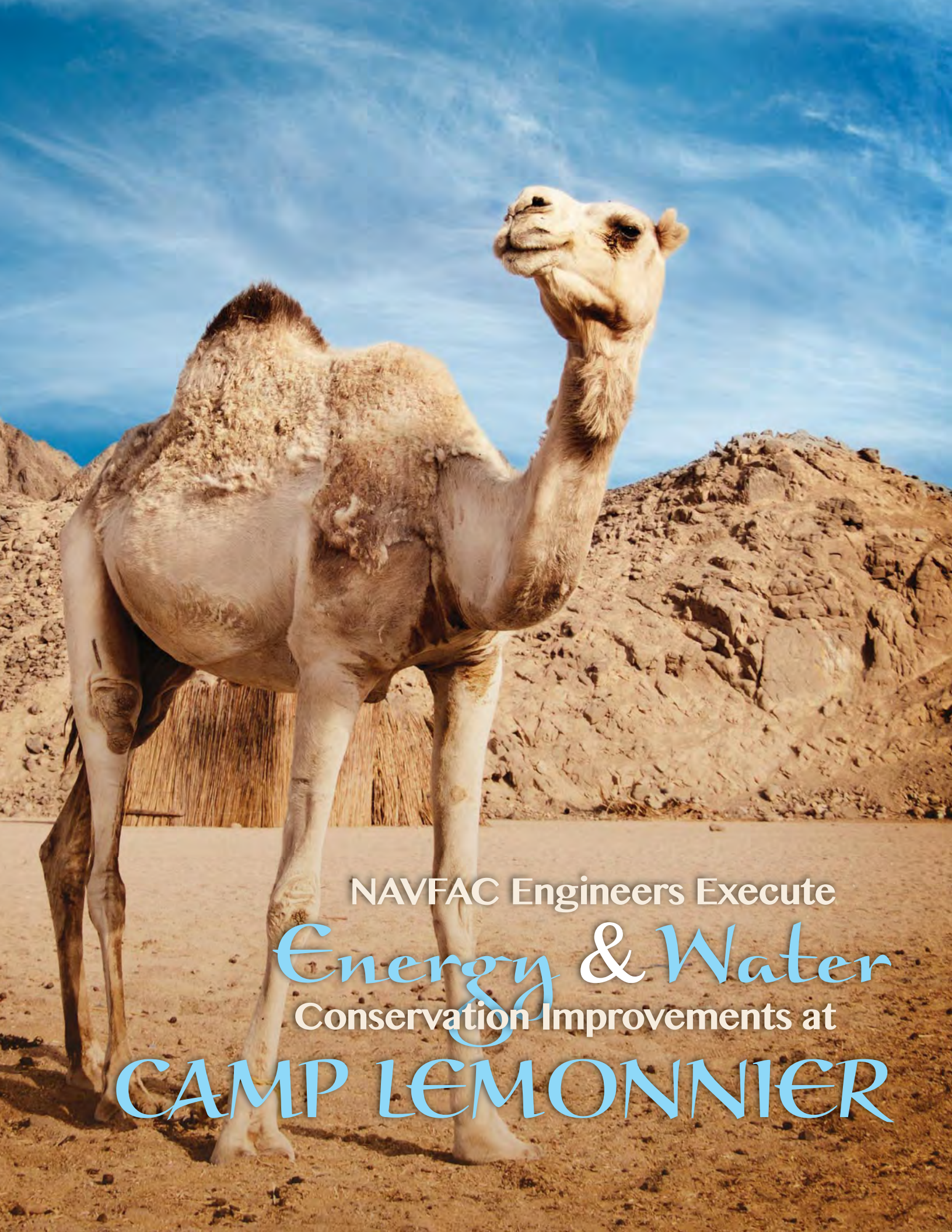


NAVFAC Engineers Execute

Energy & Water Conservation Improvements at CAMP LEMONNIER

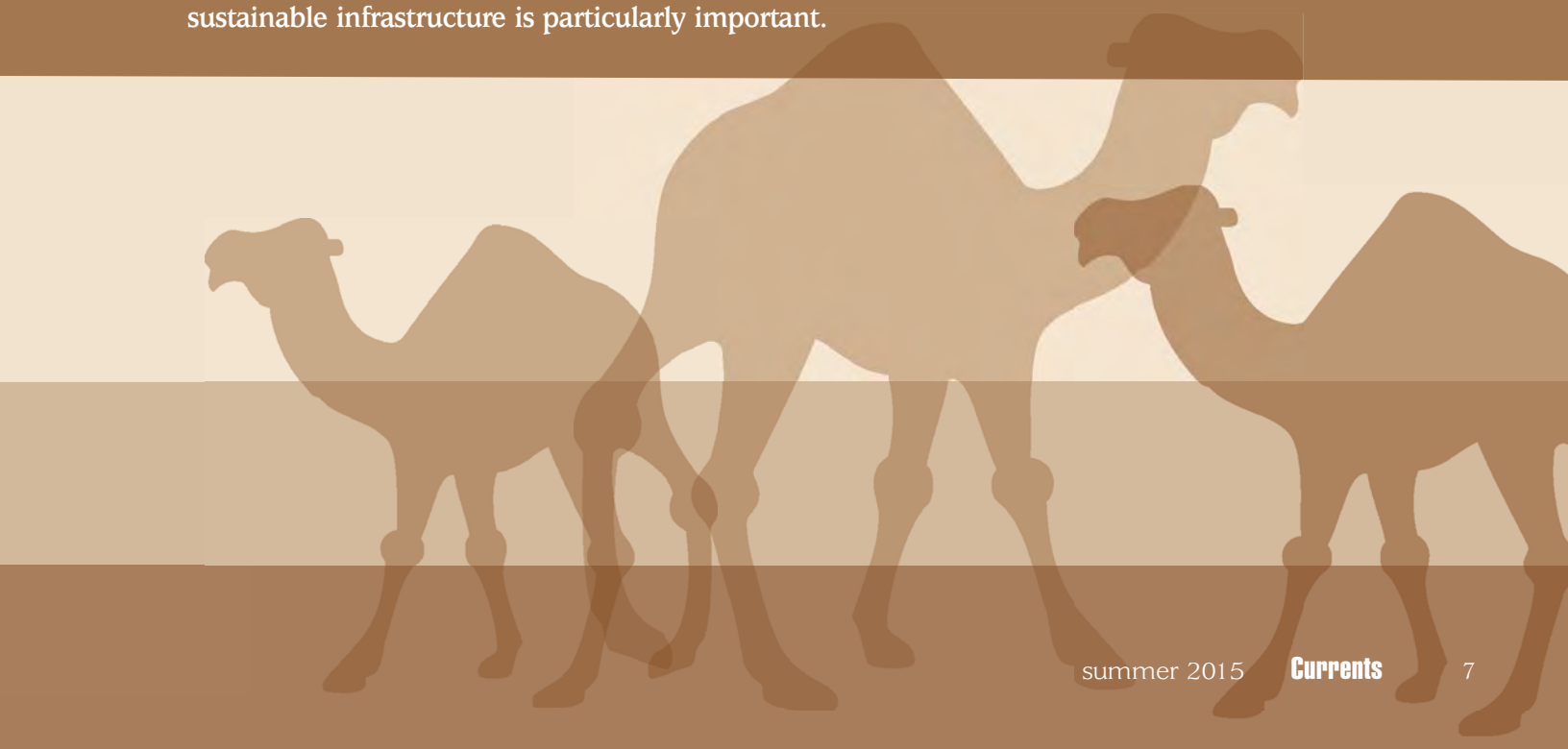
Energy Saving Initiatives & Other Efforts Successful in Forward-deployed Environment

Engineers from the Naval Facilities Engineering and Expeditionary Warfare Center (NAVFAC EXWC) successfully executed several projects to promote energy sustainability and water conservation at Camp Lemonnier, Djibouti (CLDJ) Africa.

Located in an extremely arid and harsh climate with base power provided overwhelmingly by diesel generators, the Camp Lemonnier NAVFAC EXWC Sustainability Team reduced energy intensity by 13.5 percent relative to the 2003 baseline by making efficiency upgrades to electric power generation and distribution, air conditioning units, and clothes washing machines. The team also reduced electric energy use by reducing the need for potable water generation and wastewater treatment by over 20 percent.

Their efforts were recently commended by Rear Admiral Kevin R. Slates, director of the Chief of Naval Operations Energy and Environmental Readiness Division. “Especially in areas like Djibouti, efforts to reduce water and fuel usage with no mission impact can be a huge cost saver and help reduce challenging logistics burdens,” said Admiral Slates.

Like all remote military facilities, CLDJ must contend with multiple challenges regarding energy and water use expenditures. This small country located in the Horn of Africa has a very limited supply of fresh water, a harsh climate, and an unreliable electric power grid. Because of the camp’s rapidly evolving mission with changing staffing requirements, flexible, sustainable infrastructure is particularly important.



HOW IT ALL BEGAN

The Energy Policy Act of 2005 and Executive Orders 13423 (Strengthening Federal Environmental, Energy, and Transportation Management) and 13514 (Federal Leadership in Environmental, Energy, and Economic Performance) all set mandatory goals that call for annual reductions in energy and water consumption as well as increased use of renewable energy and metering.

To identify what it would take to help CLDJ achieve its regulatory and Executive Order goals, engineers from the Naval Facilities Engineering Command's Engineering Service Center (NAVFAC ESC), now NAVFAC EXWC, traveled to the camp in 2008. They reviewed the base master plan supplied by NAVFAC Atlantic personnel, and conducted a preliminary facility sustainability assessment. The team concluded that CLDJ is unique from a sustainability perspective for the following reasons:

1. The facility's staffing and mission requirements are evolving, so infrastructure must be readably adaptable to changing needs.
2. The region does not have a reliable electric grid or potable water, so the base must be entirely self-sufficient.
3. The harsh climate imposes serious challenges in terms of developing sustainable infrastructure.

After several follow-up discussions with NAVFAC Europe Africa Southwest Asia, the NAVFAC ESC team again traveled to CLDJ to begin gathering data and researching potential solutions. They recommended that CLDJ implement the following efforts:

1. Address Containerized Living Unit (CLU) energy use.
2. Conduct energy sustainability studies.
3. Assess water conservation and aquifer sustainability.
4. Identify solid waste reduction opportunities.
5. Study the feasibility of solar photovoltaic systems.
6. Implement street lighting and conduct an energy audit.
7. Assess the viability of wind power.
8. Assess the efficiency and reliability of the camp's electric grid.

ADDRESSING CONTAINERIZED LIVING UNIT ENERGY USE

The inherent challenge with reducing energy usage at CLDJ exists because of the climate in Djibouti. The average high temperature in January is 84 degrees Fahrenheit (F) with nearly 80 percent average humidity. In July, the average high temperature is 106 degrees F with 43 percent humidity. These climate conditions require year-round air conditioning, which contributes to the base's high energy costs. Because of this, the air conditioning systems used in CLDJ's housing units were one of the team's highest priorities, and the largest single factor in reducing energy consumption.

CLDJ base personnel are primarily housed in metal CLUs, which are constructed by converting shipping containers into living spaces. The original CLUs were furnished with window air conditioners, which provided

Camels are a common sight in Djibouti.
Bruce Holden

uneven cooling at an unacceptably high noise level.

Just as important, these units place a high energy demand on the camp's diesel fuel resources. The camp estimated that CLU air conditioning consumed approximately 40 percent of its total energy load. It was thought that this could be significantly reduced by improving the overall energy efficiency of the CLUs.

The old (right) and new (left) CLU air conditioning units at Camp Lemonnier.
Bruce Holden

The objectives of this effort were to:

1. Identify the most energy efficient split air conditioning unit that was appropriate in a high humidity environment.
2. Use energy modeling and performance testing to identify the required cooling capacity.
3. Determine the optimum location for the evaporation portion of the system so that temperature differences within the living space were minimized.
4. Provide design specifications to improve the energy efficiency for newly-purchased CLUs.

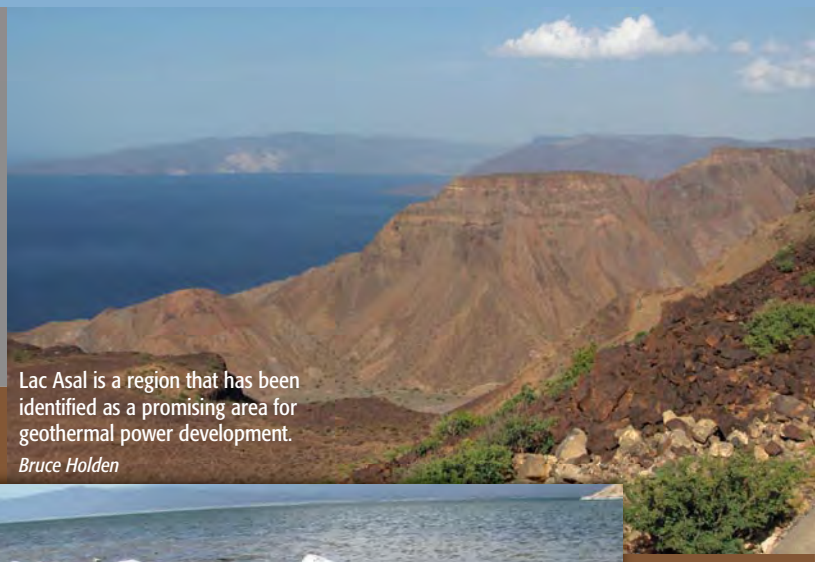
This effort began in August 2011, as NAVFAC EXWC and Naval Air Weapons Station (NAWS) China Lake personnel collaborated on a heating, ventilation and air conditioning test. NAWS China Lake was chosen as the test location due to its extreme summer weather conditions, with outside air temperature approaching levels experienced at CLDJ. A 20-foot insulated shipping container, similar in size and insulation performance to a single CLU room at CLDJ, was used to measure heat gain and experiment with several methods to distribute cooled air within the container.

These experimental data were used in conjunction with a building energy modeling software program to identify potential CLU energy conservation measures. It was determined that the existing 24,000 British Thermal Units (BTU) per hour window-type air conditioning units were much too large. A unit with 9,000 BTU per hour capacity was all that was required. This smaller unit would be less expensive to purchase and would provide better humidity control. The NAVFAC EXWC

The camp estimated that CLU air conditioning consumed approximately 40 percent of its total energy load.

Geothermal Potential?

A separate study in 2010 explored the potential for geothermal energy at CLDJ. The geothermal energy potential of Djibouti is estimated to be significant according to studies conducted intermittently since the 1970s, primarily by Djiboutian and Icelandic investigators. While the Navy Geothermal Program Office found no clear evidence of geothermal resources beneath or directly adjacent to the camp, it compiled a report detailing how to conduct a geothermal resource assessment/exploration process.



Lac Asal is a region that has been identified as a promising area for geothermal power development.
Bruce Holden

A geothermal resource must possess heat, fluids, and permeability to be a successful production prospect. As with the discovery of any natural resource in the ground, prospecting for geothermal energy revolves around identifying indicators of the occurrence of that resource. The process involves gathering and interpreting a wide variety of tectonic and geologic data to create a picture, or model, for the presence of a geothermal resource in the ground and then validating that model through actual drilling.

Close-up of Lac Asal geothermal area shows salt crytalized on exposed rocks.
Bruce Holden

If a more comprehensive geothermal study is undertaken, the first stage would be a two-year exploration program in which detailed geological and geophysical data would be gathered and used to create a three-dimensional model with specific drilling targets. This stage also includes drilling several test holes to approximately 500 feet. This effort would result in a geologic model that would enable the NAVFAC EXWC Sustainability Team to determine whether additional geotechnical studies are required or sufficient information exists to proceed to the next stage which involves drilling deep discovery wells to a depth of 3,000 to 5,000 feet.

Altogether, if sufficient geothermal resources are found at or near Camp Lemonnier, the total time from inception of exploration to an operating power plant is estimated to be a minimum of seven years. Prior to actual construction of a power plant, upfront costs for exploration and well development are estimated to be up to $17 million with no guarantee that an economically viable resource will be discovered.

If resources are found off-base, a host of other issues such as security and contracting issues would have to be addressed. Fortunately, there is a strong desire on the part of the Djiboutian government to work with the Department of Defense (DoD) in the exploration for and development of resources. Two firms, Reykjavik Geothermal and Geothermal Development Associates, have also inquired if the DoD might be interested in entering into a Power Purchase Agreement. These firms have completed preliminary explorations in the nearby Lac Asal region, a known source of geothermal energy. If an agreement were to be reached, it is conceivable that a power plant could be online in three or four years.

The payback from geothermal energy is potentially very significant but the upfront costs are non-trivial and must be accepted before the exploration process can begin.

Camels along the road to Lac Asal, a promising geothermal region.
Bruce Holden

team also determined that the optimum split type units had more than twice the electrical energy efficiency of the existing window units.

Split unit systems are so named because they have two components—an exterior compressor/condenser, and one or more interior units installed on a wall or ceiling. Refrigerant is pumped through tubing from the outdoor condenser and compressor to the indoor unit(s). Indoor air to be cooled is drawn across the unit's interior evaporator coil and distributed via a fan. Humidity is removed from the room's interior via a drain in the indoor unit.

A U.S. airman walks towards a housing area composed of CLUs at CLDJ. The triple-stacked units showed a three to five percent reduction in necessary power to cool the first and second levels simply by being shaded.
MC1 Class Eric Dietrich

Subsequent to the NAWS China Lake testing, the NAVFAC EXWC team performed numerous tests at CLDJ to identify the optimum location for the unit's evaporator such that temperature differences within the living space were minimized. NAVFAC EXWC engineers also completed performance electrical measurements to verify the results from the building energy modeling efforts. NAVFAC Atlantic personnel incorporated the split heating, ventilation, and air conditioning systems into all new CLU purchases and ensured that the correct systems were installed at Camp Lemonnier.

Since CLU air conditioning was the largest single source of electricity use on the camp, the camp's replacement of all CLU air conditioning units has been the biggest energy conservation success.

In addition to the CLU air conditioning unit replacement, the NAVFAC EXWC team also investigated the use of CLU shading structures and several reportedly highly thermal reflective paints. Both technologies were initially tested at the NAVFAC EXWC facility in Port Hueneme, California. They were later tested at CLDJ. Unfortunately, the CLDJ testing proved that neither of these approaches provided significant value in reducing the load on the CLU air conditioning units, and the shading structures did not pass long-term wind durability testing so these ideas were not pursued.

The camp's *replacement* of all CLU air conditioning units has been the biggest energy conservation success.

CONDUCTING ENERGY SUSTAINABILITY STUDIES

Because of the inherent instability of the Djiboutian power grid, the Navy has chosen to generate almost all electricity at CLDJ by onsite diesel generators. The Djiboutian power grid has been known to fail up to several times a day for hours at a time. Even when the power is available from the Djiboutian power grid, its cost is above the approximately $0.43 per kilowatt hour for the CLDJ generators.

To help reduce this dependence on fuel, NAVFAC EXWC personnel tasked the National Defense Center for Energy and Environment (NDCEE), operated by Concurrent Technologies Corporation (CTC), to oversee two energy reduction efforts at Camp Lemonnier.

Part of the effort to reduce consumption included an assessment of the energy grid. For this task, NDCEE hired Lockheed Martin to conduct an energy grid assessment. The goals of this assessment were to reduce fuel consumption by increasing generator operating efficiency and to increase overall system reliability and security. System reliability risks were also assessed through the examination of power source and distribution components by exposing single-point failures in the distribution and control design.

Lockheed Martin engineers spent one week on site gathering information pertaining to the generation, distribution and loading of the current power grid, which they then entered into their proprietary Microgrid Planning Tool to evaluate the power and energy balances between the loads and the sources. Through this tool,

Camp Lemonnier relies almost entirely on diesel fuel to power the base.
Bruce Holden

Lockheed Martin engineers developed various options for reducing fuel consumption and documented their recommendations.

About the Generators

Generators operate most efficiently at 75 to 80 percent of capacity. As the generator loading falls below this

The Basics About Camp Lemonnier

Camp Lemonnier is located on the south side of the Djibouti-Ambouli International Airport. Originally, the camp belonged to the artillery of France's 5th Overseas Task Force (5th RIAOM) and was named for a French general. Following use by the 5th RIAOM, the facility was operated by the Djiboutian Armed Forces. The U.S. government took up residence in May 2003 with the Combined Joint Task Force-Horn of Africa staff, a Marine Corp-based organization. In January 2007, it was announced that Camp Lemonnier would be expanded from 97 acres to nearly 500 acres. As part of the process of transferring the base from an " expeditionary" base to an enduring facility, tents were replaced with CLUs. Camp Lemonnier is now under the command of Commander, Navy Region Europe, Africa, Southwest Asia and is part of the U.S. Africa Command. The camp has over 4,000 residents. For more about CLDJ, visit www.cnic.navy.mil/regions/cnreurafswa/installations/camp_lemonnier_djibouti.html.

level, the generator becomes less efficient, which results in unburned fuel exhausted into the atmosphere. The result is carbon buildup inside the generators, requiring an increased maintenance frequency to remove the carbon. Underloading the generators also affects the engine bearings, resulting in greater maintenance requirements and shorter overall lifespan.

The Lockheed Martin team studied the efficiency and performance of every generator at CLDJ. Their report identified underperforming and underutilized generators and recommended installing an intelligent software control system to ensure that the most efficient generators are utilized to optimum capacity, and the that the use of the lowest performing generators are avoided except as a last resort. This control system would integrate all prime power generators, regardless of manufacturer, and adds an additional layer to the existing control system.

Diesel generators at one of CLDJ's power plants.
Bruce Holden

Changing Power Distribution

The Lockheed Martin team also recommended extending the prime power distribution feeders to include areas of CLDJ that had been serviced by less efficient spot generators. Transferring these loads to the prime power generators is estimated to result in a savings of approximately $1.2 million per year based on a reduction of 320,000 gallons/year of diesel fuel. In addition to extending the grid, the Lockheed Martin team also recommended that the existing prime power generators be integrated into one grid.

In total, the Lockheed Martin-recommended improvements to the operation of the energy grid could reduce the amount of fuel needed to produce electricity at Camp Lemonnier by up to 13 percent. Since this report was prepared, several of its recommendations have already been implemented including extending the electric grid, phasing out the least efficient generators and interconnecting the Camp's grid.

Heat Pump Water Heaters

Conventional water heaters use electricity or fuel to heat incoming water to a desired temperature. The water is stored in an insulated tank until used. Heat Pump Water Heaters (HPWH) use heat naturally present in the ambient air to heat the water and rely on electricity only to move the heat, resulting in a decrease in energy requirements. Because these water heaters can be two to three times more efficient than conventional electric water heaters,


A heat pump water heater.
Stephen Schroth

they were chosen for demonstration and validation at CLDJ.

HPWHs are designed to operate best at 40 to 90 degrees F. Although it is frequently hotter than this at CLDJ, positioning the water heaters inside a building has a secondary benefit. Because the HPWH absorbs heat from the air around it and pulls it in to heat water, it also cools the space where it is installed.

A HPWH was demonstrated at CLDJ by NDCEE personnel to evaluate its performance and to measure the resultant energy savings compared to a baseline conventional water heater.

Energy modeling was also used to model the recovery rate of the HPWHs and to calculate the maximum shower duration per day

Improvements to the operation of the energy grid could *reduce* the amount of fuel needed to produce electricity by up to 13 percent.

that could occur under desired conditions. For laundry purposes, modeling was used to calculate the maximum number of loads per day that could be washed and the maximum number of loads per hour while maintaining the desired wash temperatures.

The results of the demonstration and water use modeling effort indicated that implementing HPWHs will result in significant energy savings at CLDJ. Annual energy savings for one HPWH unit for ablution (shower and restroom) use is estimated at $1,500 with a simple payback of 2.1 years. Annual energy savings for one HPWH unit at the laundry is estimated at $4,466 with a simple payback of 0.7 years.

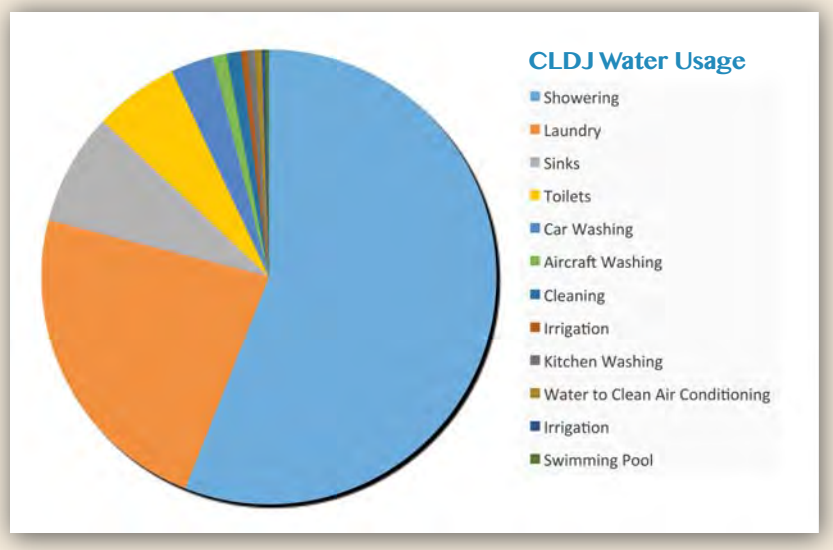
ASSESSING WATER CONSERVATION & AQUIFER SUSTAINABILITY

In addition to a punishing climate, Djibouti suffers from a scarcity of fresh water. Currently, CLDJ uses brackish groundwater beneath the camp as their primary water supply. This water is processed through a reverse osmosis system before it is suitable for drinking. In conjunction with hydrologists from the U.S. Geological Survey, NAVFAC EXWC engineers conducted a study of groundwater quality and prepared a model to help evaluate current and potential impacts of the camp on the local water table. Their findings indicate that the camp is having a minimal impact to the water table. However, the city of Djibouti is depleting the groundwater at a faster rate than it is being replenished, due to its high temperatures, low rainfall and high evaporation rates. Saltwater intrusion has already been affecting some of the city's wells, raising concerns about long-term sustainability of the water supply. For these reasons, water conservation is a high priority at CLDJ.

The groundwater in Djibouti is very limited and has a high salt content. Shown here is the camp's combined discharge from its wastewater treatment plant and reverse osmosis water treatment facility. Even though the groundwater has a high salt content, wild dogs still use it as a drinking water source.
Bruce Holden

NAVFAC EXWC engineers conducted a water conservation study and inventory in January 2012 with follow-up study and inventory in April 2012. An inventory of water fixtures and testing of fixture flow rates was conducted to quantify water consumption in male and female ablution CLUs. The largest overall usage of water on the camp is for showering. Other primary uses of water include laundry operations, vehicle and aircraft washing, toilets, and rest room unit sinks.

Based on the findings and observations from this study, options were summarized into immediate, intermediate, and long-term recommendations.



Because of their dramatic impacts to overall water savings, the installation of low-flow shower heads and water-efficient washing machines was initiated immediately. After less than six months, actual observed reduction in water use from the installation of 238 low-flow shower heads and 72 new washing machines was 13 million gallons per year or 17 percent of overall base water use. Based on a $0.05 per gallon water production and treatment cost, the installation of the first set of shower heads was estimated to save approximately

$1 million per year. The remaining 771 shower heads and high-efficiency washing machines have been installed, and the resulting base-wide water savings are expected to reach 24 percent or 19 million gallons (over $2 million per year).

Recommendations in the intermediate timeframe include installing water meters to better track water use, surveying and repairing leaks on a regular basis, and installing drinking fountains with water bottle fixtures to encourage the reuse of water bottles. The drinking water distribution system and drinking fountains are currently being installed.

Most of the long-term recommendations for water conservation relate to the treatment of wastewater. The wastewater plant at CLDJ currently treats approximately 180,000 gallons per day of wastewater. Of this, 125,000 gallons per day could theoretically be treated to tertiary standards and made available for water reuse applications. However, little of the available reuse water is actually being used. This low reuse rate is a function of not having a good reuse water distribution system.

Bruce Holden

Abigail Goss

New shower heads, sink aerators and clothes washers at CLDJ are estimated to save approximately $2.2 million per year in water costs.

IDENTIFYING SOLID WASTE REDUCTION OPPORTUNITIES

In October 2009, the NAVFAC EXWC team traveled to Camp Lemonnier to obtain onsite solid waste generation and disposal (recycling, incineration and landfilling) data. The team found that in fiscal year 2009 (FY09), CLDJ incinerated 7,897.52 tons of solid waste at a cost of $650,000. For FY09, the camp had a diversion rate of 1.04 percent. This was far below the diversion goals of 40 percent for 2010 and 50 percent for 2015 set in Executive Orders 13423 and 13514.

A challenge to meeting its diversion goals was the low performance of the camp's incinerators. The incinerators were experiencing structural internal decomposition in part due to the high moisture content of the solid waste being combusted. The incinerators were using up to 1,000 gallons per day of diesel fuel.

At the outset of this effort, the camp had just a 1.04 percent diversion rate for recycling, well below the DoD's 40 percent goal.

In 2012, the NAVFAC EXWC team conducted a solid waste characterization to identify the composition and amount of waste generated by the camp. The characterization entailed physically sorting solid waste into select categories. The intent of the characterization was to analyze the feasibility of energy recapture from the incinerators, look at the economics of a waste-to-energy (WtE) system, and identify opportunities to reduce the moisture content of the waste stream entering the incinerators. The study found the camp generated 12 tons per day of solid waste, with food waste accounting for approximately 30 percent of the camp's total waste stream, contributing to an overall moisture content of 40 percent.

Diverting the majority of this food waste would aid the camp in achieving its diversion goals as well as help the incinerators sustain a more

The resulting base-wide water savings are expected to reach 24 percent or 19 million gallons per year.

complete combustion and run much more efficiently. The heat content of the solid waste material was calculated to determine the energy available. WtE was feasible, but the current inefficient operations of the camp's incinerator made it undesirable at the time.

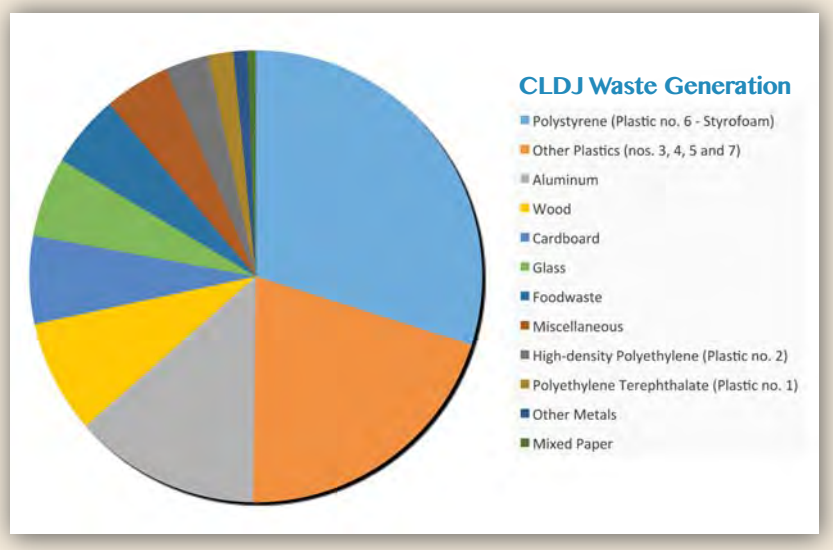
NAVFAC EXWC engineers recommended that the camp install the following:

1. Sorting Conveyor

   A sorting conveyor will increase the diversion rate, remove noncombustibles and reduce the amount of moisture in the waste sent to the incinerator.

2. Shredder

   A dual axle shear shredder will reduce the particle size of solid waste material to create better refuse-derived fuel. It would also shred plastic bottles, thereby removing excess water contained therein.



3. Composting System

   There is a suitable feedstock (food waste) to compost at CLDJ, and the incinerator's fuel usage provides a cost savings incentive to implement this program. Compost can be used as a soil amendment for the planting of ground cover, which would aid in dust suppression. Adding compost to soil also aids in water retention and provides organic material.

The addition of a new galley on the camp in 2012 had the potential to alter the waste composition entering the incinerators, so a second solid waste characterization was conducted in 2013. The purpose of this follow-up

The Basics About the Naval Facilities Engineering and Expeditionary Warfare Center

NAVFAC EXWC is the Navy's premier activity for facilities and expeditionary technology solutions, engineering services, equipment logistics and products needed to equip the fleet and meet warfighter requirements. NAVFAC EXWC also delivers specialized engineering and technology solutions that support sustainable facilities and provides logistics and expeditionary systems support for Navy combat force capabilities.

For more information about NAVFAC EXWC, visit www.navfac.navy.mil/navfac_worldwide/specialty_centers/exwc.html.

study was to quantify any changes in the moisture content and WtE potential. In general, the results of the 2013 waste characterization were similar to the results of the 2012 study. It was determined that WtE was still not economically viable.

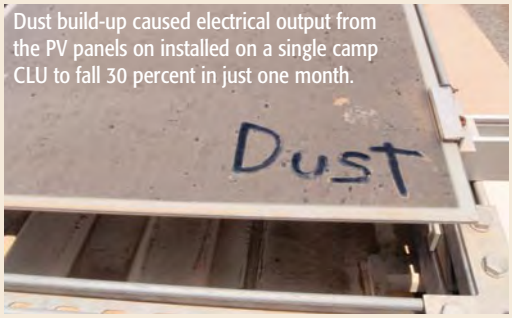
NAVFAC EXWC engineers developed an integrated solid waste management plan in 2013 that served as an update to the plan developed in 2009 and included the following recommendations:

1. Modify waste collection and segregation.
2. Convey incinerator ash off-site for proper disposal.
3. Ensure that sufficient space is available for a recycling center.
4. Develop a composting system.
5. Eliminate the use of plastic water bottles and reduce the number of liquid-filled water bottles being sent to the incinerator.
6. Ensure that construction and demolition debris is reused or recycled.
7. Eliminate the use of a local open dump through a combination of recycling, incinerating and composting.

Based on the original 2009 recommendations, NAVFAC EXWC purchased two vertical balers, recycle bins, a truck scale, pallet scale and scale management system to help CLDJ with solid waste management. In 2013, CTC conducted a solid waste management technology study and recommended a specific composting system and shredder.

NAVFAC EXWC personnel prepared an Energy Conservation Investment Program (ECIP) submittal for the acquisition of the shredder and composter. The ECIP was approved and will fund the capital cost and a portion of the operation and maintenance cost and is slated for installation in FY15.

To help reduce the camp's reliance on bottled water, CLDJ recently switched to a water distribution system (piped water). This has helped to reduce the number of water bottles incinerated or diverted off-base. Construction of a new landfill was initiated in 2012. When finished, some waste (such as compost and noncombustible material) can be disposed of there.



Dust build-up caused electrical output from the PV panels on installed on a single camp CLU to fall 30 percent in just one month.


PV panels are now cleaned three times per week by an automatic sprinkler system.

STUDYING THE FEASIBILITY OF SOLAR PHOTOVOLTAIC SYSTEMS

As a result of NAVFAC EXWC's initial 2008 assessment, it was determined that solar-generated electric power might be one of the best options for incorporating renewable power at CLDJ and thus reduce diesel fuel consumption associated with the existing generators. Djibouti is located in an area of the world with one of the highest solar radiation levels. To demonstrate the potential for solar power, solar photovoltaic (PV) panels were installed in 2010 by NAWS China Lake personnel on the roof of a single camp CLU. The installation included a data acquisition system so the team could monitor the system performance for a one-year test period.


A 12-PV CLU roof-mounted system was installed in September 2012.

The camp generated 12 tons per day of solid waste, with food waste accounting for approximately 30 percent of the camp's total waste stream.

Unfortunately, due to the dust, wind, and heat, the data acquisition system failed within two months. After a three-month period without data, the data acquisition system was briefly brought back on-line. At this point the demonstration was suspended. The limited results from this study showed that the electrical output was significantly reduced by a dust build-up on the panels, with the electric output falling up to 30 percent in one month. Particularly in the summer, Djibouti suffers from very frequent dust storms, so these results were probably not atypical.

The CLDJ PV panel installation team. Back row, left to right: Builder Constructionman (BUCN) Carnes; Construction Electrician Petty Officer 3rd Class Zonis; Construction Electrician's Petty Officer 2nd Class Piza; BUCN Seabee Combat Warfare, Michael Coria; Sam Edwards, NAWS China Lake; Matt Malone, NAWS China Lake. Front row, left to right: Steelworker Petty Officer 3rd Class Darcy Via, BUCN Hill, Utilitiesman Constructionman Smith.

Based on these results, it was decided to proceed with a new demonstration that included a panel washing system, an improved data acquisition system, and high-temperature rated inverters. The original PV system was removed and a 12-CLU roof-mounted system was installed in September 2012. Performance data were collected on the new system for a 7-month demonstration period. At the 7-month point, the new data acquisition system failed during a severe storm, although the system continues to produce approximately 57,000 kilowatt hours of electricity per year. The main result of this demonstration was to determine that washing the panels three times per week was sufficient to maintain the system performance. Although the system currently uses potable water for the cleanings, in the future, reuse water could be employed.

The Camp Lemonnier NAVFAC EXWC Sustainability Team

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*NAWS China Lake employee

IMPLEMENTING A STREET LIGHTING IMPROVEMENT PROGRAM

Early in the sustainability program, street lighting at the camp was identified as an area where significant energy improvement could be achieved. At the onset of this project, there were over 500 High Pressure Sodium (HPS) light fixtures installed at CLDJ.

A NAVFAC EXWC task force undertook a one-year demonstration to determine a more efficient lighting solution to replace the HPS fixtures. In addition to reduced energy usage, the team's goals also included equal or better lighting performance with appropriate illumination. The team performed a market survey of information on three technologies—induction lighting, Light-emitting Diode (LED) and plasma lights. Plasma lighting was eliminated from consideration since it was not yet a proven technology. So the demonstration proceeded with induction lighting and LED fixtures. Four induction and two LED fixtures were procured, installed, and monitored over a period of one year.

NAVFAC EXWC personnel recommended the procurement of induction light technology for the lamps in all of CLDJ's street lights.

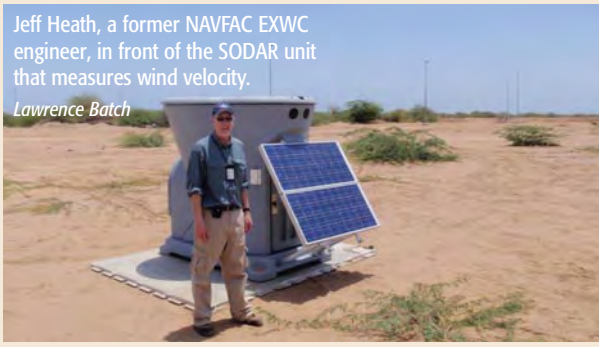
After a year, both lighting technologies performed as expected, with no observed drop-off in light intensity. Although the LED technology showed lower energy usage per kilowatt hour (kWh), the associated procurements costs are double that of the induction light. In addition, the LED bulbs provide less illumination, and CLDJ personnel encountered difficulty installing the fixtures to the existing street light poles.

Over the one-year period, the induction lights used 56 percent less energy than the HPS fixtures. This translates to an annual savings of $139,000 with an expected payback period of less than four years.

NAVFAC EXWC personnel recommended the procurement of induction light technology for retrofit of all 544 of the lamps in street lights at CLDJ. CLDJ submitted an ECIP proposal which was approved. Street light retrofits are slated for FY15.

INVESTIGATING WIND POWER

A feasibility analysis for wind turbine power was performed at Camp Lemonnier between April 2011 and June 2012. Data were collected using a Sonic Detection and Ranging (SODAR) unit—a device that is placed on the ground and sends sonic "chirps" into the atmosphere. Wind velocity is measured by detecting the shift in the reflection of the chirp. This device measures wind at 20 meter intervals from 40 meters to 200 meters high. The unit takes 10 minute averages and records wind speed, direction, and vertical speed.



Jeff Heath, a former NAVFAC EXWC engineer, in front of the SODAR unit that measures wind velocity.
Lawrence Batch

The wind resource at CLDJ was found to be poor. The average wind speed at 80 meters is 4.6 meters per second (m/s) or 10.3 miles per hour. At 40 meters, the wind speed is 4.3 m/s (9.6 miles per hour). In most cases, this would be a non-starter for a wind project since the minimum speed usually required for such a project must be at least 13 miles per hour at the turbine's hub height. But due to the high cost of energy at CLDJ, an economic analysis was performed.

Because CLDJ has an airfield and is next to an airport, there are restrictions that would limit the height of any wind turbine. Analyses were performed for two turbines of acceptable size. However, the combination of low performance and high construction costs clearly showed that neither project would break even. For all of these reasons, wind is not a cost-effective energy alternative for Camp Lemonnier.

Over the one-year period, the *induction lights* used 56 percent less energy than the High Pressure Sodium fixtures.

SAVINGS TO DATE

In total, the NAVFAC EXWC-initiated projects to reduce electricity use and produce renewable energy have reduced the total camp electric load by an estimated 3.4 percent. The split air conditioning improvements alone are estimated to save 1,575,276 kilowatt hours per year. In total, these electric savings reduced the camp's need for fuel oil by over 400 gallons per day. Additional efforts by CLDJ to consolidate the camp's electric grid into a single grid and phase out their least efficient diesel generators has led to an overall 13.5 percent reduction in energy intensity relative to the 2003 baseline. Water savings from NAVFAC EXWC's efforts have been even more substantial. A 22 percent reduction in water use has been achieved.

Significant additional savings will occur once the following ECIP projects are completed:

1. Food Waste Composting

   Food waste composting will reduce the quantity of fuel oil required to operate the waste incinerators by up to 1,500 gallons per day.

2. Street Lighting Retrofits

   Street lighting retrofits will result in daily savings of 1,835 kWh.

3. Reuse Water Piping System

   A reuse water piping system will save potable water once new military construction projects are initiated that are designed to utilize reuse water. Potential savings cannot be estimated at this time.

NAVFAC EXWC has spent $4.9 million on this five-year effort. Overall, the expected payback period is 1.6 years. In addition to cost savings, another important benefit to these projects is improved energy security achieved by the reduced consumption of fuel to run the camp's generators.

HOW OTHERS CAN BENEFIT

The energy-saving practices being enacted at Camp Lemonnier have wide-ranging implications, particularly for military bases located in hot or remote climates. Facilities in California and the American Southwest, for example, are already subject to water shortages, and many bases worldwide struggle with high energy costs. For Forward Operating Bases powered by diesel generators, the information provided in these reports and assessments provide valuable assistance with improving generator performance as well as cutting energy demand.

News about the CLU air conditioning improvements (known as the SuperCLU) is spreading. Soldier Warfighter Operationally Responsive Deployer for Space (SWORD) is using a SuperCLU administrative structure as a Command Launch Center for its test site in Cape Canaveral, Florida. SWORD is a joint DoD/National Aeronautics and Space Administration project to develop and demonstrate a very low-cost expendable nano-launch vehicle for on-call delivery of miniaturized satellites into Earth's orbit.

Transformative Reductions in Operational Energy Consumption (TROPEC) just concluded a test of the SuperCLU at Anderson Air Force Base in Guam. TROPEC is an assessment platform for expeditionary camp solutions. The Army and Air Force conducted concurrent tests. The Army has requested use of the SuperCLU prototype for 12 months. The NAVFAC EXWC team has been coordinating funding with U.S. Army Natick Soldier Research, Development and Engineering Center.

For more information on any of these projects, contact one of the members of the Camp Lemonnier NAVFAC EXWC Sustainability Team.

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