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ENERGY ACADEMIC GROUP QUARTERLY NEWSLETTER FALL 2020

Highlights

Electric power plant and the lower Manhattan skyline on the East River in New York City.

How the COVID-19 Pandemic Underlines that Electrical Systems Are Essential for National Security—And Also Vulnerable

By Ambassador (ret.) Robert F. Cekuta

While militaries have long planned for needed supplies of gasoline, jet fuel, or other hydrocarbon products and have considered this work an essential aspect of defense planning, they should also look at the possibility of attacks on electrical systems and how they might act if called upon to defend them or to retaliate against a hostile attack on these systems.

The role of electrical grids and supplies in keeping national economies functioning during the pandemic underlines their essential role in national security. Given this essential role, they can be—and, unsurprisingly, have been—targets for attacks.

This reality underlines the need for the United States and our NATO allies to focus on protecting the integrity of electrical systems through factoring it into NATO workplans and security dialogues among NATO members and partners.

The past months have driven home in new ways how essential assured electrical supplies and functioning grids are to delivering that electricity to industries, companies, government agencies, and consumers. While governments, hospitals, and larger firms likely have backup generators or battery systems in case of interrupted supplies from the grid, most consumers and businesses do not.

Without electricity to power web-based and telecom systems and a company's daily operations, the

Continued on page 2

Continued from page 1

economic contraction resulting from pandemic-related closures would have been significantly worse. With closures businesses and governments have turned, where possible, to teleworking: meetings moved to Zoom and other on-line platforms; e-commerce picked up even in emerging market countries; and tele-medical consultations and care became routine.

These trends likely will persist even after vaccines and therapeutics become available. But even beyond that, the uncertainties surrounding the discovery and availability of public health solutions mean that such uses of the net and electricity-dependent telecom systems will continue.

cyberattacks. The European Union also announced for the first time sanctions against six individuals and entities in China, Russia, and North Korea in its effort to prevent, deter, and respond to malicious cyber activities directed against either the EU or its member states.

Moreover, it is important to remember that today's situation is not tomorrow's. The growing intersection between cyber and electricity systems, including AI and smart cities, can present new vulnerabilities in our critical infrastructure. The United States and its allies have to think not only in terms of kinetic attacks on power stations and power lines, but also about how the systems can be undermined through cyber attacks. Moreover, they need to keep pace with, if not ahead of, the governments, organizations, or individuals looking to perpetrate such attacks. The reality is that where there is a vulnerability, there may be a hostile actor looking to exploit it.

Following 9/11, the United States developed lists of critical infrastructure systems and assigned USG agencies responsibility to defend them. The question is how robust these efforts are today and whether they need to be re-examined and strengthened in light of hostile actions elsewhere in the world and evolving technologies. It is the author's view that the U.S. defense establishment and other elements of the national security community need to take new looks at these evolving threats. At the same time, we should work with NATO partners to identify current vulnerabilities and prescribe actions that should be taken now as well as thinking about possible future attack scenarios on our electrical supplies.

We have the infrastructure and intellectual bases to address these concerns, including: The NATO Energy Security Center of Excellence in Lithuania; NATO HQ, which fosters increased information sharing among NATO partners on such thinking and planning; and enhanced leveraging of the expertise and intellectual capital at the International Energy Agency (IEA), of which many NATO countries and partners are members. The Agency has strong experience and capacity to do multidimensional thinking about current and developing threats to energy security, including continued assured supplies of electricity. Since inception following the 1973 oil embargo, the IEA has been an important part of the work of the Departments of State and of Energy to act against threats to energy security and to coordinate with key allies and partners. However, it has not been a priority of defense agencies.

This situation drives home the need for governments, including defense and foreign policy establishments, to consider threats to electricity supplies and how to counter them.

This situation drives home the need for governments, including defense and foreign policy establishments, to consider threats to electricity supplies and how to counter them. These threats are evolving, particularly in the context of cyber aggression. As seen in Russia's aggression against Ukraine, they include attacks on electricity supplies and grids as part of hybrid warfare. Individual hostile actors (hackers) and terrorist groups also engage in such activities to advance their various ends.

The United States Government (USG) and some allies are flagging the general seriousness of the situation. The National Security Agency and the Cybersecurity and Infrastructure Security Agency in the U.S. Department of Homeland Security issued an alert July 23 about foreign hacking groups threatening the energy sector. Press reports note the new USG concerns include malicious groups using internet accessible operational technologies such as those that manage power grids as access points for dangerous

Electrical systems are essential components of our national infrastructures and the security of the United States and our NATO allies and partners. The current pandemic is revealing the roles electrical power plays and underlines the necessity of thinking about how those systems can be attacked and how to act to prevent, counter, or at least minimize the effects of such attacks.

LEARN MORE
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FROM THE CHAIR

Dan Nussbaum, Chair of the Energy Academic Group

Is there a connection between energy security and critical energy infrastructure? Of course there is, and recent news provides plenty of supporting evidence. Just consider recent attacks on energy facilities in Armenia, Azerbaijan, Saudi Arabia, Iran, and Lebanon. Each of these locations contains critical energy infrastructure, and in each case the world's energy market has taken very real notice of these events.

In the case of the attack by Armenian forces on the Azerbaijani District of Tovuz, close to where the Southern Gas Corridor natural gas pipeline was about to open, Professor Brenda Shaffer says the new pipeline "... will bring the first new gas volumes to Europe in decades. These new supplies challenge Russia's dominance in several markets in Europe."

Similarly, the attack on the Saudi Aramco processing facilities at Abqaiq and Khurais in eastern Saudi Arabia caused large fires. Though the fires were short lived, they closed off about 5% of global oil production, with associated financial market perturbations.

For weeks in Iran, things like power stations have been blowing up or catching fire. Two significant incidents were at a liquid fuel production site for the country's missile program, and underground explosions at a nuclear facility and a nuclear enrichment facility.

There are many other examples of the connection between energy security and critical energy infrastructure, but we will let the two above suffice for the moment. From a strategic perspective, the important question is *how do we approach this issue so that we can understand and fashion strategies to manage the issue?* NPS EAG has cosponsored some recent webinars on the topic, including webinars in partnership with the Atlantic Council and the Colorado School of Mines. NPS will continue to do so.

Additionally, there is a new NATO Systems Analysis effort, SAS-163, "Energy Security in the Era of Hybrid Warfare" that will address this overall issue.

If you are interested in any of these topics, please let me know.

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Energy Academic Group Welcomes New Team Member

Dr. Brenda Shaffer

Dr. Brenda Shaffer joined EAG in May 2020 as Faculty Associate – Research. Dr. Shaffer has considerable experience as an international energy specialist, focusing on the interplay between natural gas trade and foreign policy, politics and energy in the South Caucasus and greater Caspian and Black Sea regions, Iranian natural gas exports, ethnic politics in Iran, and Eastern Mediterranean energy. With the EAG, Shaffer will focus her effort on course development, course delivery, and research.

Dr. Shaffer is also a Senior Fellow at the Atlantic Council's Global Energy Center in Washington, D.C., and a Senior Advisor for energy at the Foundation for Defense of Democracies (FDD) think tank. Over her career, she has authored several books: *Energy Politics* (University of Pennsylvania Press, 2009), *Borders and Brethren: Iran and the Challenge of Azerbaijani Identity* (MIT Press, 2002), and *Partners in Need: The Strategic Relationship of Russia and Iran* (Washington Institute for Near East Policy, 2001). *Energy Politics* is used as a text book in over 200 university courses around the globe. She has also served as the editor for *Beyond the Resource Curse* (University of Pennsylvania Press, 2012) and *Limits of Culture: Islam and Foreign Policy* (MIT Press, 2006).

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OPERATIONAL ENERGY

An Emerging Game-Changing Technology: Power Beaming

By Dr. Paul Jaffe
U.S. Naval Research Laboratory

Captured by a special camera, a laser beam invisible to the naked eye shoots across the dark expanse of the David Taylor Model Basin at the Naval Surface Warfare Center in Bethesda, Maryland. (Photo by Leonard Pieton / U.S. Naval Research Laboratory)

Many military energy applications are hamstrung by dependence on fossil fuels, batteries with limited life and capacity, and operations in areas that are difficult, expensive, and risky for energy resupply via conventional means.

Within the past few years, there has been a surge in advances in multiple technology areas that have direct and compelling relevance to these problems. Technology to support the ability to send energy over long distances without wires has gained momentum, currency, and recognition by many entities, including the Department of Defense's Operational Energy Innovation office,[1] DARPA,[2] the Institute of Electrical and Electronics Engineers,[3] industry, and in countries such as Japan.[4,5]

At its heart, the benefit and motivation for power beaming is its ability in contexts unsuitable for wires or fuel and battery delivery to move energy from a place where it is comparatively easy to generate or store to a place where it is more challenging to generate or store. The technology itself takes several forms, including: (1) optical transmission at a range of possible wavelengths to receivers consisting of bandgap-tuned photovoltaics, thermophotovoltaics, or heat engines, (2) millimeter-wave transmission using solid state or gyrotron sources to rectennas or heat engines, and (3) microwave transmission at a range of possible frequencies from vacuum or solid state electronics to rectenna receivers. Supporting technology, including high altitude vehicles, aerostats, inexpensive adaptive optics, and others have also made significant recent gains.

For defense purposes, a number of application areas are of immediate interest: swarming, teamed, and individual autonomous air, ground, and sea vehicles; offboard countermeasures; unattended ground and sea sensors; explosive ordnance disposal; and camp/convoy/port/fleet security. These cover a range of mission areas, including providing communications, intelligence, surveillance, target acquisition, and reconnaissance. They are applicable in numerous military contexts, such as forward operating bases, combat outposts, landing parties, fleet operations, and distributed sensor networks. Power beaming can also be used to enhance energy harvesting or traditional solar energy collection. Perhaps the ultimate application of wireless power is space solar, in which sunlight collected in orbit is sent to

Perhaps the ultimate application of wireless power is space solar, in which sunlight collected in orbit is sent to points of need on the earth.

Researchers transmit energy with a laser in power-beaming demonstration. (Photo by Daniel Perry / U.S. Naval Research Laboratory)

points of need on the earth.

Power beaming offers compelling crossover opportunities with other areas of great military relevance: directed energy, radar/lidar, jamming, high-rate communications, and data exfiltration. It presents a critical and disruptive opportunity to ensure our forces continue to have decisive overmatch in key areas that are undergirded by reliable energy, and it enables new operational concepts.

LEARN MORE
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Notes

1. P. Jaffe, et al., "Opportunities and Challenges for Space Solar for Remote Installations." (2019).
2. A. Bar-Cohen, et al., "DARPA/MTO & OASD(R&E) Roundtable Report: Department of Defense Power Beaming Roundtable," (2015).
3. IEEE MTT-26 Wireless Energy Transfer and Conversion Committee, https://tc26.mtt-tcc.org/.
4. J. Hongo, "Japan Space Agency Advances in Space-Based Solar Power," Wall Street Journal, March 9, 2015.
5. "MHI Successfully Completes Ground Demonstration Testing of Wireless Power Transmission Technology for SSPS," Mitsubishi Heavy Industries press release March 12, 2015, No.1879.

Enrollment Open for Defense Energy Certificate Program

The Naval Postgraduate School's (NPS) Energy Academic Group is pleased to announce the fourth offering of its Defense Energy Certificate program. This offering (cohort) will begin Monday, 29 March 2021. 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 4 January 2021.

The DL Defense Energy Certificate program is a graduate-level and accredited certificate program. It consists of four courses, offered one course (on-line) 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

OPERATIONAL ENERGY

Energy: An Essential Element for Winning Future Wars – Operational Energy Part 1

By RuthAnne Darling and Paul Mason Carpenter

And it ought to be remembered that there is nothing more difficult to take in hand, more perilous to conduct, or more uncertain in its success, than to take the lead in the introduction of a new order of things, because the innovator has for enemies all those who have done well under the old conditions, and lukewarm defenders in those who may do well under the new.[1] *—Niccolò Machiavelli*

Since the beginning *of the Industrial Age, operational energy (OE) has played an increasingly predominant role in warfare.* Without modern OE, mankind would deploy to war on horses, sail wind powered ships, and fight with swords and arrows. Without energy, available in forms useable by integrated circuitry and transmission systems, the cyber domain would be reduced to hand signals and colored flags. Today OE is a foundation of national defense and an *indispensable* attribute of military strength. Energy literally powers every action of military consequence and has been a *casus belli* for nearly a century. In addition to powering nearly all forms of communication and sensing; fueling all air, land, sea and space platforms; and energizing all electrical devices, OE has become a direct weapon within itself. Directed energy, railgun, laser, particle beam, and microwave arms are coming of age, and within a few years, will dominate the battlespace. Without an abundance of ready, secure, and forward-based OE, future militaries will falter and fail. *Therefore, our nation must thoughtfully consider OE as a critical element of military strategy, then resource and integrate it effectively within multi-domain warfare.* This will ensure that OE—like cyber—has the correct emphasis, resourcing, and support within future warfighting. The full article, available online, provides an overview of OE since World War I, discusses warfighting realms, and offers how leaders might deliberate OE in the future.

Energy literally powers every action of military consequence and has been a *casus belli* for nearly a century.

KEEP READING

Read the full article on EAG's website at **https://nps.edu/web/eag/future-wars**

About the authors

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Notes

1. Machiavelli, Niccolò, The Prince (Unabridged and Illustrated), Kindle Edition, location 556.

STUDENT ENERGY RESEARCH SPOTLIGHT

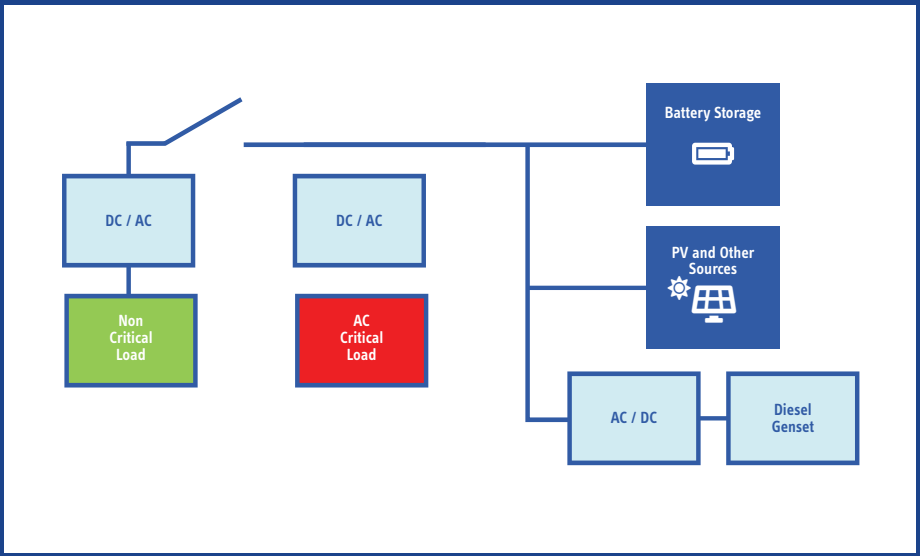
Design and Modeling of Hybrid Photovoltaic Systems in Arctic Environments

By Capt Ruth Fish, USMC

Energy Security is a key concern for military installations. A stand-alone hybrid microgrid provides energy security for remote naval facilities due to the sustainability, flexibility, and redundancy of the PV arrays, batteries, and generator, respectively.

This thesis develops a methodology to size the energy resources of a military hybrid microgrid and implements this methodology in a user-friendly tool that is easily accessible to engineers and energy managers at military facilities, especially those in remote locations and extreme climates such as the Artic. The tool focuses on increasing the resilience of specifically military microgrids and on accurately sizing distributed energy resources (DERs) to account for climate. While complying with IEEE standard 1562, the tool allows the user to specify environmental factors of the location and decide upon the total dependence of the system on solar power.

Three experiments with a commercial off-the-shelf (COTS) microgrid validated the design tool and physics-based model. Then, two case studies were conducted to understand the parameters for the design of hybrid microgrids for military installations in a range of climates. In the first case study, the annual performance of 30 differently sized DERs was compared, based on fuel consumption, size, and mission availability. Fuel consumption was plotted versus the solar fraction, which is a number between 0 and 1 to indicate how much of the load power is provided by PV arrays. In the second case study, the daily performance of the same 30 DERs was compared based on their ability to sustain their load with an inoperable generator.



A hybrid photovoltaic (PV) system provides energy security for remote naval facilities.

The research revealed the relationship between solar fraction and fuel consumption in various climates as well as considerations for microgrid design in environments with great variability in the amount of available sunlight throughout the year.

Capt Ruth Fish, USMC

About the author

Capt Ruth Fish, USMC, is a student of the Electrical Engineering Department at the Naval Postgraduate School. Contact Dr. Giovanna Oriti at goriti@nps.edu for more information about this research.

EAG INTERN RESEARCH HIGHLIGHTS

Public-Public Partnerships Reveal Best Practices for Incorporating Climate and Energy Resilience into Master Plans

By Cameron Steagall Middlebury Institute of International Studies, International Environmental Policy '20

Instance of recurrent flooding at Naval Station Norfolk (Photo by Ian Swoveland / U.S. Naval Station Norfolk)

The Department of Defense first recognized climate change as a risk to national security in the National Defense Authorization Act (NDAA) FY 1991. The NDAA FY 2020 called for installations to incorporate energy, climate, and cyber resiliency measures into master plans. While installations and DoD cannot protect entire communities from the effects of climate change, their resilience to its effects may mean the difference between safeguarding those communities from domestic and foreign threats. This summer, the Energy Academic Group undertook an analysis to analyze and offer the best practices for partnerships between DoD and municipal governments that can advance installation resiliency. The analysis focuses on a vital element of climate and energy resiliency: public-public partnerships.

The primary partnerships analyzed were the Hampton Roads Sea Level Rise Preparedness and Resilience Intergovernmental Pilot Project (known as the IPP), the Monterey Model, Presidio of Monterey partnership, and intergovernmental support agreements. The report details the following best practices:

- Information Sharing
- Institutional Knowledge
- Relationship Building
- Prioritization of Resiliency
- Necessity of a Convener
- Customization

The findings target the cultivation of relationships to increase efficiency and productivity of partnerships geared toward increased resiliency. The research serves as a guide to help Planning Liaison Officers and municipalities build from existing relationships and policy structures to tackle the resiliency needs of communities and DoD installations.

LEARN MORE

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

Contact Cameron Steagall at steagalljames@gmail.com or Kristen Fletcher at kristen.fletcher@nps.edu

EAG INTERN RESEARCH HIGHLIGHTS

Operations and Communications Remain Challenges in Arctic

By Philip DeCocco
Marquette University, Political Science and Philosophy '23

Coast Guard Cutter Healy (WAGB-20) is one of two ice breakers in U.S. service and is the only military ship dedicated to conducting research in the Arctic. (Photo by Senior Chief Petty Officer NyxoLyno Cangemi, USCG / U.S. Coast Guard)

With the significant increase in year-round commercial and military activity in the Arctic, many Arctic states are creating or revising Arctic strategies, including those focused on defense activities and needs. This summer, the Energy Academic Group undertook a comparative analysis of the Arctic defense strategies of four Arctic states—the United States, Canada, Russia, and Denmark.

The harsh and rapidly changing environment in the Arctic region includes rapidly receding ice and rising temperatures leading to increased navigation for longer periods. Home to an estimated 30% of the world's undiscovered natural gas, approximately $1 trillion dollars worth of earth minerals, and a multibillion dollar fishing industry, open passages mean an increase in commercial navigation as well as military activities and search and rescue operations. The geopolitics and outstanding legal questions of the region pose a unique challenge for states that operate there, including questions regarding inland waters claims of Russia and Canada and China's claimed status as a "Near-Arctic State."

Analysis of strategies of these four Arctic states revealed the common priorities of: the necessity of multinational partnerships, meeting communications challenges, exercising the right of sovereignty, and closing operational gaps. Investments trended toward improved forecasting and modeling, increasing the number of icebreakers, and reducing the impact of the conditions on personnel and equipment. The report's goal is to understand common priorities among select Arctic states in order to strengthen future U.S. strategic positions and activities in the region.

LEARN MORE

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

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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.

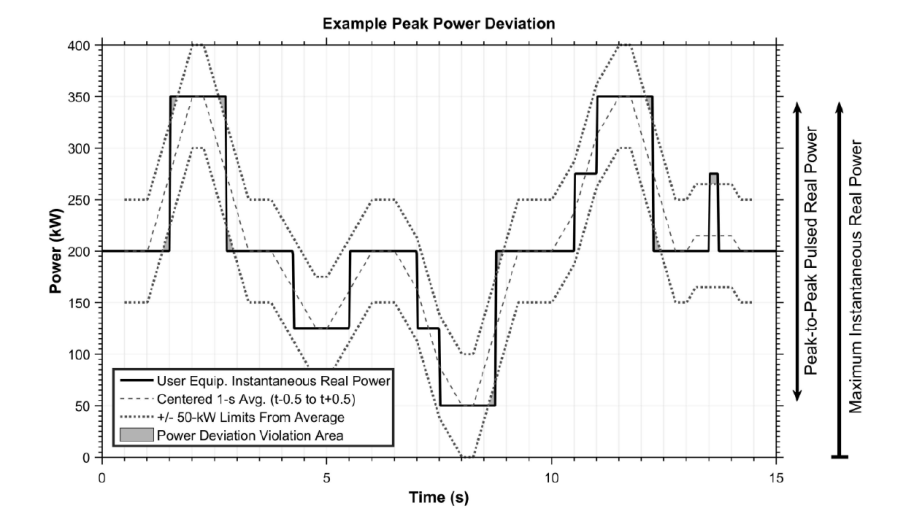
STUDENT ENERGY RESEARCH SPOTLIGHT

Shipboard Voltage Source Inverter Control System to Meet MIL-STD-1399-300 Limits for Pulsed Power Loads

By LT Daniel DeToma, USN

As the Navy, Marine Corps, and DoD continue to research and deploy advanced radars, sonars, railguns, and directed energy weapons, the demand for electrical energy will continue to increase. These weapons and sensors can require repetitive power inputs for a few seconds at a time. As a radar changes its search pattern and transmits power, for example, the power consumed will pulse. Similarly, a laser may generate a repetitive pulse, that if left uncontrolled, could result in unacceptable voltage and frequency transients on the power source. The MIL-STD-1399-300 revised in 2018 has new requirements for pulsed loads.

This research seeks to minimize the effect of pulsed loads on a microgrid, whether that microgrid is a Marine Forward Operating Base (FOB) or the shipboard power distribution system, by designing a controller for a three-phase voltage source inverter (VSI) that limits the effect of pulses on the power source. In a shipboard environment or FOB, traditional generators are smaller than those on a utility-scale power grid and are therefore more susceptible to pulsed loads. Increasingly FOBs are making use of solar, wind, and other renewables and storing that energy in supercapacitors or batteries, which can be utilized by the VSI.



Example Pulsed Power Waveform from MIL-STD-1399-300

The proposed control system supplies the instantaneous power to pulsed loads from the energy storage system and limits the generator's real power output deviation from average, as required by MIL-STD-1399-300. Thus, the generator can slowly adjust to more loading within its mechanical limitations. Additionally, the current waveform from the VSI can be controlled to correct the grid power factor to unity, thus reducing the overall size of a generator. A physics-based model has been developed to simulate the functionality of the controller and compare the generator's output power to the limits in MIL-STD-1399-300. A hardware implementation of a three-phase grid and VSI is currently under development to validate the model.

LT Daniel DeToma, USN

About the author

LT Daniel DeToma, USN, is a student of the Electrical Engineering Department at the Naval Postgraduate School. Contact Dr. Giovanna Oriti at goriti@nps.edu for more information about this research.

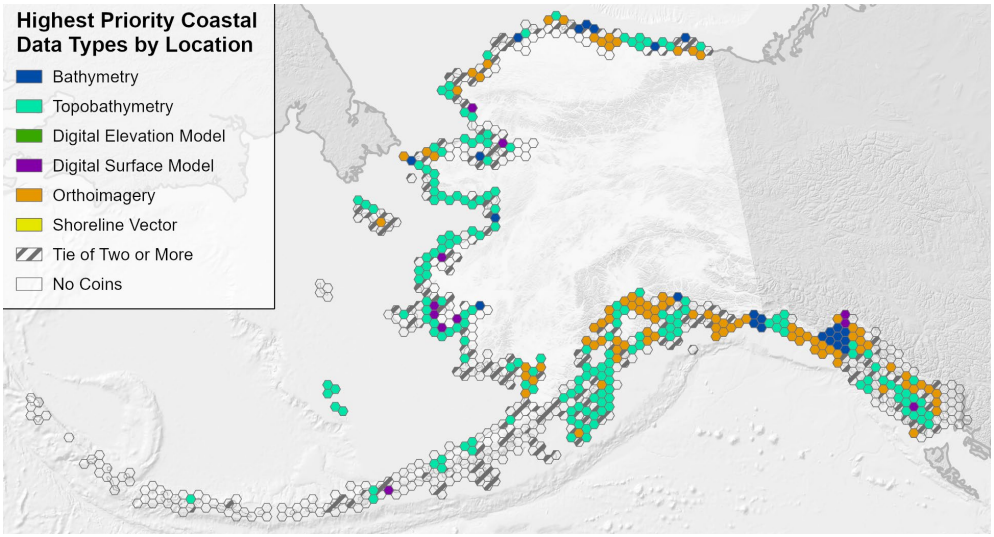
ENERGY RESEARCH

Ocean Mapping a U.S. Priority

By Kristen Fletcher, Faculty Associate-Research, Energy Academic Group

Recent presidential actions have prioritized ocean technology and mapping, including the U.S. Exclusive Economic Zone (EEZ) and Alaska shore. Following the November 2019 White House Summit on Partnerships in Ocean Science and Technology, President Trump issued a *Memorandum on Ocean Mapping of the United States Exclusive Economic Zone and the Shoreline and Nearshore of Alaska.*

Noting that only 40% of the EEZ has been mapped and that Alaska and the Alaskan Arctic lack the shoreline and nearshore maps available across the U.S., the memorandum calls for the Ocean Policy Committee, led by the Office of Science and Technology Policy and Council on Environmental Quality, to develop a national strategy for mapping, exploring and characterizing the EEZ. It directs NOAA to work with the State of Alaska and Alaska Mapping Executive Committee, which includes DoD representation, to develop a strategy to map the shoreline and nearshore of Alaska. Goals include identifying potential new sources of critical minerals, energy, and other resources and streamlining permitting for exploration, mapping, and research activities in the EEZ. A 10-year strategy to map the Alaskan Coast was released in June. This effort will be critical in defense readiness in the Arctic which is experiencing some of the globe's most rapid climate-related changes.



2019 Alaska Stakeholder Spatial Prioritization Survey (Integrated Ocean and Coastal Mapping, NOAA)

In response to the 2019 Presidential Memorandum, the Ocean Policy Committee released several documents in June detailing mapping strategies for the EEZ and Alaska shoreline and recommendations for increasing permitting efficiency. The *National Strategy for Mapping, Exploring and Characterizing the US EEZ* includes calls for interagency coordination for mapping, and developing and maturing science and technology for mapping. It establishes a council to coordinate approaches and prioritizes public-private partnerships and the utilization of federal platforms, such as Navy oceanographic ships and Coast Guard ice breakers, to accomplish these goals.

LEARN MORE

White House Ocean Policy Initiatives are available at **https://www.whitehouse.gov/ceq/initiatives/ocean-policy/**

Executive Orders and other Presidential Actions are available at: **https://www.whitehouse.gov/presidential-actions/**

The Mapping the Coast of Alaska strategy is available at: **https://iocm.noaa.gov/about/documents/strategic-plans/alaska-mapping-strategy-june2020.pdf**

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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/

Calendar of Events

Fall 2020 Defense Energy Seminar Series
Due to rapidly changing circumstances surrounding the COVID-19 virus, the Defense Energy Seminar Series will be offered exclusively online for the Fall Quarter. Please visit our website at **https://nps.edu/web/eag/seminars** for upcoming seminar dates and all EAG event details.

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 ACADEMIC GROUP
NAVAL POSTGRADUATE SCHOOL

Connect with the Energy Academic Group

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

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Contribute to an issue of *Surge*

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