"Leading the Way in Delivering Air Force Installation Energy Assurance"

ENERGY express

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By Melissa Tiedemam
SAF/IEE Public Affairs

October is Energy Action Month across the federal government, and for the Air Force, it represents an opportunity to remind Airmen of the role energy plays in fulfilling the Air Force's mission.

The Air Force theme this year, "Protect the Power," calls on Airmen and the larger Air Force community to practice smarter, more efficient energy and water consumption behaviors to enhance mission assurance.

"With threats to our power infrastructure increasing -- in numbers and severity -- enhancing mission assurance through energy assurance is critical to readiness. Now is the time to address these challenges; every kilowatt-hour, every gallon, and every idea counts," said Acting Assistant Secretary of the Air Force for Installations, Environment and Energy, Richard Hartley.

"As we look to the future, improving resiliency through optimized demand and assured supply will play a key role in enhancing our combat capabilities. We need every Airman to play a part, reducing their demand for energy and innovating to bring resilient and efficient approaches to the table," Hartley said.

The Air Force consumes significant quantities of energy protecting the nation's interests. With so many of our

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missions operated from our bases, building resilience, reliability and efficiency into energy operations is vital to our combat capability. To achieve these objectives, Deputy Assistant Secretary of the Air Force for Environment, Safety and Infrastructure Mark Correll, encourages Airmen to participate, both at work and at home.

"Energy Action Month is an important reminder to everyone that energy is a critical aspect of all Air Force missions," said Correll. "Regardless of where or what the mission is, we require electricity and fuel to operate. By increasing their energy awareness and understanding, Airmen make energy a consideration in all they do and, in turn, increase our capabilities."

"Fuel consumes 82 percent of the total Air Force energy budget, however increasing energy efficiency means more than just cost savings," said Roberto Guerrero, deputy assistant secretary of the Air Force for operational energy. "Making energy a consideration in future platforms and looking at current processes for ways to optimize energy use is the key to bringing greater combat capability, more training, and lower sustainment costs to the Air Force mission."

From the Base to the Fight, Every Airman can Protect the Power

Airman making smarter energy choices and integrating energy efficient technologies and fuel optimization measures has a direct positive impact on combat capability. That is why we are challenging Airmen to increase their awareness of the energy and water they use, understand its impact on the mission, and continuously look for ways to better utilize these critical resources.

This means many Airmen taking small steps, such as turning off lights. And it means the Air Force making large enterprise-level moves, such as energy savings performance contracts that finance multimillion dollar energy saving infrastructure improvements or optimizing fuel use and increasing training opportunities by adjusting aircraft training routes. No matter the size or complexity of the change, every Airman can take action to "Protect the Power."

For more information on Energy Action Month, visit the SAF/IE Energy Action Month website at: http://www.safie.hq.af.mil/Programs/Energy/Action-Month/.

Fiscal Year 2016 Air Force Energy Facts:

- Spent $5.8 billion last year for electricity, heat, and fuel
  - 82 percent for aviation fuel
  - 16 percent for installation electricity & heat
  - 2 percent for ground vehicle and equipment fuel
- Reduced facility energy usage by 10 percent since 2011
- Increased on-site renewable energy usage by 12 percent from 2015 to 2016
- Have more than 134 megawatts of on-base renewable energy capacity
- Reduced total fuel consumption for ground vehicles by 20 percent since 2008
- Improved aviation energy productivity by 5.7 percent since 2011
- Reduced aviation fuel consumption by 23 percent since 2011

Microgrids: breaking down the buzzword

By Brian Garmon
AFCEC Public Affairs

TYNDALL AIR FORCE BASE, Fla. - The term microgrid is a "buzzword" that is commonly used and just as commonly misunderstood.

The Air Force Civil Engineer Center is partnering with installations around the world in locations like Joint Base Pearl Harbor-Hickam, Hawaii, and Otis Air National Guard Base, Massachusetts, to test and determine the future of microgrids as a powerful tool in the energy assurance toolbox.

This article, the first in a series on microgrids, will define them and their key components. Future articles will include information on the Air Force's current microgrid projects, the Air Force's direction for microgrids, and what they mean for installations in the future.

The Air Force's perspective on what a microgrid is and is not, is an important first step that ensures a common understanding of the term.

Across industry and the federal government, the Department of Energy's microgrid definition in their initiative report has been widely adopted. As stated in the report, "A microgrid is a group of interconnected loads and distributed energy resources within clearly defined electrical boundaries that acts as a single controllable entity with respect to the grid. A microgrid can connect and disconnect from the grid to enable it to operate in both grid-connected or island-mode."

Tarone Wately, AFCEC subject matter expert on energy surety, explains the practical components of microgrids and what this means for the Air Force. "A microgrid should contain four primary components," says Watley. "It must have energy resources, either conventional or renewable, multiple energy loads, controllers to direct the power and optionally, storage."

Energy resources include sources powered by either fossil fuel or renewables, and can be of any scale appropriate to the loads required to support the microgrid. In many cases, it may be appropriate to have a mix of backup diesel generators in conjunction with certain types of renewable sources to provide the greatest resiliency to the mission being supported by the microgrid.

The way a microgrid is configured and the loads it will support are determined by the criticality, size and complexity of the base's tenant missions.

For the Air Force, Watley says microgrids will likely be either a campus microgrid supporting two or more buildings on an installation or a whole-installation microgrid configured for the entire base.

"Right now, microgrids are mostly being demonstrated with campus configurations," says Watley. "Furthermore, bases may see multiple campus configurations on their installations that address different, but similarly critical, missions in the near future."

The controls that grid-connect or island a microgrid can be low-tech, using a series of manual devices for activation and directing power to the loads within it, or can be "smart," using automated software algorithms from a computer system. An even more complex

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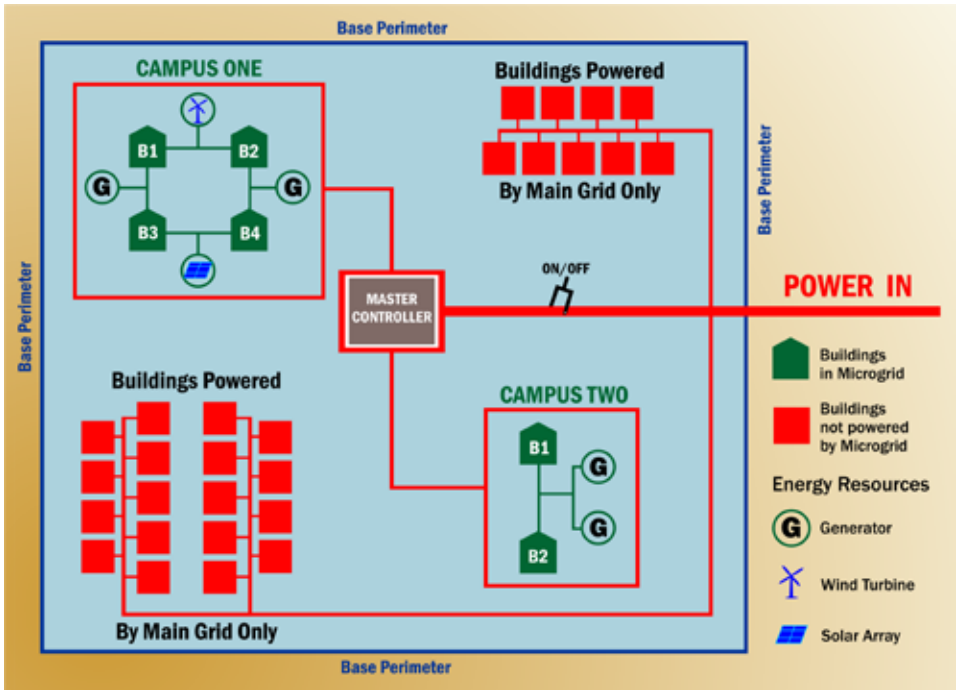

This is a basic representation of campus microgrids on an Air Force installation. Each campus has separate energy resources and are both controlled by a master controller that can island them and direct power within or between them.

E|e *Profile*

Jesse Gary

Resource Efficiency Manager
Misawa Air Base, Japan

Jesse Gary is the resource efficiency manager at Misawa Air Base, Japan, and has served in the role for nearly two years. Gary has a Bachelor of Science in Mechanical Engineering from Texas A&M University and a Master of Arts in Intercultural Studies from Union University. He has worked in the energy sector for approximately 15 years, 10 of those working in renewables and efficiency. Prior to coming to Misawa, he spent six years at the Department of Energy working with the solar energy technologies program and then in the Federal Energy Management Program. During his time at the department, he also did a one-year detail at the Department of State, where he developed a strategic energy conservation roadmap for overseas department facilities and initiated energy efficiency and renewable energy projects at a number of U.S. embassies.

How would you describe your role as an Energy Manager?
I work to create and develop strategic, sustainable programs and initiatives that -- improve lives, lead toward a clean energy future, and pay for themselves. Within the Air Force, that includes putting energy concerns into the proper context and getting people who are focused on a very important mission to pay attention to energy consumption. The SAF/IEE approach of emphasizing resiliency and mission assurance through energy assurance has proven very effective in connecting the dots for base leadership. This communicates that improving our energy infrastructure puts us in a better position to execute our mission.

What motivates you about working with Air Force Energy?
While at FEMP, I quickly learned that DOD consumes the vast majority of the energy across the U.S. federal government, and the Air Force consumes about half the energy across DOD. The Air Force actually consumes more energy than many smaller nations. It stands to reason that if you want to make the greatest impact in terms of energy, the Air Force is the place to do it.

What is the most interesting part of your role?
At Misawa, we're putting together one of the first Air Force energy savings performance contracts outside the continental U.S. and potentially one of the largest ever. It includes fuel conversion to natural gas, cogeneration, 12-15 MW of solar, a peaker plant generator, new boilers, energy management and control systems, microgrid, HVAC systems and LED lighting upgrades among

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Jesse Gary

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other energy conservation measures. We're looking to reduce the energy consumption of the base by about 25 percent and the energy utility costs by almost 40 percent. There are many challenges to overcome, but it's also extremely rewarding. Being able to do all this while living in Japan is a nice bonus.

Describe the relationship you've had with the Air Force Civil Engineer Center's Energy Directorate?
The AFCEC Program Development division at Tyndall has been involved with the Misawa ESPC since the beginning. They've provided a great deal of structure and guidance to make the initiative a success, especially when making sure we adhere to all the requisite Air Force requirements and protocols. Thanks to their efforts, there are now four more bases in PACAF—Yokota, Kadena, Osan, and Kunsan—with ESPCs in development.

What is your favorite energy-saving tip for airmen?
Be energy conscious and do your part. Just as it's important for airmen within CE to understand their role and contribution to the larger mission, it's important for them to understand that decisions they make every day affect the energy footprint of the base.

Is there anything else you'd like to add?
I'm grateful to be able to do something for a living that I'm passionate about and I find purpose in my work on both a professional and personal level. Sustainability is one of the most pressing and frequently discussed issues of our time, and energy is such a multifaceted field that's linked to almost every aspect of our lives. There are certainly days that seem tedious, overwhelming and frustrating, but ultimately it's inspiring work and that keeps me driven.

If you would like to nominate someone to be profiled in one of our upcoming issues, please contact us at afcec.pa@us.af.mil

Microgrids

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controller can be found inside next-generation microgrids, where the controller leverages artificial intelligence to direct all microgrid functions.

The primary differences between these three controller options are the time required to bring the microgrid online and restore power, and the amount of human-in-the-loop interactions. Each element is extremely important to the responsiveness and effectiveness of the microgrid and affects potential mission impact.

The final, optional, component of a microgrid is storage. Adding energy storage to a microgrid can help minimize grid downtime and create a buffer that helps the microgrid ride though power fluctuations or loss of intermittent resources. According to the Energy Storage Association, the main purpose of storage is to "balance power supply and demand instantaneously – within milliseconds."

"Storage stiffens the microgrid against sudden changes such as loss of a large load or a solar or wind renewable resource," Watley said.

These systems are commonly electrochemical (batteries), mechanical (flywheels) or thermal systems.

"Providing our warfighters with reliable, resilient energy is a key component of mission assurance," said Maj Josh Aldred, deputy director of AFCEC's Energy Directorate. "AFCEC is committed to providing installations the support they need to determine where innovations such as microgrids can complement and enhance their plan for energy assurance."

Equally important to understanding the basic components of a microgrid is understanding what a microgrid isn't.

"In the larger conversation about energy assurance, microgrids are not an all-encompassing solution," Watley said. "They are simply one tool that can get installations closer to energy assurance."

If you have questions about microgrid design or implementation, experts at the Air Force Civil Engineer Center are readily available to assist you. These experts in power and energy routinely solve implementation problems while ensuring compliance with Air Force energy and cybersecurity directives. Contact them through the Reachback Center, available through CE DASH or at 888-232-3721.

Editor's note: *This is the first in a series of articles published on microgrids. The connecting and over-arching theme of these articles is to illustrate how the Air Force intends to use microgrids to provide mission assurance through energy assurance in support of the warfighter.*

AFRL researchers 'twist' yarns

By Marisa Novobilski
Air Force Research Laboratory

WRIGHT-PATTERSON AIR FORCE BASE, Ohio – Scientists at the Air Force Research Laboratory have 'twisted' upon a new way to harvest mechanical energy using 'yarns' that weigh less than a common housefly.

Carbon nanotube-based "twistron" yarns, developed in collaboration with researchers from the AFRL's Materials and Manufacturing Directorate along with scientists from the University of Texas at Dallas and Hanyan University in South Korea, are composed of twisted bundles of individual nanotubes, each of which is 10,000 times smaller than the diameter of a human hair. When nanotube yarns are coiled and paired with an ionic material such as an electrolyte, ocean water or even human sweat, they become supercapacitors, and once pulled or stretched, they generate electrical power.

"Technologies like this do not yet exist," said Dr. Lawrence Drummy, a senior materials engineer at the AFRL. "These are energy harvesters for mechanical energy, and they could potentially eliminate the need for external power supplies, such as batteries, on a host of wearable devices. The potential application space is enormous."

Typical power generation devices such as piezoelectrics, are hard, often made of ceramic material, and generate power mechanically, usually through an external charge. Since they are hard, there is a limited ability of these materials to capture energy when deformed. Twistron yarns, by contrast, are able to deform and still capture energy. Often, all that is required is a submersion in an electrolyte to charge the yarns, enabling energy output.

The flexibility, low weight and broad range over which the twistron yarns can harvest mechanical energy offers a wide range of potential applications for the new material. Perhaps most exciting for the Air Force researchers are the possible applications for powering of flexible devices and for augmenting the human-machine interface.

"Humans move a lot, so in order to have something that interfaces well between the human and machine, it has to move like a human and be able to stretch a lot—like skin," said Dr. Benji Maruyama, the AFRL Flexible Materials and Processes Team Lead. "The superior properties of these yarns which can twist and pull and generate their own voltage and power, open the potential for generating power through a human's movement and even by using their own sweat."

This human-machine application of the yarns was tested in the laboratory in a number of ways over the course of the research. By connecting a yarn to an artificial muscle that contracted and expanded, researchers were able to convert the change in temperature into electrical energy. In another instance, twistron yarns sewn into a shirt were used to monitor and sense changes in respiration.

Scientists at the Air Force Research Laboratory are exploring the use of carbon nanotube-based twistron yarns for energy generation. This twistron yarn image, captured by X-Ray tomography, is a 3-D rendering of the coiled nanotube fibers. (U.S. Air Force photo by Matt Lucas)

"If you wear clothing with these yarns sewn in, it's possible that just by moving your body, you can generate power. It would be almost like wearing a superhero suit," said Maruyama.

The high-tech yarns were also tested in nature. By immersing the coiled twistron yarns in the Gyeonpo Sea off the coast of South Korea, research collaborators there demonstrated the yarn's ability to harvest the energy of ocean waves. Ultimately, the yarns may prove useful in harvesting enormous amounts of energy simply by using the sea.

Since the research is still in the early stages, harvesting sea energy or outfitting Airmen with superhero suits is still far in the future. For now, scientists at AFRL are working to better understand just how the twistron yarns work by examining their carbon nanotube structure at the nanoscale.

By examining the carbon nanotube fibers using an X-ray nano-tomography system, Drummy hopes to better understand the three-dimensional structure of the yarns and how structure changes when they are deformed. The x-ray tomography system enables him to characterize the material at the nanoscale—smaller than the diameter of a human hair—to see how they behave and gain a better understanding of the dynamic process of energy generation.

"There are a still a lot of unanswered questions, even at our current research state. What is the detailed mechanism that make these work? How does the structure evolve under mechanical strain? How can we optimize them for the future? We need to understand how the yarn fibers deform to allow ions to go in-and-out to generate power," said Drummy.

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ERCIP- a tool in the energy assurance toolbox

By Brian Garmon
AFCEC Public Affairs

TYNDALL AIR FORCE BASE, Fla. - One tool available to installations seeking mission assurance through energy assurance is the energy resilience and conservation investment program (ERCIP).

The program is a subset of the defense-wide military construction program that funds projects to increase resilience, save energy or water, produce energy or reduce the cost of energy for the Department of Defense. It supports construction of new, high-efficiency energy systems and modernization of existing ones. Projects in this program aim to improve energy resilience in a cleaner, cost-competitive manner.

"In order for the warfighter to execute the mission, reliable, resilient energy is a must," said Les Martin, Air Force Civil Engineer Center Program Development division chief. "ERCIP is one of the tools that help installations achieve that."

Projects can be as large as $15 million, though even larger projects may be phased to meet this guideline. The Air Force typically receives approximately $40 million annually to fund between eight and 12 projects. Last year, the Air Force received $49.5 million that funded six projects.

"Historically the Air Force has received substantial funding that supports bases in addressing their respective pressing energy requirements," said Nate Hix, interim ERCIP program manager at AFCEC.

The AFCEC Program Development division issues a call for projects during the fourth quarter of each fiscal year to be executed two years out (projects submitted in fiscal year 2017 will be for 2019 projects). After projects are submitted to AFCEC, they are validated, ranked and submitted to the Office of the Under Secretary of Defense in October. OSD normally publishes the selected list the following January.

Project selection is based primarily on economics with a strong focus on enhancing energy and mission resilience. All projects are given a life cycle cost analysis to assess long-term cost effectiveness. Savings to investment ratio, simple payback, energy saved to investment ratio and resiliency score are important factors in project ranking, along with answers to the following questions:

- Is there a documented base energy plan in the Department of Defense form 1391, and how will the project affect that?
- Does the project integrate multiple energy savings, monitoring or renewable energy technologies to realize synergistic benefits?
- Does the project implement a technology validated in a demonstration program or an innovative technology that represents potentially significant improvement?
- How does the project demonstrate improved energy resilience in compliance with Department of Defense Instruction 4170.11?

Once awarded, projects are executed by the Army Corps of Engineers, unless an installation desires to execute the project locally. This allows base personnel to allocate resources throughout the installation as opposed to executing the project.

"The ERCIP program provides bases a prime opportunity to utilize OSD funding to complete projects that enhance energy and mission resilience but are not candidates for third-party financing or operations and maintenance funding," said Hix. "We are always available to assist bases with their submissions."

The Program Development division of AFCEC can be contacted with questions you may have about this program or to provide guidance as you navigate the process through the Reachback Center. Contact them through CE DASH or at 888-232-3721.

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By understanding the way they work, scientists can better fabricate them and apply them to the technology the Air Force needs now and in the future.

"This is the first time this material was demonstrated, and the yarns really open up the potential to power new applications. Though there are still questions unanswered, we have the tools to figure them out," concluded Drummy.

The twistron yarns research was published in the journal, Science, on August 25, 2017 with the title "Harvesting electrical energy from carbon nanotube yarn twist." It is available online at http://science.sciencemag.org/content/357/6353/773

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