



# SURGE



ENERGY ACADEMIC GROUP QUARTERLY NEWSLETTER SUMMER 2019

## Highlights

- BATTERY ENERGY STORAGE SYSTEMS
- CLEAN AIR ENERGY RESEARCH
- AIR FORCE AGILE PROJECTS
- BOOST CONVERTER RESEARCH
- RESILIENCY CORNER



*The frequent cyber attacks on energy control systems that Ukraine experiences are not isolated to that nation. NPS is responding to these threats by building on its established strengths in the cyber domain as a leader in the education of cyber security professionals.*

## Energy Academic Group Working with NPS Cyber Security Faculty to Address Threats to Critical Energy Control Systems

Although we intuitively understand the importance of cyber security, the integral nexus between cyber and energy security is not always well understood. However, as we see a rise in hybrid and emerging security threats, the role of energy and energy

security cannot be overlooked. With an increasing dependency on automation and integrated, connected systems, technology, and the energy it requires, now touches almost all aspects of our lives. It is therefore of critical importance to ensure the technology we depend upon is secure, private, and reliable. Consider the operational impact of losing part or all of our energy grid for any significant length of time. Many of the basic services we rely on now would cease to function within days, and we would quickly lose the ability to communicate and coordinate.

In 2017, the Energy Academic Group (EAG) supported a NATO-led exercise in Ukraine to assess the country's response to cyber attacks on its critical energy infrastructure. Although the attacks in the exercise were simulated, these

kinds of attacks are very real, and the frequency and severity of these attacks on Ukraine's energy infrastructure is alarming. Many experts believe these attacks are being performed by certain state actors who are using Ukraine's infrastructure as a training playground to hone their skills for future attacks elsewhere. Moreover, Ukraine is not an isolated case. These kinds of attacks target operational control systems, yet there is a current lack of comprehensive education and training in this specific focus area to help nations shore up and defend their critical infrastructure from these types of attacks.

The Naval Postgraduate School is responding to these threats by building on its established strengths

**CONTINUED ON NEXT PAGE >**



# Principal's Thoughts

Dan Nussbaum, Principal, Energy Academic Group

There are changes on the way for the Defense Energy Seminar (DES) Series. Until now, and under the outstanding leadership of NPS' Kevin Maher (CDR, USN, Ret.), and with visionary support from RuthAnne Darling at the Office of the Secretary of Defense, the EAG has been presenting this seminar series, bringing in a mix of academic and business personnel to provide insights on aspects of the worldwide energy landscape.

Now we want to take the DES to a new level, bringing in even more senior people to talk about aspects of the energy ecosystem that are important both geopolitically and for future naval officers and national security leaders to understand. The newly structured DES will provide a forum for leading voices within the field to make presentations that open

the conversation on current issues in defense energy. Consistent with past practices, a major goal of the seminar series will be a live presentation in front of an audience of 30–60 people, composed of faculty and students from NPS as well as other local educational institutions such as Middlebury Institute of International Studies, Cal State Monterey Bay, and members of the local government. Additionally—and this is a new objective—we will generate TED Talk-like videos which will be widely available within the defense and government communities from our website at [nps.edu/web/eag/seminars](http://nps.edu/web/eag/seminars).

Our lineup for the fall includes a world-class author, a former U.S. ambassador to a major oil producing country, a senior scientist working on strategic energy projects at a major Silicon Valley firm, and a world-class

scholar on world energy trends. More information is available on our website.

I would be interested in your suggestions in at least two areas: 1) what speakers would you like to hear, and 2) how can we help bring these important topics closer to you, by, for example, hosting online seminars with people in your office? I look forward to hearing from you.



## CONTACT DAN NUSSBAUM

Email [danussba@nps.edu](mailto:danussba@nps.edu)  
or call 831-656-2387



## Defense Energy Seminar Series

NPS' academic programs in Defense Energy are supplemented by a seminar series which provides a forum for leading voices within the field, practitioners, and other Defense Energy influencers. Please see the Calendar of Events in this issue of *Surge* or visit [nps.edu/web/eag/seminars](http://nps.edu/web/eag/seminars) for upcoming and archived seminars.

### < CONTINUED FROM PREVIOUS PAGE

in the cyber domain as a leader in the education of cyber security professionals, and the EAG is now working with cyber security faculty from across the campus to develop a new, dedicated course focusing on the security of these critical control systems and the nexus between energy security and cyber security.

Development of the new course,

called the Cybersecurity of Operational Technology Systems, is being led at NPS by Bob Garza from the Information Sciences (IS) Department; together with J. D. Fulp from the Computer Sciences (CS) Department; and Chad Bollman, Carson McAbee, and Mike Thompson, all from the Electrical and Computer Engineering (ECE) Department. There is already strong demand for this course,

which will be offered from the spring of 2020 to partner nations and via the NATO School Partnership Program in Oberammergau, Germany.



## LEARN MORE

Email Alan Howard  
at [arhoward@nps.edu](mailto:arhoward@nps.edu)  
or call 831-656-3855

## OPERATIONAL ENERGY

# The Economics of Using Batteries to Reduce Installation Energy Costs

Battery Energy Storage System (BESS) at Fort Carson. Image: Lockheed / Cypress Creek.

Recent improvements in battery and power electronic technology have created a unique opportunity for energy managers to implement battery storage at their facilities as a way to save on utility bills. In utility bill structures with variable time-of-use rates, battery energy storage systems (BESS) can be applied to shift daily peak demand from times of the day when energy is more expensive to hours with a lower cost per kilowatt-hour (kwh). Other utility billing structures include a demand charge based on the highest power demand during any

tools are available for free online to help determine potential savings. ReOpt by National Renewable Energy Laboratory (<https://reopt.nrel.gov/tool>) and ESyst by Growing Energy Labs Inc. (<https://geli.net>) are two examples of such tools that use real utility rate structures and the user's actual energy data to determine the potential cost savings of implementing BESS, but energy managers should be cautious when using the results from these tools to inform investment decisions; these tools do not take into account the large costs associated

guaranteeing a minimum return on their investment.

Battery storage has the potential to deliver significant cost savings, and the business case for battery storage will only improve as batteries improve and become less expensive. In the near term, there are still challenges in finding reliable contractors and suppliers to provide and service battery systems, but this will become less of a problem as the market matures. Navigating DoD processes to get a BESS approved will remain a persistent challenge, but the



**Battery energy storage systems (BESS) can be applied to shift daily peak demand from times of the day when energy is more expensive to hours with a lower cost per kilowatt-hour (kwh).**

15-minute interval during the billing cycle, and a BESS can reduce these peak demands if they can be anticipated. Fort Carson is an excellent example of such a system where an 8500 kwh BESS has been employed to reduce peak demand from predictable air conditioning system loads, resulting in a guaranteed \$600,000 savings per year in demand charges and a 13-year payback period. The batteries in this system are expected to last for 26 years (80 cycles per year), making this a great long term investment.

The potential savings from a BESS are highly situational depending on energy demand characteristics and your local utility's billing structure, but a number of

with navigating the approval processes inherent to working within the DoD.

Because battery energy storage systems are an emerging technology, naval facilities managers may not feel confident in their ability to design, implement, and maintain a BESS. In these cases, energy managers may wish to use a contracting mechanism such as an Energy Savings Performance Contract (ESPC) to avoid the hassle of managing and maintaining battery systems themselves. The BESS at Fort Carson is an example of such a case where the base formed an ESPC with GELI and other contractors to delegate responsibilities for maintaining their BESS while also

payoff can be significant. In summary, battery energy storage for facilities can be a great long term investment, but energy managers must take care to ensure that a proposed BESS is appropriate for their facility's needs, that they have chosen to work with reliable contractors and suppliers, and that they are familiar with the procedural challenges that must be overcome to get a BESS approved.



### LEARN MORE

For more information regarding the business case for battery energy storage at naval facilities, contact Mr. Brandon Naylor at [bnaylor@nps.edu](mailto:bnaylor@nps.edu).

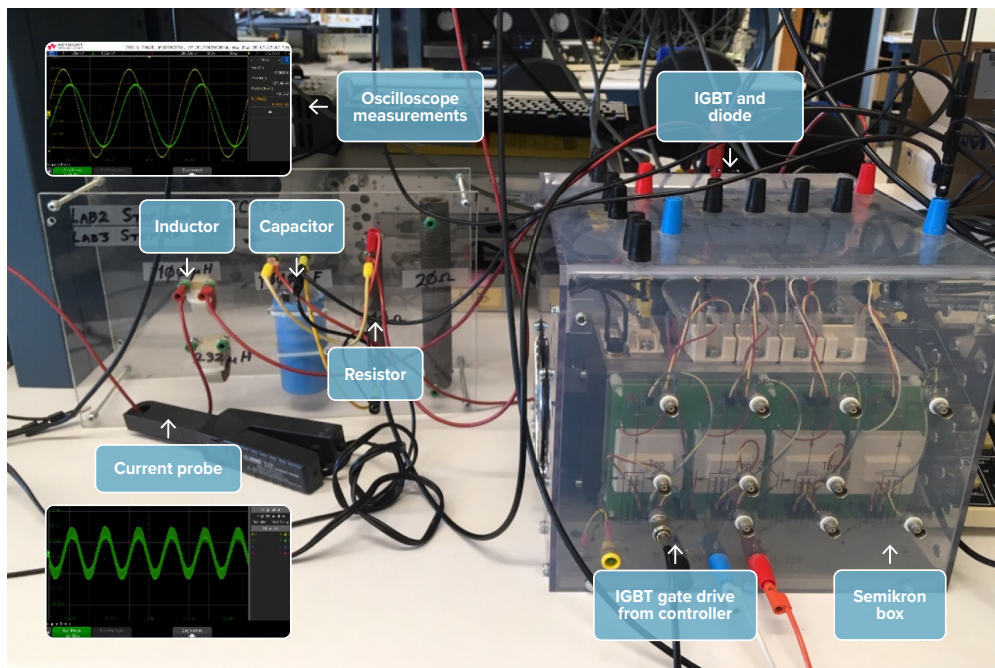


## STUDENT ENERGY RESEARCH SPOTLIGHT

# Modeling and Control of Boost Converter for Microgrid Energy Storage Interface

By LT Theodoros Karapas

Distributing the electric energy and controlling power converters play an important part in a modern Navy, since that way the autonomy of a ship is increased, the operational cost is reduced, and environmental pollution is reduced. One of those power converters is the DC-DC boost converter which converts the low voltage of a battery to the higher voltage required by the loads. The converter control is becoming more and more important as ships with integrated electric propulsion (like the U.S. Navy Makin Island and the UK Royal Navy Type 45 destroyer class) and



*Project research includes a computer simulation (using MATLAB and Simulink software) as well as a laboratory experiment to verify the boost converter small signal model.*

a fully electric ship (U.S. Navy DDG 1000 Zumwalt) are commissioned.

Our research examines five different control strategies to regulate the output of the DC-DC boost converter. Four of them are innovative control strategies, implemented by modifying regular K-factor and regular voltage mode control. The fifth control strategy is called current mode, which is widely used as the industrial standard. The performance of all controllers is

evaluated and compared. Our research includes a computer simulation (using MATLAB and Simulink software) as well as a laboratory experiment to verify the boost converter small signal model. The research provides alternative control strategies and allows more effective selection of a suitable control strategy for each application. This selectivity leads to increased energy efficiency, and reduced fuel consumption and pollution.



LT Theodoros Karapas

### About the author

LT Theodoros Karapas is a Greek naval officer and a student in the Electrical Engineering Department of the Naval Postgraduate School. Contact Dr. Giovanna Oriti at [goriti@nps.edu](mailto:goriti@nps.edu) for more information about this research.

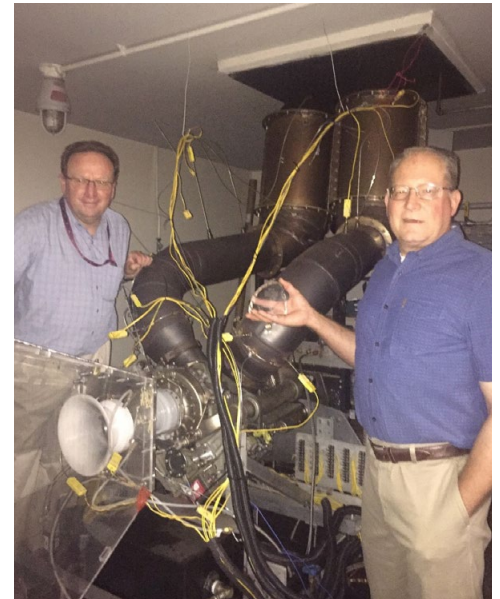
# Monterey Bay Air Resources District Recognizes Energy Research Efforts

By Douglas L Seivwright,  
Dept. of Mechanical and  
Aerospace Engineering

On May 16 of this year, at its annual awards banquet, the Monterey Bay Air Resources District honored the efforts of Dr. Garth V. Hobson and Douglas L. Seivwright with a Clean Air Leaders Award for their work in extracting heat energy from a gas turbine exhaust flow and repurposing it for useful work. Each year, the Monterey Bay Air Resources District recognizes those individuals, organizations, and companies in the Monterey community who demonstrate leadership by their actions in ensuring good air quality. The award received by Garth Hobson and Doug Seivwright was in the category of developing and/or implementing policy and practices

has mandated that 50% of the energy consumed by its shore installations and facilities come from renewable energy sources.

The project, Waste Heat Recovery from Gas Turbine Exhaust, demonstrates the ability of extracting heat energy from the exhaust stream of an engine (between 60–65% of the energy created by the engine is lost to the exhaust) and applying the recovered energy to other requirements. Efforts have been geared toward developing a system that utilizes Carbon Dioxide (CO<sub>2</sub>) as the working medium in a power cycle which will offer higher thermal efficiencies and power density in power



*Dr. Garth Hobson and Douglas Seivwright (holding Clean Air Leaders Award) in front of Waste Heat Recovery test rig*

**The award received by Garth Hobson and Doug Seivwright was in the category of developing and/or implementing policy and practices in the use of technology that efficiency contributes to decreasing outdoor air pollution.**

in the use of technology that efficiency contributes to decreasing outdoor air pollution.

The work stems from initiatives by the DoN to reduce its fossil fuel use by improving energy efficiency (i.e., reducing wasted energy) and shifting to renewable energy such as biomass, hydropower, geothermal, wind, and solar to meet operational and installation needs. One of the goals set by the DoN

generation than one normally finds in standard steam cycles that are seen, for example, at Moss Landing. This approach has the potential of operating close to 50% efficiency and could aid in reducing emissions as much as 34%. This will aid in fewer natural resources being necessary for generating the same amount of power while reducing greenhouse gas emissions.

This project was funded by multiple

sponsors, including the Office of Naval Research-sponsored Naval Enterprise Partnership Teaming with Universities for National Excellence (NEPTUNE) program which is managed by the Energy Academic Group at the Naval Postgraduate School.



## LEARN MORE

Email Garth Hobson  
[gvhobson@nps.edu](mailto:gvhobson@nps.edu) or Doug  
Seivwright [dlseivwr@nps.edu](mailto:dlseivwr@nps.edu)



## OPERATIONAL ENERGY

# The Air Force Is Becoming More Agile—One Project at a Time

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

The term ‘Agile’ has been on the lips of Department of Defense (DoD) senior leaders with increasing frequency recently—often citing its importance for developing functional, innovative software that better equips the warfighter to respond to uncertain and ever-changing environments.

### So, what is Agile?



The Agile methodology, known just as Agile, has been the cornerstone of commercial software development for decades. Various forms of Agile gained speed in the 1990s, culminating in 2001 with the “Agile Manifesto,” which sought to bring together those ideas in a more cohesive approach.

Simply put, it’s a method of developing software that is collaborative (often the developers are co-located with the customer to allow for direct and on-going communication) and adaptive (changing priorities are expected and encouraged throughout the project), with a focus on continuous delivery (getting functional software to the customer quickly for

immediate feedback).

“You plan it, you build it, you launch it, you get feedback. And you do this constantly,” explained Gen. Ellen M. Pawlikowski, former Commander of Air Force Material Command, in 2017.

While the private sector adopted Agile a long time ago, the DoD is just beginning to embed Agile methodology in acquisitions programs and other projects.

### Why is the Air Force embracing it?



With a history of lengthy acquisition processes, as well as significant documentation requirements and review practices, the Air Force—and the DoD as a whole—has not been very agile in software development. However, in an effort to increase capabilities at the “speed of relevance,” the Air Force is following the lead of organizations like Defense Innovation Unit (DIU) to implement a more modern, less bureaucratic, approach to development that brings capabilities to the warfighter faster, and cheaper.

Previously, the DoD used a ‘waterfall approach’ to software development—which traditionally flows one direction (like a waterfall), from determining

the requirements of the software to designing and implementing them. This approach has been shown to be less flexible, slow, and costly because once the requirements are set, it is difficult to go back and change aspects that may not work for the customer.

Agile is not perfect—but it does allow for more flexibility and the ability to update the software as it is being developed, rather than after it has already crossed the finish line.

### What is the Air Force doing to become more Agile?

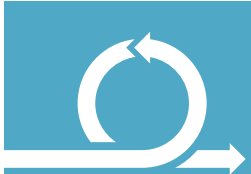


A couple of prime examples of Agile software development in action are in the world of aerial refueling and tanker allocation.

#### Jigsaw

[Tanker Planning Software for Aerial Refueling](#)

In 2016, DIU partnered with the Air Force and software development company Pivotal, Inc. to develop Jigsaw, a tool that digitized and streamlined aerial refueling planning for air operations centers (AOCs). They sent Airmen to Pivotal Labs in San Francisco to not only help build the software, but to learn Pivotal’s Agile



**“You plan it, you build it, you launch it, you get feedback.  
And you do this constantly.”**

**– Gen. Ellen M. Pawlikowski, former Commander of Air Force Material Command**

process so they could bring their skills back to their units.

The Air Force Operational Energy team (SAF/IEN) was impressed with the tool's results—significant fuel savings, decreased planning time, and more efficient tasking of tanker assets—and decided to fund the next phase of development, which will enable Jigsaw to match tankers to receivers automatically, using advanced data science optimization techniques.

## Magellan

### Tanker Allocation and Planning Software

After the success of Jigsaw, Air Mobility Command received funding from Air Force Operational Energy to initiate their own software development project, Magellan, with support from Pivotal. The goal of Magellan is to optimize how the Air Force allocates mobility aircraft for missions over extended time periods,

which will give operational planners more visibility for long-term planning. This will enable planners to de-conflict recurring missions and high-demand periods, and eventually to optimize the pairing of tanker aircraft with receivers. It will also increase planning flexibility, enabling planners to more easily and quickly adjust plans when priorities change.

On April 8, 2019, Pivotal launched the project, hosting a kick-off meeting in their Chicago office, alongside Airmen who will work side by side with software developers, designers, and product managers to develop the tool. The first phase involves discovering problem areas with the current technology and targeting specific pain points, then framing and working toward solutions. Like the Jigsaw project, the Airmen will not only create the software, but will return to their units to apply the Agile development process to new projects.

## What's next?

Jigsaw and Magellan are only a small selection of the many Agile projects in development at Kessel Run and across the Air Force, but they are prime examples of how to do it—and the potential benefits to be gained. At Kessel Run alone, more than 20 applications (mission capabilities) have been created in collaboration with Airmen and Pivotal team members. As an increasing number of success stories emerge from the Department of Defense, more and more senior leaders will want their initiatives to start and end with Agile.

### LEARN MORE

For more information on energy optimization efforts in the Air Force, visit: [safie.hq.af.mil/OpEnergy](http://safie.hq.af.mil/OpEnergy)



## RESILIENCE CORNER

# Don't Design for Threats, Design for Surprise.

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? In the previous *Resilience Corner*, we discussed how resilience should be differentiated from established notions of risk as the two concepts are fundamentally different. Resilience is more like a verb than a noun, and resilient military systems should be designed to handle any possible problem instead of only pre-defined

threat scenarios. But how do we start approaching this problem of resilient design when we cannot define specific threats?

In a recent article published in the journal *Risk Analysis*, we answered this question by relying on military theories of surprise. Surprise has always played an important role in military activities by influencing intelligence and operational decisions to generate a surprise attack and overtake an adversary or to avoid being surprised and overtaken. Historical examples of surprise attack on allied forces teach us the kinds of situations we should focus on for resilient design. Reflecting on the Yom Kippur War of 1973, when a combined Syrian and Egyptian attack took Israel by surprise and nearly overwhelmed Israeli forces, Zvi Lanir defined at least two kinds of surprise we should be resilient to (Lanir 1986): situational and fundamental surprise.

To help make sense of surprise for design, we distinguish surprise from normal events with an example from the lottery. Normal events are when you buy a lottery ticket and lose. Situational

surprises are rare events like buying a lottery ticket and winning. Fundamental surprises are the unimaginable events like when you do not buy a lottery ticket, and you still win.

Resilience asks us to design our military systems to handle all these events, especially the fundamental surprises that lie outside our current understanding. This means resilient design starts with a different question than normal design processes. Rather than asking the question, “what threats do we care about?” before approaching starting to design resilient systems, we should ask, “what plans, processes, and capabilities do we have in place to respond to situational and fundamental surprises?” Importantly, there should be a greater emphasis on learning from historical examples of military surprise prior to making any design decisions to improve resilience.

### LEARN MORE

Email Dan Eisenberg at [daniel.eisenberg@nps.edu](mailto:daniel.eisenberg@nps.edu) or call (831) 656-2358.





# Calendar of Events

## JUL

July 9, 2019

### Defense Energy Seminar Series

Dr. Chuck Louisell, Strategic Programs Manager from Cisco Systems will speak about networking technology and the emerging risks in this critical area.

July 23, 2019

### Defense Energy Seminar Series

Peter Zeihan, the critically acclaimed author of *The Accidental Superpower* and *The Absent Superpower* will speak about what's happening next in geopolitics and energy.

July 30, 2019

### Defense Energy Seminar Series

Mr. Hayes Magnuson from Amazon Web Services will speak about critical energy infrastructure protection (CEIP) and energy management in the commercial realm.

## AUG

Aug 6, 2019

### Defense Energy Seminar Series

Ambassador Robert F. Cekuta served as the U.S. Ambassador to Azerbaijan from 2014–2018, and will speak about the connections between the military and energy.

Aug 13, 2019

### Defense Energy Seminar Series

Dr. Wolfgang Peters, a leading expert on gas markets, will speak about the future of natural gas and the controversy surrounding Nordstream 2.

## SEP

September 3, 2019

### Defense Energy Seminar Series

Speaker TBD



## 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 theses and other research is available on the EAG website: [nps.edu/energy](https://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:

- Alan Howard**  
arhoward@nps.edu | 831-656-3855
- Lawrence M. Walzer**  
lmwalzer1@nps.edu | 831-656-3777
- Brandon Naylor**  
blnaylor@nps.edu | 831-656-1986
- Kevin Maher**  
kjmaher@nps.edu | 831-656-2691



## 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](mailto:lkhazard@nps.edu).

*Surge* is published quarterly by the Energy Academic Group at the Naval Postgraduate School.  
Lois Hazard, Editor-In-Chief | Frank Chezem, Art Direction and Graphic Design