SURGE
ENERGY ACADEMIC GROUP QUARTERLY NEWSLETTER SUMMER 2022

Highlights

Baltic Defence College in Tartu, Estonia

EAG Faculty Present at the Baltic Defense College's Operational Level Energy Security Course

By Larry Walzer, Faculty Associate-Research, Energy Academic Group

From 14 – 18 March 2022, the Naval Postgraduate School's Energy Academic Group (EAG) partnered with the NATO Energy Security Center of Excellence to support the execution of the Baltic Defense College's Operational Level Energy Security Course in Tartu, Estonia. The Baltic Defense College is an English-speaking international institution of Estonia, Latvia, and Lithuania that provides professional military education at the operational and strategic level for military and civilian leaders of the Baltic states, their allies and partners. This was the fourth iteration of the annual course that the EAG has supported.

Due to COVID-19, this was the first time since 2019 that the course has been conducted as a resident program. The return to the classroom coincided with the return to a much more effective program, enabled by the face-to-face interaction of the participants from eight countries gathered to discuss shared challenges and highlight best practices during course exercise breakout sessions.

The aim of the course was to provide participants with knowledge of the importance of energy and energy security in the current geopolitical situation and its influence on military operations. Course objectives included: interpret NATO's energy security pillars (energy security awareness, critical energy infrastructure protection, and energy efficiency in military operations); analyze the links between energy and crisis (conflict/hybrid) as well as energy and geopolitics; and analyze energy

development and vulnerabilities as part of the new challenges to security and the crosscutting nature of emerging threats in the Baltic Sea region. This year there was much discussion surrounding Russia's invasion of Ukraine and the nexus of energy and the conflict. The EAG deputy, Dr. Daniel Nussbaum, and EAG faculty members Dr. Arnie Dupuy and Mr. Lawrence Walzer provided lectures on maritime security, energy in conflict, critical energy infrastructure protection, the terrorist threat to energy infrastructure, and the importance of operational energy and energy security. Mr. Walzer further developed and presented red and blue cell training exercises for participants to conduct during breakout groups, which were monitored by present faculty. Participants included uniformed and government civilian officials from Canada, Estonia, Germany, Latvia, Lithuania, Poland, and the United States. For those interested, the course will again be hosted by the Baltic Defense College next year from 20-24 March 2023. The POC is retired USMC Capt. Bill Combes at william.combes@baltdefcol.org.

LEARN MORE

Email Mr. Larry Walzer at lmwalzer1@nps.edu

ENERGY TEAM UPDATE

EAG Welcomes Two New Team Members

LtCol Charles Lynn, USMC, Ret.

Retired USMC LtCol Charles Lynn joined the EAG in May of 2022 as a Faculty Associate – Research. Charles brings 25 years of experience as a Marine infantry officer who has planned and conducted operations in peacetime and combat, from the platoon to the Service component level. In addition to his operational experience, he has served as a professor and an administrator at several echelons of Marine Corps PME and within civilian academia.

As a member of the EAG team, Charles will focus on energy education, training, and outreach within the Naval Service PME institutions and with our International partners.

Peter Zeihan is an expert in geopolitics: the study of how place impacts financial, economic, cultural, political and military developments. He presents customized executive briefings to a wide array of audiences which include, but are not limited to, financial professionals, Fortune 500 firms, energy investors, and a mix of industrial, power, agricultural and consulting associations and corporations. Mr. Zeihan has been featured in, and cited by, numerous newspapers and broadcasts including *The Wall Street Journal, Forbes, AP, Bloomberg, CNN, ABC, The New York Times, Fox News* and *MarketWatch.*

As a member of the EAG team, Peter will focus on the geopolitics of energy and its impact on naval operations.

Peter Zeihan

ENERGY OUTREACH

EAG and NATO continue to support the Energy Efficiency in Military Operations Course (EEMOC) in Vilnius, Lithuania

By Andrew Jennings, Faculty Associate–Research, Energy Academic Group

Thirty-five selected officers, NCOs, and civilians working in the energy sector attended the EEMOC held in Vilnius, Lithuania, in May 2022.

The Naval Postgraduate School's Energy Academic Group (EAG) came together with the NATO Energy Security Center of Excellence in May of 2022 to conduct NATO's annual Energy Efficiency in Military Operations Course (EEMOC).

This year's course was once again conducted in Vilnius, Lithuania, and was attended by 35 selected officers, NCOs, and civilians working in the energy sector. Nine different nations were represented in the May 2022 EEMOC.

The EEMOC serves to raise awareness and knowledge regarding the importance of seeking energy efficient solutions in the military domain, particularly during military operations. The course introduced students to topics such as climate change, battery storage, innovative and renewable technologies, hybrid power generation, energy management planning, case studies, behavior change, and more. Participants also had the opportunity to visit local camps in the region and were challenged by the SPARK simulator to create an energy efficient camp. There was also the opportunity to develop participants' understanding of energy efficiency via a wargame that focuses on generator use, renewable technologies, and alternative energy solutions related to expeditionary base camp power. Participants shared that this wargaming group work and the syndicate work developing an energy management plan were highlights of the course. The course featured multinational instructor staff, including subject matter experts from ENSEC COE, EAG, NATO Headquarters, SHAPE, EMA DEO, US Army CEERD CERL, Natural Resources Canada, and the Fraunhofer Institute of Chemical Technology as well as some industry specialists.

The EEMOC serves to raise awareness and knowledge regarding the importance of seeking energy efficient solutions in the military domain, particularly during military operations.

The EEMOC is slated to continue providing instruction to select participants annually and is constantly evolving in content, style, and delivery, adapting to feedback from former participants. It strives to match the rapid emergence of new technologies and their integration into military operations. The next course is set to return to Vilnius May 21–25, 2023.

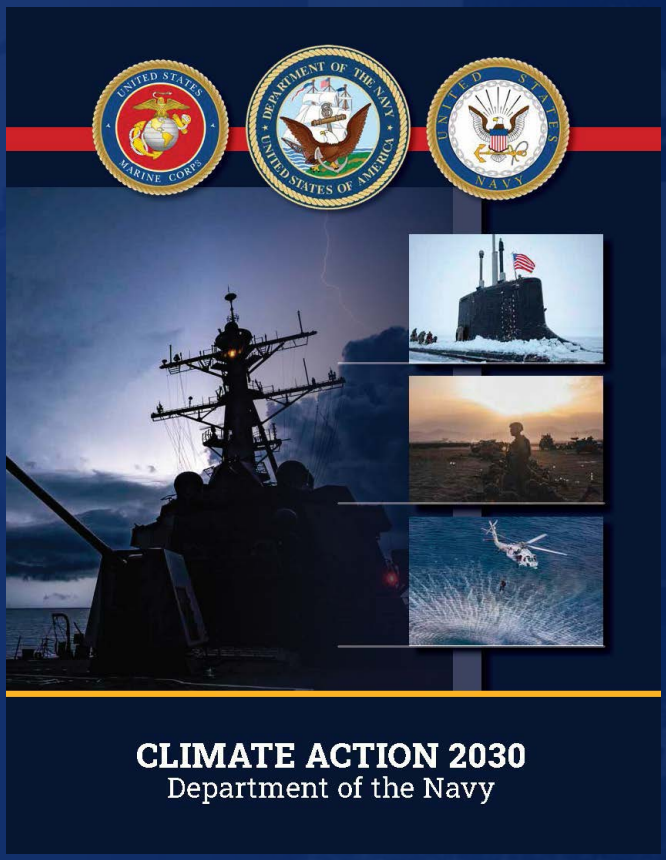
LEARN MORE

To learn more email Larry Walzer at lmwalzer1@nps.edu

CLIMATE STRATEGY

Department of the Navy Releases Climate Strategy

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



On 24 May, the Department of the Navy released Climate Action 2030, the strategy that sets goals to address emissions, infrastructure adaptation, and impacts of climate change on operations. Recognizing climate change as one of the most destabilizing forces today, the strategy recognizes that it exacerbates other national security concerns and poses serious readiness challenges.

To build a climate-ready force, the DON has set two Performance Goals: (1) Build Climate Resilience, including effective and efficient operations in the face of a changing climate and (2) Reduce Climate Threat, including reduction of greenhouse gas emissions and achieving the nation's commitment to net-zero emissions by 2050.

The plan specifically states that the Navy will transition to zero-emission vehicles by 2035 and cut its emissions by 65% over the next three decades. The Navy also will reduce emissions from buildings by 50% by 2032 and divert at least half of its waste from landfills by using other methods like composting food.

To meet these goals, the strategy is developed around DoD's five lines of effort on climate change including:

- LOE 1: Climate-Informed Decision-Making
- LOE 2: Train and Equip for Climate Resilience
- LOE 3: Resilient Built and Natural Infrastructure
- LOE 4: Supply Chain Resilience and Innovation
- LOE 5: Enhanced Mitigation and Adaptation through Collaboration

The release of the Strategy kicks off a period of implementation planning. Each of the LOEs will have 90 days to develop an implementation plan for their LOE for their key initiatives. It is anticipated that the implementation planning period will run through early September.

LEARN MORE

The Climate Strategy is available at **https://www.navy.mil/**

Related resources are available through the NPS Climate & Security Network at **https://nps.edu/web/climate-and-security/resources**

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

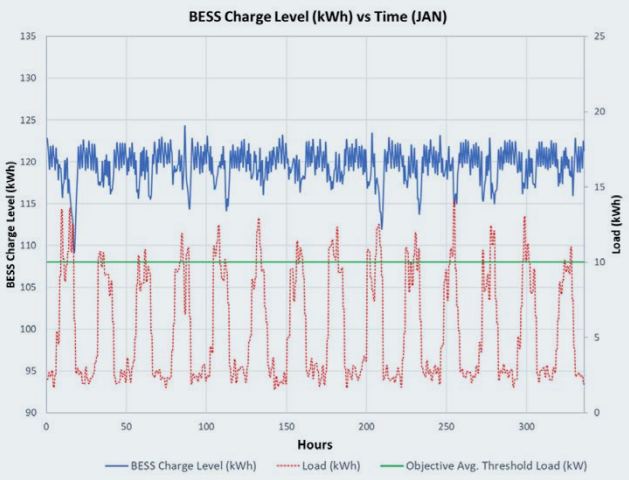
ENERGY RESEARCH

Mobile Microgrid Concept to Improve Installation Energy Resilience

By MAJ Daniel Varley, USA

An article on hybrid mobile microgrids for military applications written by MAJ Daniel Varley was recently published in *The Systems Journal*. The research examined the potential for mobile hybrid microgrids, constrained within an International Standards Organization (ISO) Triple Container (TriCon) and not to exceed 10,000 lbs., to provide power in a fuel constrained environment for DoD small critical loads (average loads of 10 kW).

The research proposed a system architectural design that attempted to find a suitable balance in energy density between a photovoltaic (PV) array, diesel generator, and battery energy storage system (BESS), using commercial off the shelf products, that could meet a 14-days-of-autonmy requirement for installation backup power systems. The design provides low voltage power from the BESS to allow for immediate hookup and follow-on setup of the PV array and generator as well as mitigate the handling of transients. The research assumed that building static, customized microgrids at individual critical loads was not warranted if an installation microgrid already exists; however, a mobile backup power solution might be warranted to provide the confidence and increased energy resilience needed in the event of installation microgrid failures. The research showed that the proposed design was able to fall within the size and weight constraints and handle the average 10 kW load for 12 hours a day with zero load shed over a 14-day period with low average solar irradiance (average of 2.8 hours @ 1-sun/day). This is accomplished while reducing reliance on the diesel generator by nearly 40%.



This figure shows a snapshot of a single run of the system for the 14-day period of analysis using January GHI input data. The green line represents the design objective threshold load. As seen, the load often exceeds this during peak work hours due to the stochastic nature of the model. The BESS is able to handle the load and the PV and EDG are able to recharge sufficiently to avoid load shed (BESS reaches zero).

ABOUT MAJ VARLEY

MAJ Varley was commissioned in 2006 from the United States Military Academy, West Point, with a Bachelor of Science in Mechanical Engineering. He served the first eight years of his career as an Armor Officer before transitioning to the Army Acquisition Corps in 2014. Dan earned his Master of Science in Systems Engineering from the Naval Postgraduate School in June 2022. His next assignment will be to the Army's Armaments Center, Combat Capabilities Development Command, Picatinny, NJ.

LEARN MORE

Email Dr. Van Bossuyt at **douglas.vanbossuyt@nps.edu**

Read the full article at **https://www.mdpi.com/2079-8954/10/3/74/htm**

The Midshipmen at the United States Naval Academy Design Microgrids for Energy Resilience

By Bill Anderson, PhD, Director, Utilities Engineering & Management, NAVFAC EXWC SH13
and Karen Flack, PhD, Department of Mechanical Engineering, United States Naval Academy

Dr. William Anderson, MIDN Matthew Martin, MIDN Ben Diny, MIDN Ross Massey, MIDN Jack Dabek, and Professor Karen Flack.

Engineering teams recently presented at the United States Naval Academy (USNA) Capstone Day designs for microgrids at two Navy installations. The overall goal of the projects was to increase energy resilience while decreasing carbon emissions. The teams, mentored by USNA Professors Karen Flack (Mechanical Engineering) and Dan Opila (Electrical Engineering) researched, tested, and deliberated with their customers regarding different power generation, energy storage, and control solutions. Dr. William Anderson and his team at Naval Facilities Engineering Systems Command (NAVFAC) Engineering & Expeditionary Warfare Center (EXWC) provided additional mentoring and expertise.

Midshipmen 1st Class Jack Dabek, Ben Diny, Matthew Martin and Midshipman 2nd Class Ross Massey, worked with Mr. Kostas Kavasis, the installation energy manager, to understand the electrical power needs of Naval Support Activity Souda Bay in Crete, Greece.

Ultimately, it was determined that the base should increase solar, decrease diesel generation, and install battery capacity. This would meet the primary objective of increased resilience by ensuring the base has power to sustain critical operations during a grid blackout.

Figure 1 shows the logic programmed into the system so that power generation would flex to meet load demands.

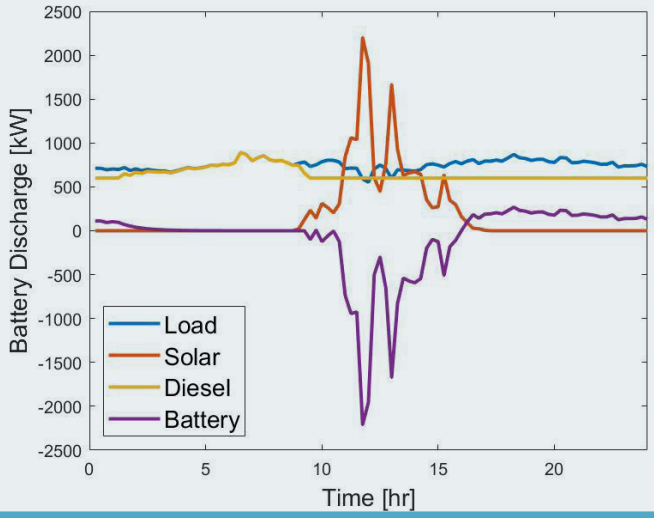


Figure 1: Sample day showing controller logic

Midshipmen pictured with solar panels installation.

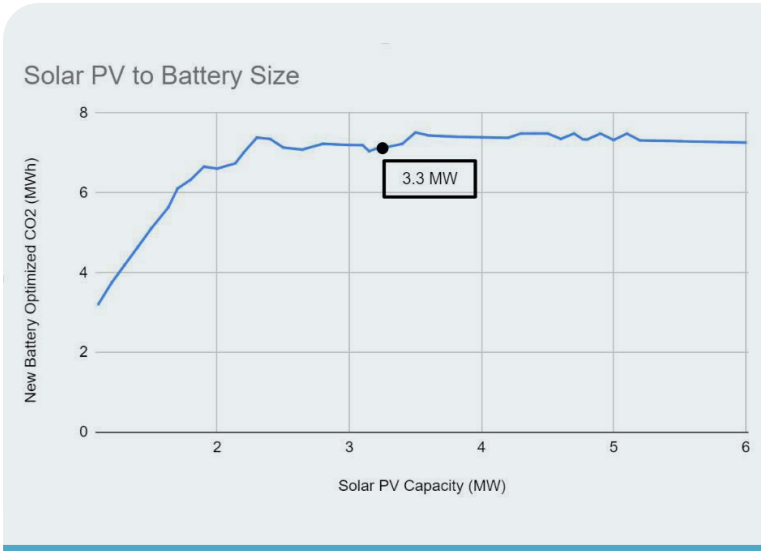


Figure 2: Battery capacity vs. PV capacity

Figure 2 shows the results of optimization to minimize CO2 emissions indicating a 3.3 MW solar PV combined with a 7.5 MWh battery to minimize emissions.

A second student team consisting of Midshipmen 1st Class Lindsey Asbury, Brendan Farmer, Mason Hart, and Lincoln McKenzie worked with Mr. Jonathan Saldarriaga, the Facilities Electrical Engineer at Atlantic Undersea Test and Evaluation Center (AUTEC) on Andros Island in the Bahamas.

Currently, AUTEC relies exclusively on diesel generators and needs improvements to both resilience and redundant sources of power. The final design solution uses the existing diesel generators, along with new solar panels, a wind turbine, and lithium-ion batteries to provide power and storage.

Figure 3 shows the power supplied by each source at Site 1 with diesel, solar, wind, and battery power for one day. This shows that with a diesel base load of 60kW, there is very little additional diesel added to meet the load.

Figure 4 shows the total power supplied and the load demand for one day at Site 1. This shows that using diesel power, solar panels, a wind turbine, and batteries provides sufficient power and sometimes exceeds the demand of the site. When the power supplied exceeds the demand, the batteries are charging.

Both designs for AUTEC and Souda Bay increased the percentage of the load covered by renewable energy, decreased the annual cost of diesel fuel, and significantly cut carbon emissions.

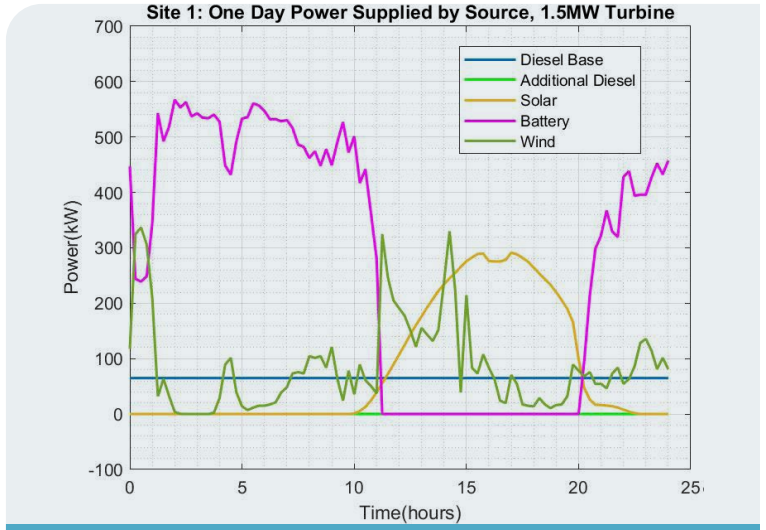


Figure 3: Power supplied by source at Site 1 with wind

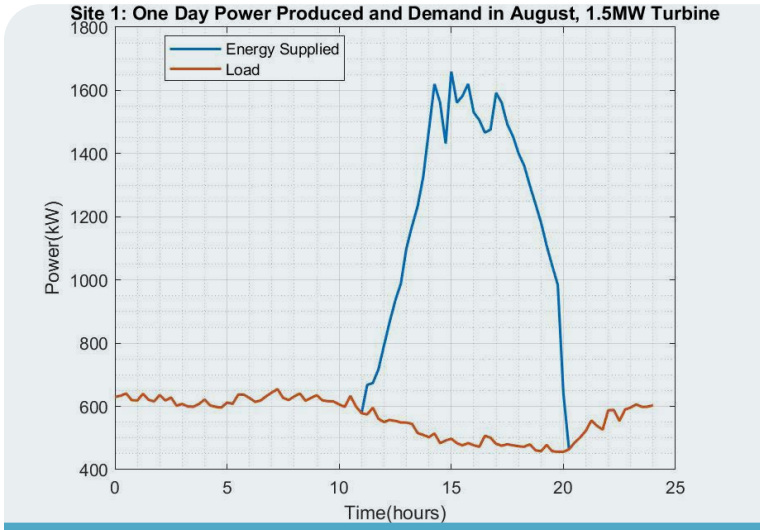
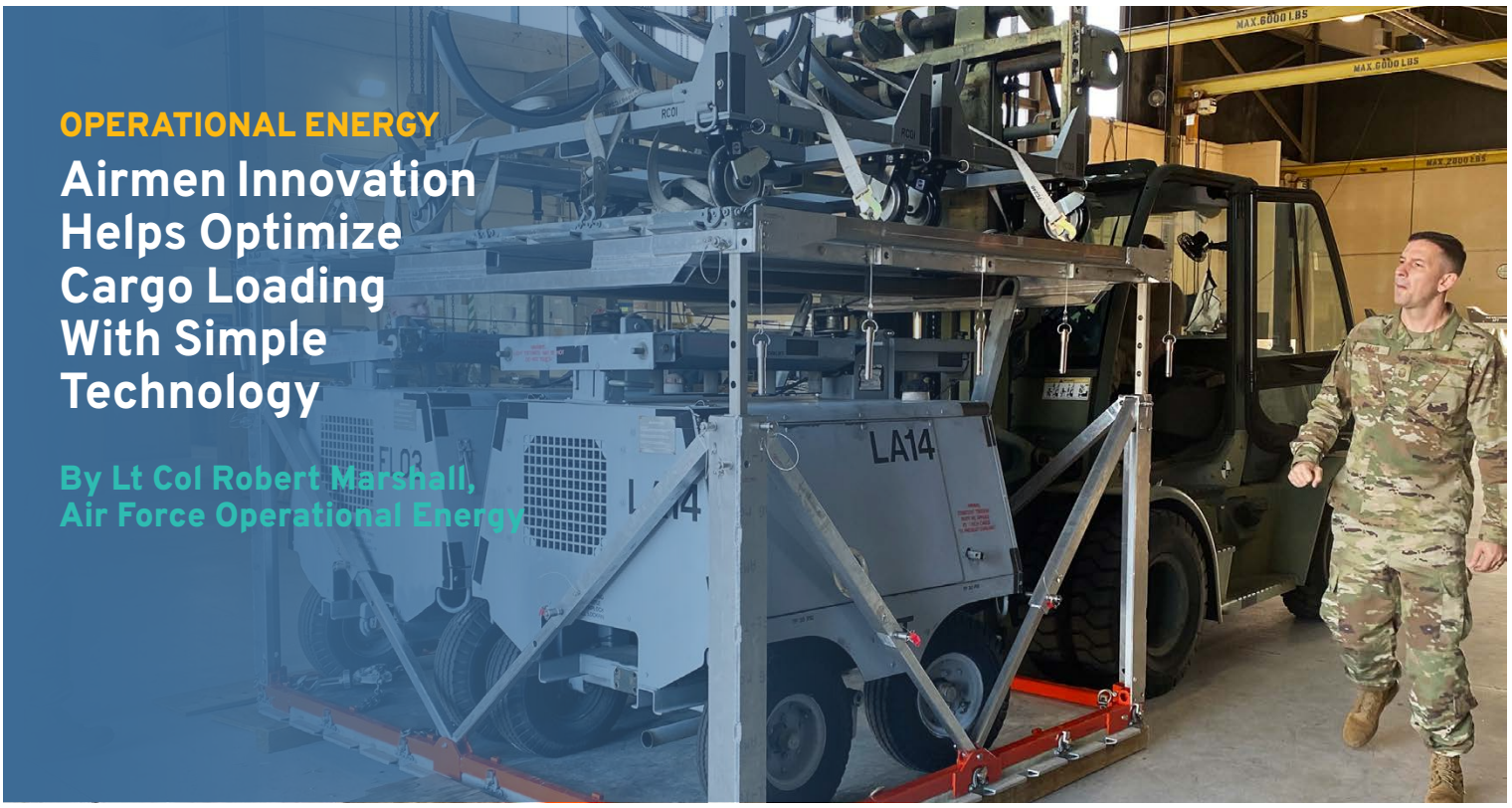


Figure 4: Total power supplied and load at Site 1 with no wind

LEARN MORE

For more information, email Dr. Bill Anderson at william.w.anderson6.civ@us.navy.mil



OPERATIONAL ENERGY

Airmen Innovation Helps Optimize Cargo Loading With Simple Technology

By Lt Col Robert Marshall, Air Force Operational Energy

Members of the 147th Attack Wing test a vertical pallet stacking system at Ellington Field JRB, Houston, Texas January 5, 2022. The Wing is partnering with Air Force Research Laboratories, USTRANSOM and the University of Dayton to test the innovative technology that allows for cargo pallets to be stacked on top of each other, enabling cargo aircraft to carry more. (Air National Guard Photo by Sean Cowher)

Content originally published May 2022, provided by the U.S. Air Force Air Combat Command, and reprinted with permission.

In partnership with Air Mobility Command, Air Force Research Laboratory, and Air Force Operational Energy, Airmen are conducting operational testing on prototypes of the Vertical Pallet Stacker for multiple mobility aircraft to enable more optimized and effective cargo-loading and transport per pound of fuel used.

Originally developed by the now-defunct Air Expeditionary Force Battlelab at Mountain Home Air Force Base, Idaho, and currently managed by the Air Force Research Laboratory, the Vertical Pallet Stacker (VPS) (previously known as the Bi-Level Airlift Loading System) significantly increases the amount of cargo a mobility aircraft can move at one time.

Designed and certified for C-17 Globemaster III, C-5 Galaxy, and C-130 Hercules use, the VPS is an aluminum frame that provides a second level of storage on top of a standard cargo pallet, enabling up to 3,000 pounds of cargo per pallet space to be placed on the top pallet.

This allows Airmen to take advantage of the often underutilized vertical space in an aircraft's cargo bay, increasing cargo capacity and decreasing required transport sorties.

Ed Clark, Aviation Program Lead for the Future Force Energy and Power division at the Air Force Research Laboratory, is one of the key contributors to bringing the VPS from concept to operational capacity and is overseeing its production and distribution to multiple Air Force mobility units.

"The meetings we've held regarding the VPS have the most interest and attendance I've seen in ten years. It just makes sense," said Clark.

The idea for stackable pallets has been considered as far back as the 1970s; however, it was not fully developed until the AEF Battlelab took on the challenge in 2003. With the help of Al Vatcher, an engineer with the 812th Aircraft Instrumentation Test Squadron at Edwards Air Force Base, California, they built the first prototype, but it never flew or gained traction in operational units.

Eventually the idea lost steam and was shelved until roughly a decade later when the VPS concept was revived by

The idea for stackable pallets has been considered as far back as the 1970s; however, it was not fully developed until the AEF Battlelab took on the challenge in 2003.

retired Col. Adam Reiman, who at the time was a doctoral student in logistics at the Air Force Institute of Technology. Subsequently, Brad Anderson, then an Assistant Professor of Logistics Management at the Air Force Research Laboratory, helped get it the attention it deserves by submitting it to an Air Force Operational Energy AFWERX Challenge.

There are only a handful of VPS units in existence today, but that will change as the Texas Air National Guard's 149th Fighter Wing out of Joint Base San Antonio starts a small production line.

Their goal is to create 20 units each year for the next two years, costing approximately $27,000 each. According to Clark, any squadron can build their own VPS or have a local certified welding shop make one from the available plans.

One logistics unit out of Joint Base Anacostia-Bolling estimated that on specific missions the VPS can save over $16,000 per sortie and decrease their pallet position requirements by 50%. In an Air Force Institute of Technology research paper, Capt. Nathan Carlson of the 28th Logistics Readiness Squadron at Ellsworth Air Force Base, South Dakota, estimates "up to $1.6 billion in savings if the VPS was maximized throughout our logistics network," which includes semi-trucks.

Those cost savings also mean less fuel burned per pound of cargo moved and more agile and rapid deployment of combat material or humanitarian aid at a moment's notice. All thanks to the ingenuity and tenacity of our Air Force team.

LEARN MORE

Email Corrie W. Poland, Strategic Communications Lead, Air Force Operational Energy (SAF/IEN) at corrie.poland.ctr@us.af.mil

Interested in Energy-related Thesis Research?

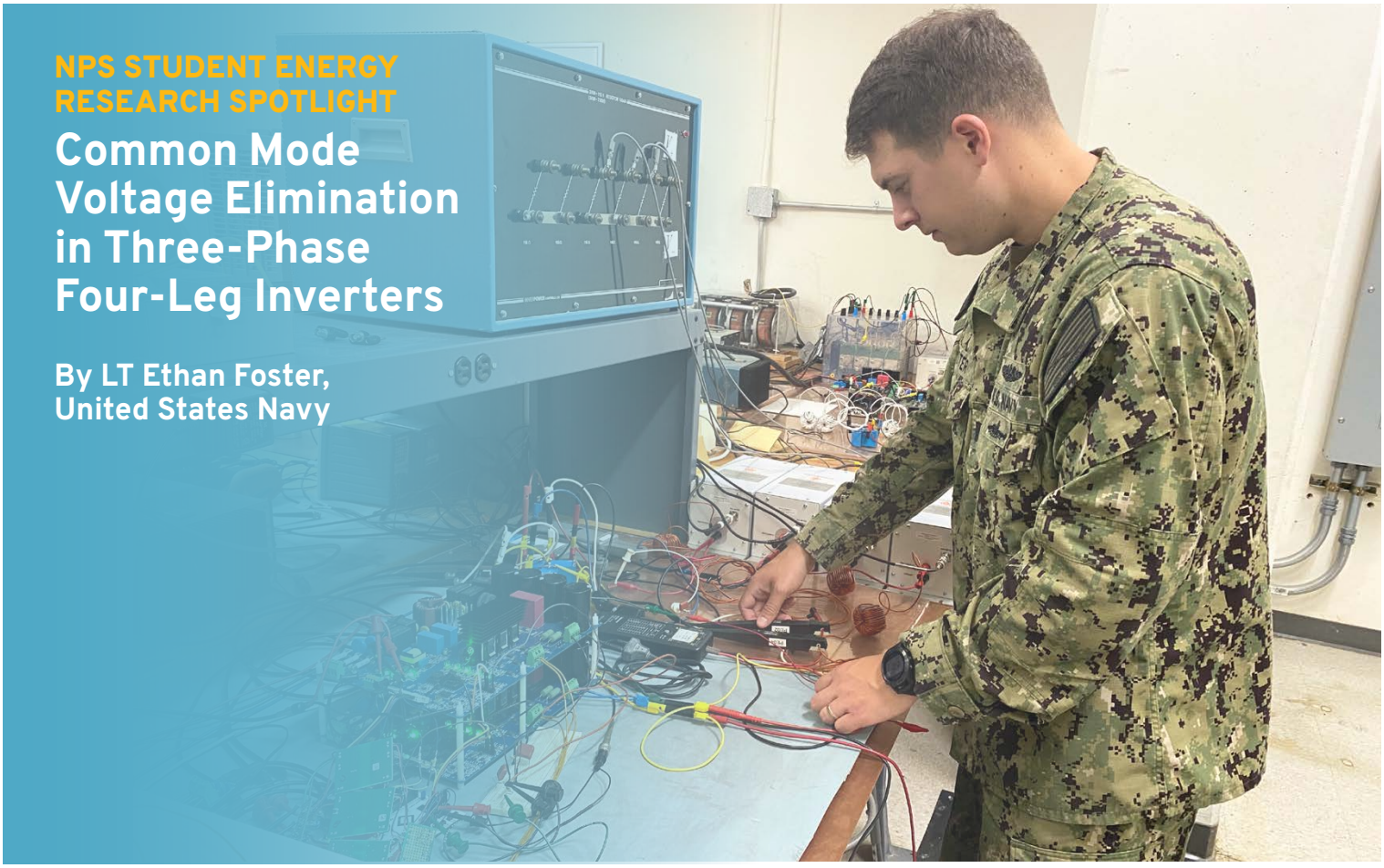
Since 2013, NPS and the EAG supported a plethora of student thesis research in the area of energy. Publicly viewable student theses can be searched from the Resources page of the EAG website at **nps.edu/web/eag/resources**. The EAG's extensive resources, intellectual capital, and connections with multi-disciplinary faculty and energy professionals provide students enhanced support for energy-related research. If interested in energy research, please reach out to the EAG team!

nps.edu/energy

NPS STUDENT ENERGY RESEARCH SPOTLIGHT

Common Mode Voltage Elimination in Three-Phase Four-Leg Inverters

By LT Ethan Foster, United States Navy



LT Ethan Foster, USN

This thesis advances state-of-the-art power converter technology in the area of interface distributed energy resources, such as battery energy storage systems and photovoltaic panels. Grid-connected inverters are a key enabling technology which increase the use of renewable energy resources. However, they produce conducted electromagnetic interference (EMI) which produce circulating ground currents that can damage nearby electronic systems.

Typically, EMI reduction is achieved through passive measures, such as common mode (CM) chokes and passive filters. This thesis research explores removing the need for these passive devices in three-phase, four-leg grid-following inverters by eliminating CM EMI using pulse density modulation (PDM) in conjunction with model predictive control (MPC) and delta modulation.

A physics-based model of the equipment under test (EUT), utilizing state-space modeling, was analyzed using computer simulations, and a laboratory prototype was designed to validate the model, utilizing Silicon-Carbide switching devices. The physics-based model of the proposed control system was converted to Verilog, a hardware description language (HDL), utilizing MATLAB HDL coder. This was done to control the laboratory prototype via a field-programmable gate array (FPGA). Simulated and experimental results demonstrate both the unbalanced load requirements in MIL-STD-1399, and the conducted emission limits in MIL-STD-461G are met with the proposed controller, all while the grid-following converter supplies a desired current to the load.

This technology is applicable in shipboard power systems, where the continuous increase in energy demand requires increased energy density and efficiency, while meeting current military standards.

ABOUT THE AUTHOR

LT Ethan Foster is a U.S. Navy officer and is a MSEE candidate at NPS. For more information about this research contact Prof. Giovanna Oriti at goriti@nps.edu

ENERGY RESEARCH

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 t heses available on Calhoun: **https://calhoun.nps.edu/**

ENERGY EDUCATION

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. These professionals give presentations, engage in brown bag discussions, and facilitate informal gatherings that encourage Defense Energy faculty and students to discourse over current issues in Defense Energy, supplementing classroom teaching with practical, professional experiences. The Defense Energy Seminars Series is a permanent part of NPS' Defense Energy program, and a key to its real-world relevance.

LEARN MORE
Please visit **nps.edu/web/eag/seminars** for upcoming and archived seminars.

Calendar of Events

SEPTEMBER

September 19–23, 2022
Nordic Pine 2022 TTX
TBD

September 19–23, 2022
Regional Energy Security Symposium
Baku, Azerbaijan

OCTOBER

October 24–28, 2022
CORE 22 CEPS TTX
Versailles, France

NOVEMBER

November 28–December 2, 2022
Energy Security Awareness Course
Ankara, Turkey

DECEMBER

December 12–16, 2022
Energy Security Course
Oberammergau, Germany

UPCOMING

Q1 FY23
The Nordic Region Wargaming for Hybrid Threats and Resilience
TBD

February 13–24, 2023
Energy Security & Critical Energy Infrastructure Protection (MASL # P179929)
Monterey, CA

Upcoming 2022 Defense Energy Seminar Series

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

ENERGY ACADEMIC GROUP
NAVAL POSTGRADUATE SCHOOL

Connect with the Energy Academic Group

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

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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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