



SURGE



ENERGY ACADEMIC GROUP QUARTERLY NEWSLETTER WINTER/SPRING 2019

Highlights

GLOBAL ENERGY FORUM
ENERGY INFRASTRUCTURE
OPTIMIZING AERIAL REFUELING
FUTURE OF ENERGY RESILIENCE
DEFENSE ENERGY SEMINAR
SERIES



Students from NPS ECE and Stanford Precourt Institute for Energy at Stanford's Global Energy Forum (NPS Students include LT Dimitrios Kanavros, Hellenic Navy, Greece; LT Petros Siritoglou, Hellenic Navy, Greece; LT Burnell Clemmer, USN; and Capt John E. Dommert, USMC)

NPS Students Attend Stanford's Global Energy Forum

By Capt John E. Dommert

On November 1st and 2nd, students from the Naval Postgraduate School's Electrical and Computer Engineering (ECE) Department had the opportunity to engage with industry and academia at Stanford's inaugural Global Energy Forum. The two-day forum covered a multitude of issues within the energy sector and featured speakers such as Condoleezza Rice, George Schultz, and Bill Gates. Discussion panels unpacked

trends in electric vehicles, increased renewables and distributed resources on the grid, growing advances in battery technology, and leveraging autonomy.

Due to the nature of the event, discussion was focused on general industry and consumer topics with some mention of impacts to national security. However, it became clear that dedicated conversation and solutions are not required for defense interests to benefit. The push for the democratization of the utility grid is creating solutions that enable installation resilience. Electric vehicles and renewables continue to fuel the search for better energy storage, providing robust remote energy options for deployed units. Furthermore, increased digitization is growing not only the computing to optimize systems, but

the security to keep them operational. All of these advances are creating opportunities for more capable products at a lower cost for our service branches.

At the conclusion of the scheduled program, students from across the country had a chance to interact and discuss their research in energy. The event was productive and highlighted an opportunity for the Naval Postgraduate School to inform the next generation of energy innovators through student collaboration and engagement.



LEARN MORE

Email Jack Templeton at jctemple1@nps.edu or call (919) 696-1398.



Principal's Thoughts

Dan Nussbaum, Principal, Energy Academic Group

Two energy-related topics to share with readers in this issue of *Surge*: a recently completed Table Top Exercise (TTX) on Critical Energy Infrastructure (CEI) and an emerging big idea at the Naval Postgraduate School on microgrid research.

Critical Energy Infrastructure

The NATO Energy Security Center of Excellence (EnSecCOE), with the support of NPS' EAG, hosted Coherent Resilience 18 (CORE 18). The aims of TTX CORE 18 were to:

- Evaluate hybrid threats to CEI, with implications for collective defense in SACEUR's AOR
- Increase awareness and shared understanding of hybrid threats (cyberattacks, physical sabotage, information warfare, etc.) to CEI
- Understand the interdependencies and vulnerabilities among various energy infrastructures (energy, water, telecommunications networks, etc.)
- Understand the dependence of military forces on civilian energy infrastructure and transport capacities
- Consider measures to protect infrastructure
- Identify shortfalls in plans, policies, procedures, and resources related to resilience of critical energy infrastructure

Yes, that is quite a large target-set of goals! It follows TTX CORE 17 held in Kiev. The purpose of that exercise was to support the national authorities of Ukraine to build resilience through improved emergency preparedness, planning, prevention, and threat response to strengthen Ukraine's capability to protect electricity-related Critical Energy Infrastructure. Unlike the Ukrainian exercise, CORE 18 expanded the focus to include hybrid warfare, which incorporates simultaneous and adaptive employment of a complex combination of conventional weapons, irregular warfare, terrorism, and criminal behavior into the battlespace to achieve political objectives. The Evaluation Report for CORE 17 was widely distributed within NATO and is available upon request. The Evaluation Report for CORE 18 is due to be published by March 2019.

Microgrid Research

The Electrical and Computer Engineering (ECE) Power Electronics Research Group, led by Associate Professor Giovanna Oriti, is focusing its attention on microgrid research and recently hosted a multidisciplinary study group with the active participation of professors and students from several Graduate School of Engineering and Applied Sciences (GSEAS) departments as well as the Energy Academic Group. A working definition of a microgrid is an integrated energy system with the following components:

- Intelligent management and control features
- Multiple sources and multiple loads
- Common, linked interfaces
- Automatic protection and reconfiguration features
- Capability to operate in either an islanded or connected mode

The goal of the study group is to support these research and to share information about microgrids and their relevance to the Department of Navy. The study group is currently addressing hierarchical control and power flow management in tactical microgrids. If you are interested in this research, please contact Associate Professor Giovanna Oriti, at goriti@nps.edu.



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STUDENT ENERGY RESEARCH SPOTLIGHT

An Operational Model of Interdependent Water and Power Distribution Systems

By LCDR Brendan Bunn

As military and public needs become more complex and interconnected, so too does our infrastructure. Both military and civilian communities require critical services for daily life, including water, food, shelter, energy, mobility, and communications among others. The infrastructure systems providing these services are sometimes interdependent, such that the systems themselves require critical services to operate. This is especially common for water and power systems found on military installations and remote island territories where local electricity needs water to run generators and water needs electricity to run pumps. These interdependencies often improve the efficiency of both systems by sharing scarce resources and making operations easier. However, during natural disasters and extreme events interdependencies also lead to service failures that impact both systems simultaneously and are difficult to manage. To plan for extreme events, we need detailed engineering models that include water-power interdependencies. Unfortunately, these models do not yet exist.

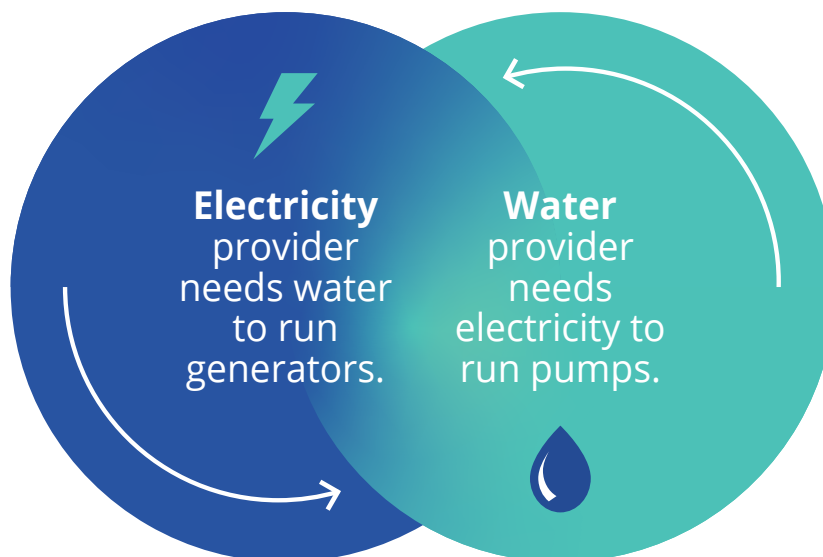
We filled this gap by developing an interdependent model of potable water distribution and electric power distribution operation at the island and installation scale. We aimed to

capture key attributes and essential interdependencies of these systems with enough fidelity to represent real infrastructure physics, measure how networks perform in various crisis scenarios, and present new insights on interdependencies. Our final model links established engineering models for water and power networks which we used to study interdependent water-power system behavior across a series of emergency scenarios.

Results reveal important insights for interdependent infrastructure modeling and analysis. Most notably, we found different classes of interdependencies

can lead to similar failure outcomes, and that these failed states happen even when dependencies between systems are not bi-directional (i.e., water depends on power, but not vice versa). This result has implications for infrastructure management on military installations and remote island territories and may impact design choices moving forward. Overall, the final model provides both realism and simplicity, making it an ideal foundation for future analysis for more complex water-power systems in military and civilian contexts.

Interdependent Systems



LCDR Brendan Bunn

About the author

LCDR Brendan Bunn is a recent graduate of the Naval Postgraduate School's Operations Research program and is a Navy Civil Engineer Corps Officer. He is currently working for OPNAV N81 as a force generation shore readiness analyst.

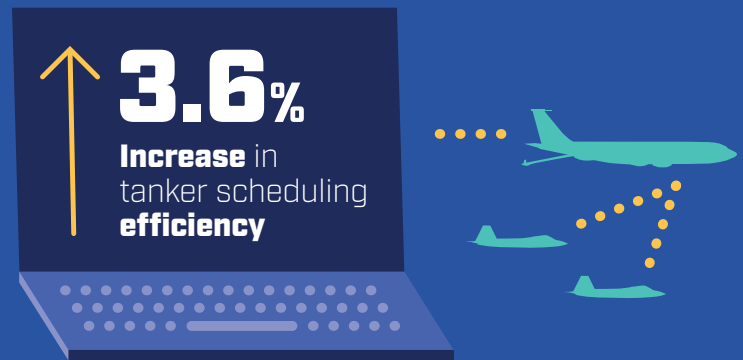
Contact the EAG team at nps.edu/energy for more information about this research.

Data showed us that increasing F-22 aerial refueling speeds **decreased fuel use** by 6% and flight time by 10%



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Reduces fuel use by **180,000 GALLONS WEEKLY**



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3-4 Fewer tails and crews required in theater

Reduces tanker sorties required by **2 PER DAY**

OPERATIONAL ENERGY

DoD Joins NATO Partners to Discuss Future of Military Energy Resilience

By Corrie Poland,
Air Force Operational
Energy (SAF/IEN)

Article originally published November 26, 2018. Provided by the SAF/IEN office and reprinted with permission.

As part of Innovative Energy Solutions for Military Application (IESMA) 2018, a collaborative symposium led by the NATO Energy Security Centre of Excellence, international experts from the energy and defense communities came together to discuss leading developments in energy resilience and security. Over 500 participants, including many distinguished military and governmental leaders representing NATO member and partner nations, attended the biennial event held in Vilnius, Lithuania from November 14 to 16.

The event provided a forum for participating nations to discuss the future of innovative energy capabilities, and exchange best practices on how to increase combat capability through efficient operations and cutting-edge technology. Senior defense and industry representatives spoke on a number of topics, including secure energy logistics, infrastructure and storage, energy management, next generation power systems, optimized mission planning, and alternative fuels, among others.

Leaders from the Office of the Secretary of Defense, Air Force and Navy represented United States interests aligned with the National Defense Strategy, and collaborated with participating nations on how to move forward to integrate smart energy solutions across the Alliance.

"We are in the midst of revolutionary changes that make energy even more critical," said Lucian Niemeyer, a Strategic Advisor on energy programs



Principal Director of United States Air Force Operational Energy Policy, Michael Penland, describes how using data and technology to optimize aircraft operations leads to increased capability and readiness while speaking at the 2018 Innovative Energy Solutions for Military Application conference.

for the Under Secretary of Defense for Acquisition and Sustainment. "As our forces require more power, and energy is increasingly a target, energy resilience and security will have an increasingly direct relationship on warfighter capabilities."

Underlying each discussion emerged several common themes. Speakers emphasized the increased lethality brought by more efficient military operations. By reducing energy demand, forces can ensure a more reliable supply—especially in remote locations, increase range, and reduce operational risk.

Principal Director of United States Air Force Operational Energy Policy, Michael Penland, described how using data and technology to optimize aircraft operations leads to increased capability and readiness. "Optimizing aviation fuel use leads to a number of second and third order effects like increased range, fewer maintenance issues, and reduced costs—funds that could be used for things like more training or new technology," he explained.

"We need to organize for innovation," said Oliver Fritz, Principal Director in the Office of the Deputy Assistant Secretary of Defense for Energy. "It's essential that we not only improve our use of energy, but focus on being resilient to energy disruptions," he continued.

Another important topic highlighted the strategic importance of collaborating with industry and allied partners to provide secure energy solutions for the warfighter.

In his opening statement, Col. Romualdas Petkevičius, Director of the NATO Energy Security Centre of Excellence, encouraged participants to collaborate with industry vendors to adopt modern technologies and address energy challenges. "Pay attention to what companies can offer as they bring solutions that already work and have been tested in civilian environments, as well as in industry practice," he said.

Throughout the event, attendees were prompted to visit the exhibition hall to network with commercial companies providing energy solutions and learn of industry best practices that could be applied to the military. Attendees also participated in a number of networking events to share information and continue to build international and cross-organizational relationships.

The mix of distinguished guests and subject matter experts present highlighted the importance of the topic and the variety of ways that militaries and organizations are trying to address today's energy challenges. This year boasted the highest attendance for any IESMA symposium yet, and it is only expected to grow in depth and variety of topics in the coming years. The next IESMA is scheduled for 2020 in Vilnius.



LEARN MORE

For more information and news on Air Force Operational Energy visit: safie.hq.af.mil/OpEnergy



RESILIENCE CORNER

Think of Resilience as a Verb, not a Noun

By Dan Eisenberg, PhD,
Department of Operations
Research, NPS

Resilience is a “new” term creeping into military directives, but what does it mean and how do we use it to guide decisions? Part of the reason that resilience is so difficult to apply is that the word itself occupies an awkward position in the English language. Although *resilience* is used as a noun, the most popular definitions describe it as a capacity to act—which makes resilience an action that systems perform, like a verb, rather than a property that a system has, like a noun. There is a historical precedent to this way of thinking¹, as the word resilience originates from the Latin word *resilio*, “to leap” or “bounce,” and first entered

the English language in the 1500s as the verb *resile*, meaning, “to retract”, “to cancel”, or “to return to a former position.” Thinking of resilience as it was originally used—as a verb—has important implications for how we make military installations and operations more resilient.

Comparing different forms of the words *risk* and *resilience* illustrate this point². While both *risk* and *resilience* work well as abstract nouns, only *risk* works as a quantifiable noun. This may explain why risk analysis across the DoD and federal government involves quantified threats, vulnerabilities, and consequences with little to no ambiguity. This may also explain the difficulty experts have coming up with quantifiable, concrete measures of resilience. Trying to measure resilience may simply be a lost cause, stemming from the linguistic fact that “to leap”, “to cancel”, or “to return” cannot be meaningfully counted.

In contrast, the action verb form of *risk* is a poor choice, whereas the word *resile*, although obscure, is nonetheless proper and useful. *Risk* works well as a linking or helping verb, but *resile* does not. This highlights the fact that risk management actions only pertain to a specific threat with known consequences (e.g., flooding). Instead we should think of resilience not just

in the capacity to act, but in the action itself. Resilience flips our perspective from identifying and mitigating known risks towards *understanding the systems, processes, and actions taken to manage any risk*.

Consequently, the tools and methods for measuring and addressing risks are not appropriate for resilience, as these two related concepts are fundamentally different. An appropriate risk-based question for a military installation is, “How can we mitigate the damages from the next flood?” Answering this question requires measures of future flooding probability and the likelihood that this flooding will damage military systems and results in recommendations to mitigate these impacts. On the other hand, an appropriate resilience-based question for the same installation is, “What do we do when we flood?” Answering this question focuses attention on understanding how floods are sensed, anticipated, responded to, and learned from on base and results in new systems that enhance these actions during disasters.



LEARN MORE

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RISK & RESILIENCE

Parts of Speech	Risk	Resilience
Abstract Noun	✓ What is risk?	✓ What is resilience?
Concrete / Quantifiable	✓ What is a risk?	✗ What is a resilience?
Action Verb	✗ I risked.	✓ I resiled.
Linking Verb	✓ I risk floods.	✗ I resile floods.
Helping Verb	✓ I risk flooding.	✗ I resile flooding.

✓ Indicates grammatically correct sentence ✗ Indicates grammatically incorrect sentence

REFERENCES:

- Alexander, David E. "Resilience and disaster risk reduction: an etymological journey." *Natural hazards and earth system sciences* 13, no. 11 (2013): 2707–2716.
- Eisenberg, Daniel A. "How to Think About Resilient Infrastructure Systems." PhD diss., Arizona State University, 2018.

ENERGY RESEARCH

Defense Energy Seminar Examines Navy's Future Use of Electrical Energy Tech

By MC2 Patrick Dionne

Article originally published November 7, 2018. Provided by the Naval Postgraduate School Public Affairs Office and reprinted with permission.

A group of energy officials from across the Navy teamed up to provide the NPS community with an overview of the Navy's future electrical energy technology development during the latest Defense Energy Seminar. Navy Capt. Lynn Petersen (retired), program officer for the Office of Naval Research (ONR); Cmdr. John Stevens, Associate Chairman of the U.S. Naval Academy's Department of Electrical and Computer Engineering; and Cmdr. Stephen Markle (retired), Director of the Electric Ships Office, joined forces to provide an update titled, "U.S. Navy Electrical Leap Forward...A Vision for the Future of ONR Technology Development."

The talk focused heavily on updating the power and energy requirements throughout the fleet to take better advantage of upcoming changes in technology, including energy weapons like lasers and stochastic electronic warfare systems, radiated energy systems such as the Air and Missile Defense Radar, and advances in kinetic energy weapons including electromagnetic rail guns.

"We have determined that power is the foundation of the kill chain of the future, which means directed energy weapons and sensors are all dependent on power and energy," said Markle. "So, we are here to talk about where the Navy is headed in 30 years."

"Think of science fiction movies," he continued. "There are people in this



Navy Cmdr. Kevin Maher (retired), far left, presents certificates of appreciation to, from left to right, Navy Capt. Lynn Petersen (retired), Cmdr. John Stevens, and Cmdr. Stephen Markle (retired) for their participation in the November 2, 2018 Defense Energy Seminar. U.S. Navy photo by MC2 Patrick Dionne

room that are working on technologies like rail guns...We are bringing science fiction into reality today."

"Our job at ONR is to give our warfighters an unfair technical advantage," added Petersen. "If we give them an equal playing field with our adversaries, we as scientists and engineers have not done our jobs. We at ONR are here to try to address those gaps so we can mature the technology and hand it off to the next step."

Part of that technology development includes the evolution of systems designed to handle the electrical requirements these new systems require. The team discussed the Integrated Power and Energy System (IPES), for example, which is a medium-voltage, direct-current (MVDC) system that offers the potential to provide significant warfighting capability at an affordable cost.

Ultimately, the officials agreed. Ensuring the officers and scientists at NPS are well versed in these technologies helps ensure their integration into the fleet in the not-so-distant future.

"The operators on future naval platforms will have to think about power when they fight the ship in ways that they don't necessarily have to think

"There are people in this room that are working on technologies like rail guns...We are bringing science fiction into reality today."

— Cmdr. Stephen Markle (retired),
Director of the Electric Ships Office

about right now," said Stevens. "These young officers are the ones managing, building and operating our future fleet, and it's important for them to understand how to operate what new technology is being introduced, because they will be the ones living with it."



LEARN MORE

Please see the Calendar of Events in this issue for upcoming Defense Energy Seminar or visit nps.edu/web/eag/seminars for upcoming and archived seminars.



Calendar of Events

JAN

January 11, 2019
Defense Energy Seminar
Series: Modular
Microgrid Technology
1300-1430

January 14-17, 2019
Naval Innovation
Process Adoption:
Undersea Warfare
Sprint Workshop

January 25, 2019
Defense Energy Seminar
Series: Hydrogen Cell
Technology
1300-1430

FEB

February 1, 2019
Defense Energy Seminar
Series: The Growing
Conflicts in the Global
Energy Enterprise
1300-1430

February 8, 2019
Defense Energy
Seminar Series: The
Geo-Politics of Energy
Security: China, India,
& Indonesia
1300-1430

February 22, 2019
Defense Energy
Seminar Series:
Ludington Pumped
Storage: Michigan's
"Big Battery"
1300-1430

MAR

March 11, 2019
Defense Energy
Seminar Series:
Air Force Operational
Energy
1300-1430



Interested in Energy-Related Thesis Research?

Over the past five years, NPS and the EAG supported a plethora of student thesis research in the area of energy. A compilation of abstracts on student thesis and other research is available on the EAG website: www.nps.edu/energy. The EAG's extensive resources, intellectual capital, and connections with multi-disciplinary faculty and energy professionals provide students enhanced support for energy-related research. If interested in energy research, please reach out to the EAG team!



ENERGY ACADEMIC GROUP
NAVAL POSTGRADUATE SCHOOL



Connect with the Energy Academic Group

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

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Contribute to an issue of Surge

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