebecca at rebecca.grippo1@nps.edu.



Rebecca Grippo

LT Lennard Heidtmann (Germany) joined the Energy Academic Group (EAG) in July 2024 as an international military student from the German Army. He will work with the EAG team until the end of year, supporting research in the field of academic education, with a focus on battery technology and energy storage in Europe. His work will be integrated in the ongoing Battery Workforce Development project. His previous experience abroad and diverse interests make him a valuable asset to the EAG team.

During this time, Lennard will write his master's thesis in the field of critical marine infrastructure under the supervision of Dr. Dan Nussbaum and Dr. Mary Sims. Feel free to contact LT Heidtmann at lennard.heidtmann.gy@nps.edu.

Call for Applicants

Master of Operational Energy (OE) 321

Sponsored by the Deputy Assistance Secretary of the Navy, Operational Energy (DASN OE)

The Naval Postgraduate School is pleased to announce the Master of Operational Energy (OE) beginning Spring Quarter AY 2025. It is an accredited graduate degree that consists of three stackable operational energy certificates. It is delivered via an asynchronous distributed learning (DL) degree model that equips graduates with the essential skills and knowledge to enhance their effectiveness in the modern battlespace. Apply at nps.edu/web/admissions/apply1 and ensure that all your official transcripts are available. For more details, please visit our website nps.edu/web/eag.

For more information

Please visit <https://nps.smartcatalogiq.com/current/academic-catalog/groups-and-committees/energy-academic-group/operational-energy-curriculum-321-dl/> or contact the Program Manager Dr. Colleen McHenry at colleen.mchenry@nps.edu

GLOBAL ENERGY

China is Main beneficiary of West's Futile Energy Transition Push

By Brenda Schaffer, Faculty Associate-Research, Energy Academic Group

U.S. President Joe Biden, U.N. Secretary-General Antonio Guterres, European Commission President Ursula von der Leyen, the heads of the World Bank, International Monetary Fund and World Economic Forum, and almost all mainstream media agree that the world is in the midst of an energy transition from fossil fuels to renewable energy.

They all present this as an undisputed fact even though there are no indications that renewable

energy is really taking the place of global consumption of fossil fuels. But this wishful assumption of an energy transition is contributing to the squandering of economic resources and Western deindustrialization, as well as generating significant national security hazards.

China is the main benefactor of the West's energy transition policies. It is set to retain a huge competitive advantage in manufacturing from cheap and reliable electricity, while the West moves to more expensive, unreliable power sources.

Most transition policies are centered on Western efforts to reduce emissions, with little reciprocal behavior demanded from China. It is time to face facts about the prospects for an energy transition and to take a U-turn on policies that are mostly benefiting China. Energy and manufacturing policies should instead be based on reality.

After several decades and trillions

of dollars of subsidies, consumption of fossil fuels stands at 84% of global energy consumption, down two percentage points from 1973, when wide government support for renewables initially took off.

Last year saw new records set in demand for coal, oil and natural gas. Recent growth in renewable energy capacity has filled some of the rising global demand for energy but has not reduced demand for fossil fuels.

READ THE FULL ARTICLE

Visit <https://asia.nikkei.com/Opinion/China-is-main-beneficiary-of-West-s-futile-energy-transition-push>

EAG Contact: Brenda Schaffer at brenda.shaffer@nps.edu for more information.

Space-Based Solar Power

By ENS Jacob Lowe, USN

Given the complexity of at-sea operations and the ever-increasing need for power at sea, finding ways to optimize energy delivery is at the forefront of the Department of Defense's (DoD) priorities. Via a concept known as power beaming, these satellites harness the power of the sun by capturing its energy and converting it in space to a medium that can be beamed down to a receiver on Earth. Although still in a relatively infant state, the development of Space-Based Solar Power (SBSP) could revolutionize the distribution of energy and strengthen the overall energy network for the DoD in their operations. The methods used in this thesis study included a literature review, a conceptual design process, cost estimation calculations, evaluation of generated alternative designs, a listing of potential naval applications, discussion of technological challenges, and finally compilation of international progress in the field.

After completion of these research methods, a conclusion was made about the current status of SBSP. Although research indicated that systems have indeed improved within the last five to ten years, the readiness level of the technology is not quite high enough to greenlight large-scale production. While small and intermediate capacity systems can feasibly be powered onboard naval vessels (the guided missile destroyer and Virginia class submarine were the illustrated examples) as well as assist in P-8A flight operations via sonobuoys, limitations in the capture and power beaming of energy prevent SBSP from powering large-scale systems to include ships and high-draw weapon systems. The main

limitations in the technology include the low end-to-end efficiency, the large size of deployed receivers, the ability to only power low-to-intermediate scale systems, and the high cost-per-watt metrics relative to other forms of alternative power. For these reasons, it is recommended to further research technology prior to its complete adoption.

However, while SBSP currently stands at a low overall technology readiness level, it should not be brushed off as simply too expensive or impractical. While high in cost relative to traditional as well as other alternative energy systems, the item that sets SBSP apart is its flexible nature and ability to beam power to many different locations. Modifying the delivery coordinates for the satellite transmitter in space is much simpler than changing the route of a supply ship or aerial refueling aircraft. Additionally, SBSP offers an uncontested delivery range that traditional methods simply cannot compete with. While the main pitfall of the technology is its low end-to-end efficiency, it is recommended that future research monitors progress in various areas to include obtaining more specific cost estimates for each individual component, tracking improvements in end-to-end transmission efficiency, and obtaining data on real world system performance. By observing these three items, future theses and research can continually update the feasibility status of SBSP systems with the goal of eventually deeming the technology sufficiently developed for wide-scale adoption and rollout by the Navy and DoD as a whole.



ABOUT THE AUTHOR

ENS Jacob Lowe, USN, has been researching orbital lasers for beaming solar power down to at-sea naval applications—to power UAVs, shipboard weapon systems, and remote sonobuoys. While previous studies had targeted terrestrial applications of the technology, mainly for use by the U.S. Army, Jacob examined the technology specifically in regard to the Navy. He recently presented his research at the Directed Energy Professional Society Annual Science and Technology Symposium in Colorado Springs on May 22, 2024. Jacob's research focused on three areas: (1) a technology assessment of the capabilities, limitations, and maturity of the space-based solar power/laser concept, (2) a cost-estimate of several design alternatives, and (3) the potential naval applications that could benefit from this future power source.

Jacob is a recent 2023 graduate of the U.S. Naval Academy and obtained his undergrad degree in Weapons, Robotics, and Control Engineering. He graduated with a Master of Science in Systems Engineering from NPS in June 2024.

Contact Dr. Bonnie Johnson at bwjohnso@nps.edu for more information about this research.



Calendar of Events and Important Dates

NOVEMBER

November 12-13, 2024 • 14:00-17:30 (CET)
SAS-190 Research Symposium, “Enhancing Energy Security Resilience, Capabilities and Interoperability”

Hosted by NATO. 14:00–17:30 (CET) via WebEx. This is a virtual event only. Participation will be open to nationals from NATO nations, STO Enhanced Opportunity Partners, Partnership for Peace nations and Global partners.

For full event details and to register, go to the **STO Events site**. The information to connect via WebEx will be shared with validated participants only.

DECEMBER

December 11, 2024
Refuel (Contested) Logistics Certificate application deadline

For more information, please visit nps.edu/web/eag/operational-energy-certificate

UPCOMING

2024 Defense Energy Seminar Series
Watch for upcoming dates and full event details as they become available on the EAG website at nps.edu/web/eag/seminars

EVENT UPDATES

For updates to our calendar, please visit the EAG website and Events tab at nps.edu/web/eag/events



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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Lois Hazard
Editor-In-Chief

Frank Chezem
Art Direction and Graphic Design

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Connect with the Energy Academic Group

The Energy Academic Group is located in Suite 537, 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:

CHAIR

Dr. Daniel Nussbaum
danussba@nps.edu
831-324-3228

ASSOCIATE CHAIR

Alan Howard
arhoward@nps.edu

ENERGY ENGINEERING AND INNOVATION

LCDR Eric Hahn, USN, Ret.
ehahn1@nps.edu

ENERGY CURRICULUM DEVELOPMENT

Dr. Arnie Dupuy
arnold.dupuy@nps.edu

ENERGY AND SECURITY THREATS

LtCol Lawrence Walzer, USMC, Ret.
lmwalzer1@nps.edu
831-656-3777

CLIMATE AND SECURITY

Kristen Fletcher
kristen.fletcher@nps.edu
831-656-6195



EAG WEBSITE
nps.edu/energy



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