NSETTI Program's Energy Innovation Demonstration Projects Showing Promise

Efforts Include Hybrid Electric Vehicle Validation & Use of Seawater for Air Conditioning

FOUR PROJECTS LAUNCHED by the newly-formed Navy Shore Energy Technology Transition and Integration (NSETTI) program—ranging from the validation of a hybrid electric utility vehicle to exploring the use of seawater for island base air conditioning—are already showing promise.

The NSETTI program is an energy research, development, test and evaluation program that seeks to address the Navy's emerging energy needs and help to meet the Department of Navy's (DoN) energy goals. The program focuses on demonstration/validation of technologies that fill gaps in the following four areas:

1. Renewable/Alternative Energy
2. Efficiency and Systems (e.g., lighting, heating, ventilation, and air conditioning (HVAC) microgrids)
3. Energy Storage
4. Transportation and Fuels (non-tactical)

The program, also known as Directed Energy Research (0928), was formed in 2012, and is managed out of the Naval Facilities Engineering and Expeditionary Warfare Center (NAVFAC EXWC) in Port Hueneme, California.

Sponsored projects support feasibility evaluation, modeling and prototype testing of innovative energy technologies for use at naval installations with the greatest potential for enterprise-wide implementation. Several projects, highlighted below, are already chalking up accomplishments.

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Hybrid Electric Utility Vehicle

In July 2015, utility line maintenance personnel at Joint Base Pearl Harbor-Hickam finished a year-long demonstration of a new electric plug-in heavy bucket truck. Sponsored by the NSETTI program, the project was staged on behalf of the Naval Facilities Engineering Command's (NAVFAC) Base Support Vehicle and Equipment (BSVE) product line.

Heavy duty plug-in hybrid electric trucks are in an early commercial production phase, and have not previously been validated by the Department of Defense (DoD). Generally, these trucks have been found to be more efficient and produce lower tail pipe emissions than conventional diesel trucks. Hybrid trucks also permit clean and quiet work operations that would otherwise require continuous idling of the vehicle.

David Cook from NAVFAC EXWC is the Alternative Fuel Vehicle Team Lead and the principal investigator for this NSETTI project. "The non-plug-in hybrid conserves fuel by operating in a battery-only mode for aerial lift operations, though for limited to short durations," he said. "The plug-in hybrid trucks have capability for direct grid recharging operations, as well as up to 15 times the capacity for the electric-only work mode. The larger battery pack also enables enhanced efficiency gains for driving operations."

At the start of the one-year demonstration period, a bucket truck was equipped with special instrumentation for hands-free monitoring. The automated system collected data on the truck's usage in both the driving mode and the engine-off working mode (used in the aerial lift and hydraulic tools). The system also monitored the truck condition and diagnostic codes, and the on-board telematics system transmitted data to a website several times per day. Factors such as noise, unscheduled maintenance, reliability, and drivability were also captured. These data were used to compare efficiency of the hybrid with the baseline truck, a conventional diesel truck with a similar chassis, engine and utility system.

The new hybrid truck in lift mode.
Dave Cook

The vehicle's electric plug-in system was projected to increase fuel economy by 40 percent over the conventional truck. Results are still being tallied, but the fuel economy was better than predicted when the truck was in aerial lift mode—nearly triple that of the diesel truck. Fuel economy during driving mode was not significantly better than its conventional counterpart.

Noise was greatly reduced as well when the truck was in aerial mode, and overall drivability was slightly improved.

Assuming all results are favorable, NAVFAC BSVE will integrate plug-in heavy hybrid utility trucks into their long-term vehicle procurement plans. Results of the demonstration and a final report will be made available to other non-tactical fleet managers as well.

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The hybrid bucket truck in the field.
Dave Cook

Lighting accounts for approximately 23 percent of total energy use Navy-wide.

The LED fixtures utilize an upward projecting light for indirect lighting as well as a downward projecting light for direct lighting.
Paul Kistler

The new lighting system will include daylight sensors that dim in the presence of adequate natural light.
Paul Kistler

Hangar Illumination Demonstration

Currently, lighting accounts for approximately 23 percent of total energy use Navy-wide. In an effort to reduce the energy used for lighting in DoD aircraft hangars, an NSETTI-sponsored team conducted an investigation into the appropriate ambient light levels in hangars.

This past summer, the project team, headed by Paul Kistler and Robert Okwera of NAVFAC EXWC, replaced fluorescent lighting with LED fixtures at a hangar at Naval Base Ventura County (NBVC), Point Mugu. LED lighting was chosen for this project because LED lighting can be very easily dimmed over a wide range of light levels.

The current standard for lighting in hangar bays as required by the Unified Facilities Criteria (UFC) is 500 lux. (A commonly used measure of illumination, one lux is equal to the illumination supplied by a single candle at a distance of one meter.) In contrast, the UFC requirement for office interiors is only 300 lux. Experts believe that the ambient lighting in hangars can be reduced to the 300 lux range since aircraft mechanics utilize portable task lights when performing tasks requiring a higher light level.

The main goal of this project is to determine how far the illumination levels could be reduced before visual performance and user satisfaction suffered.

The quantity and quality of light in the aircraft hangars is extremely important given visibility factors such as color rendering, glare, and reflectance that can create various safety issues to the working crew performing inspection and aircraft maintenance. It is therefore imperative that the tasks be performed in the most suitable work environment.

In July 2015, existing fluorescent fixtures were replaced with dimmable LED fixtures at the hangar building. The lighting levels will be reduced incrementally over a test period of one to two months. Workers will be given checklists every other week as the lighting levels are reduced from 100 percent to a low of 60 percent of the original 500 lux. These checklists provide an opportunity to report lighting problems such as a dim work environment, defective lamps, strong glare and reflections.

The LED fixtures utilize an upward projecting light for indirect lighting as well as a downward projecting light for direct lighting. These lights are capable of providing up to 500 lux in the hangar, but this maximum level can be reduced. The fixtures are equipped with internal motion detectors, which further the energy savings by turning off the lights when the building is unoccupied. Each hangar bay also has daylight sensors to dim the lights when the hangar doors are open during the day. Additionally, the LED fixtures are more durable and break-resistant than fluorescent fixtures.

If it is determined that worker safety and performance is not diminished by a reduction from 500 lux to 300 lux conditions, annual energy savings with LED lighting would be at least 40 percent. Controlling the lighting in response to daylight availability and occupancy are expected to increase this savings to 60–70 percent.

Once these light levels are proven to be acceptable for this application, a request will be made to the NAVFAC Atlantic, Engineering Criteria and Programs Office to change the ambient lighting levels for hangars.

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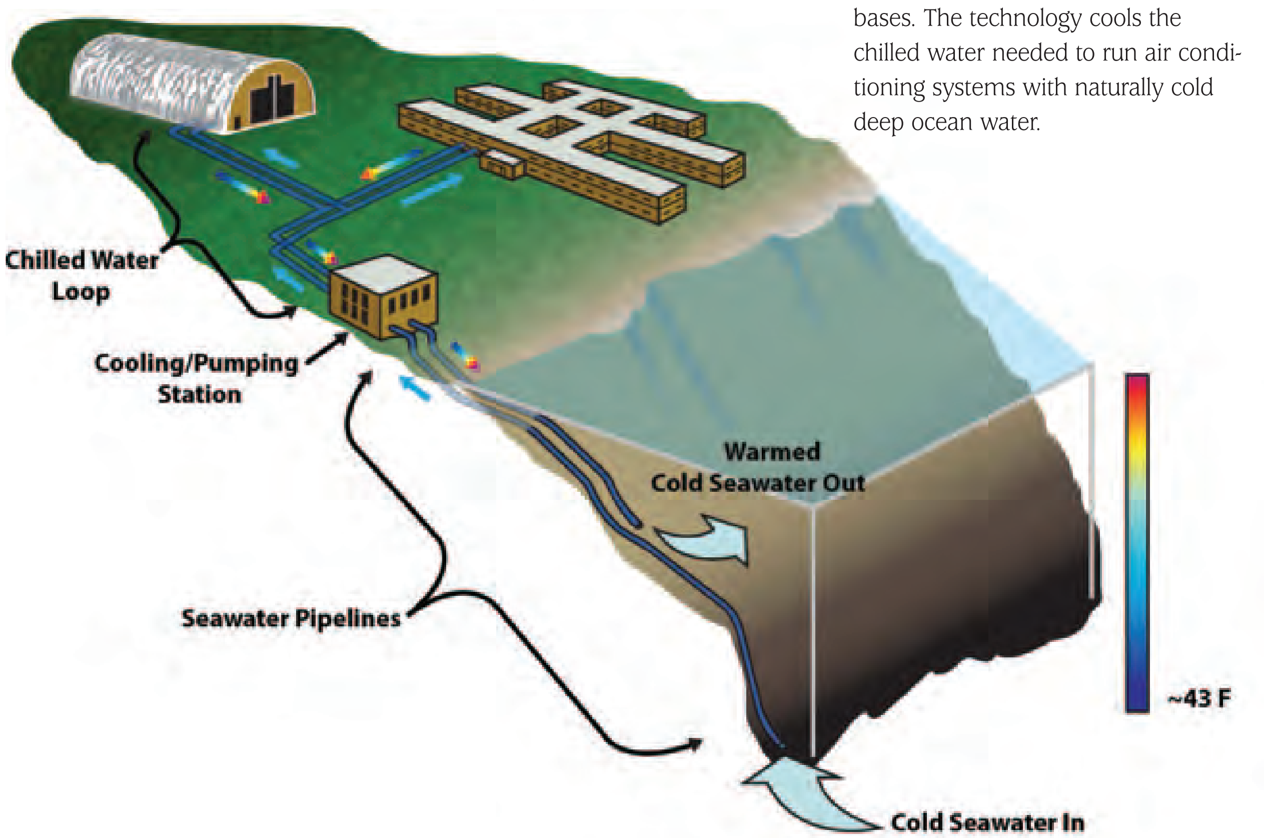
Seawater Air Conditioning

Seawater Air Conditioning (SWAC) is an existing technology that could dramatically cut energy costs at island bases. The technology cools the chilled water needed to run air conditioning systems with naturally cold deep ocean water.



A conceptual drawing of how SWAC works.

SWAC would use approximately 85 percent less energy than conventional air conditioning to cool Navy Base Guam.

The NSETTI project team, headed by Nate Sinclair, has conducted various planning, design, and cost estimating activities to assess the technical and economic merit in implementing SWAC systems at Navy bases.

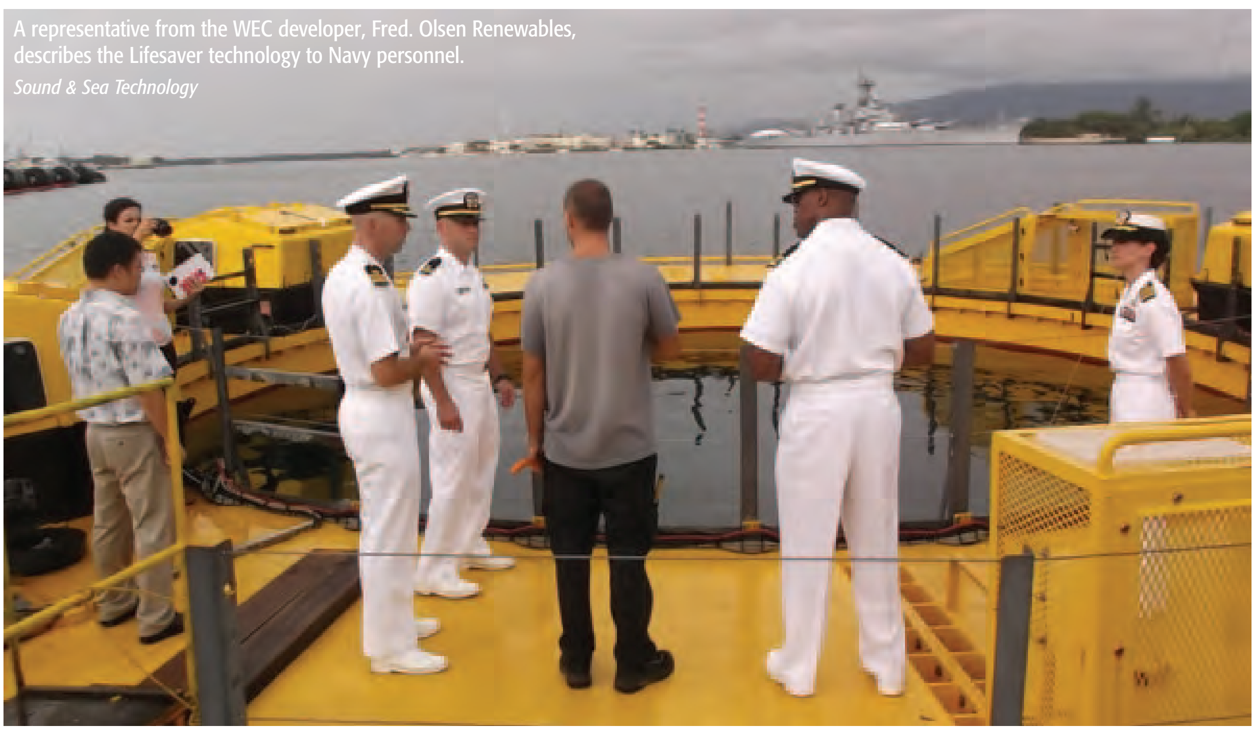
Naval facility buildings are currently cooled with a mix of small direct expansion air conditioners and small chilled water distribution systems. Seawater air conditioning is a means of bypassing the chillers used in both types of cooling systems, and using deep sea water and a heat exchanger to chill the fresh water which is used to condition building air via a district cooling network of pipes.

As an example, there are 160 air conditioning chillers at Navy Base Guam, with a total peak cooling demand of 8,300 tons. The base has a high energy demand, as the mean average temperature is 81 degrees, with high humidity levels. A SWAC system implemented at Navy Base Guam would likely use a deep seawater intake pipeline extending approximately four kilometers (2.5 miles) offshore, to a depth of approximately 750 meters (2,500 feet); and bring 42-degree Fahrenheit (F) seawater ashore. The pipeline would pass through a tunnel under the reef, across the shoreline, and into a pump station. Heat exchangers inside the pump station would use the cold seawater to chill fresh water that is circulated in a closed loop and delivered to all of the base air conditioning (AC) systems. Each building would receive cold fresh water at 45 degrees F, the same temperature as with traditional air conditioning.

After it cools the incoming AC chill water, the warmed seawater would leave the pump station and be returned to the ocean, through another pipeline. Operation of the AC air handling units within the buildings on base is basically unchanged.

The idea of seawater AC is particularly attractive at places like Guam because of the ease of access to deep water, the concentration and quantity of buildings requiring AC, the high rate of AC use, and the relatively high cost of electricity.

The results of the study indicate that SWAC is a technically feasible and cost-effective way of delivering air



A representative from the WEC developer, Fred. Olsen Renewables, describes the Lifesaver technology to Navy personnel.
Sound & Sea Technology

conditioning to Navy Base Guam. SWAC would use approximately 85 percent less energy than conventional air conditioning to cool the island base. Carbon emissions would also be reduced by 30,000 tons per year. In addition, energy costs with SWAC will remain relatively flat, providing greater independence from future utility price increases.

Upfront capital costs for SWAC systems are substantial (100 million dollars or more) given the large amount of infrastructure and AC retrofitting required. However, estimates show a favorable payback period.

It is expected that SWAC could be a similarly viable technology for other island-based facilities, such as Joint Marine Corps Base Finegayan, Andersen Air Force Base, Naval Support Facility Diego Garcia, and Naval Station Guantanamo Bay. The technology is best suited to locations where the distance to deep offshore water is relatively short, the AC system output is more than 2,000 tons, AC usage is relatively high, and the cost of electricity is high.

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This infrastructure makes the WETS the nation's only grid-connected, open-water test site.

Wave Energy Test Site

Ocean waves are a huge, largely untapped energy resource. But Wave Energy Conversion (WEC) technology, which is still in its infancy, converts the energy of waves, tides or ocean currents into electricity.

The Navy entered the field of WEC study in 2003 (then called the "Wave Energy Technology" project) with the construction of what is now known as the Wave Energy Test Site (WETS) in the waters off Marine Corps Base Hawaii. Hawaii is one of the locations in the United States where the wind blows with enough consistency and force to provide continuous waves along the shoreline. The WETS effort was funded with Congressional Budget and Appropriation dollars.

The first device to be tested at the WETS was a shallow-water buoy developed by Ocean Power Technologies. This buoy assembly was located at a depth of about 100 feet, approximately three-quarters of a mile offshore. A subsea power cable connected the buoy to an onshore data collection facility.

As more and more people became interested in exploring WEC technology, the Navy entered into various partnerships with government and private industry, allowing them to utilize the WETS, and in some cases, assisting with funding.

In 2014, the NSETTI program joined the Office of Naval Research, the Department of Energy's (DOE) Wind and Water Power Program, and the University of Hawaii's Hawaii Natural Energy Institute to construct two additional deep-water berths at the site. The berths, at 60 and 80 meter depths (200 and 262 feet), will enable companies to test their WEC devices in an open ocean environment and connect to a power grid. The electricity produced during testing will be used by the Navy on the Marine base. This infrastructure makes the WETS the nation's only grid-connected, open-water test site.

The new berths will be used for testing two WEC technologies with Navy support—the Lifesaver, deployed by Sound & Sea Technology, and Columbia Power Technologies' StingRAY device.

Both of these devices employ "point absorber" wave energy technology—one of the four main approaches to the science. Point absorbers use floats and a rolling centerpiece called a nacelle to collectively capture wave energy. According to the Bureau of Ocean Energy Management, the relative up and down bobbing motion caused by passing waves is used to drive electromechanical or hydraulic energy converters to generate power.

More About the NSETTI Program

THE NSETTI PROGRAM (Directed Energy Research Program 0928) is sponsored by the Chief of Naval Operations (CNO) Shore Readiness Division (N46). The program is focused on three primary objectives that influence management priorities and directly affect the program's success:

1. **Collect, Validate & Rank Energy RDT&E Needs**
   Expand awareness of program opportunities within the Navy shore side community to encourage and facilitate the submittal of well-defined energy needs and requirements.
2. **Resolve High Priority Needs**
   Ensure that program investments and the resulting projects maintain a direct and consistent link to the defined user needs.
3. **Integrate Solutions & Validate Benefits**
   Maximize the number of program-derived solutions that are successfully integrated into the shore side facility environment and verify that the solutions provide the anticipated benefits.

For FY16, the program launched its first needs solicitation and received 52 needs. Of these, 67 percent fell under the Energy Efficiency, Security and Systems thrust area. Of the remaining needs, 19 percent were in Renewable Energy, and the remaining 14 percent was divided between Energy Storage and Transportation and Fuels. Additionally, the needs were geographically dispersed so Navy-wide representation was achieved.

A total of 23 needs were grouped into the focus areas as shown in the table on the following page. Many of these focus on the problems created by the high penetration of renewable energy and the need to maintain grid stability using energy storage and smart, autonomous controls. Controlling and managing these systems remotely, autonomously or both creates a cyber-security and information technology vulnerability that the program plans to address in shore energy Research, Development, Technology and Evaluation projects in the future. The FY16 call for proposals is already underway that will begin to address these needs.

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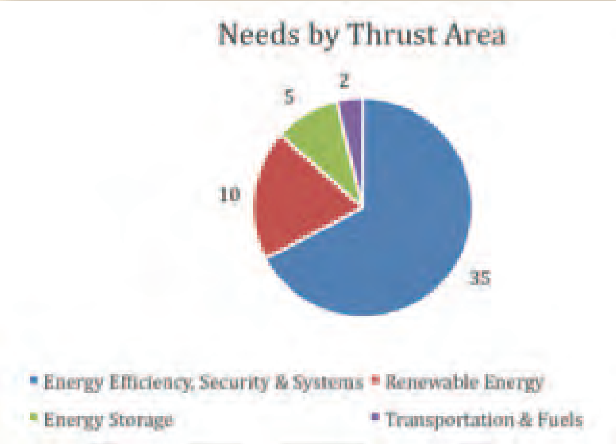

The Lifesaver, considered one of the most sophisticated WECs in the market today, was developed in Norway by Fred. Olsen Renewables and will be the first WEC to be tested at the WETS deep berth site. It was scheduled to be installed in October 2015.

According to Alexandra De Visser, NAVFAC EXWC principal investigator, the Lifesaver was successfully deployed for two years at the Falmouth Bay Test Site, an English site where marine renewable energy devices are also being tested.

Bryan Law, Regional Energy Manager for NAVFAC Hawaii, agreed that the Lifesaver is an innovative device that shows considerable promise for Navy applications of wave energy.

"Most installations in the Pacific [Rim] have pretty good access to waves and a shoreline, so there is good potential for those particular bases to reduce their fossil fuel use by being able to plug directly into the grid, so to speak, and harness this kind of wave energy," he said.

Technology testing supported by the DOE's Wind and Water Power Program will support the efforts of two more companies that will install their devices at the new WETS deep water berths.

Northwest Energy Innovations of Portland, Oregon, is currently testing their Azuza point absorber device in the shallow water berth and will build and test a full-scale model of the device for testing in a deep water berth in fiscal year (FY) 2017 or 2018.

NO.	TITLE	DESCRIPTION	PRIORITY
1.	Utilize Energy Storage to Enable Renewable Generation	There is a need for cost-effective energy storage to enable renewable energy generation. Many bases have met their renewable threshold and cannot add more renewable energy without energy storage.	High
2.	Energy Security through Battery Reuse	The Navy recycles batteries that no longer meet first use criteria but still have additional capacity such as "fleet return" submarine batteries. There is a need to demonstrate and evaluate the ability to reuse these batteries as energy storage for uninterruptible power supply, enabling islanding capability during a power outage, integrating with renewable systems, demand response or other grid stability issues. The demonstration should include a study on the applicability throughout the Navy with different types of used batteries.	High
3.	Reliable and Resilient Power Enabled by a Microgrid, Renewable Energy and Energy Storage	Naval installations need a reliable and resilient power supply with the ability to operate while the main grid is down. In addition, the Navy needs a way to integrate renewable energy resources and energy storage smoothly into the grid. There are several installations that are at the renewable threshold limit and cannot support any additional renewable power without energy storage and Microgrid controls systems. The Navy is involved in Smart Power Infrastructure Demonstration for Energy Reliability and Security (SPIDERS). Any projects proposed should build on the work that SPIDERS has already done.	High
4.	More Energy Efficient HVAC systems	The Navy needs more efficient technologies to cool and heat its buildings. In addition, there is a need to provide technology transfer and publicity for energy efficient and effective HVAC technologies that have been successfully demonstrated on Naval installations.	Medium
5.	Lighting	The Navy needs a way to maximize energy savings of lighting while maintaining lighting quality. Areas of interest: wireless controls, innovative lighting controls while meeting cyber security requirements.	Low

Also in the same time period, Ocean Energy USA of Sacramento, California will provide its buoy device for testing at the deepest berth. Their technology is classified as a terminator device, which in this case employs an oscillating water column to convert wave energy into electricity by harnessing the energy from air that is compressed and forced through a turbine with the rise and fall of ocean waves.

The NSETTI program's goal in the ongoing work is to help determine which WEC systems will prove to be most promising for future deployment at appropriate Navy and Marine Corps bases. In addition to assisting with the construction of the new berths, NSETTI is providing support with permit acquisition and project management.

Through the research, the Navy and the companies hope to prove that the connected devices are durable in the open ocean environment, while measuring power output at full scale and evaluating the cost of energy produced by the devices.

It is hoped that this technology will offer a way to offset high electrical costs and to ensure energy security in far-flung geographic regions, and eventually to provide the public with a viable sustainable energy alternative.

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