Net Zero Progress Report

Net Zero Pilot Installation Initiative

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Assistant Secretary of the Army
(Installations, Energy and Environment)

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ACRONYMS AND ABBREVIATIONS

BTU	British thermal unit
CEP	central energy plant
CHP	combined heat and power
CSP	concentrated solar power
DLADS	Defense Logistics Agency Disposition Services
DoD	Department of Defense
DOE	U.S. Department of Energy
ECM	energy conservation measure
EEAP	Energy Engineering Analysis Program
EISA	Energy Independence and Security Act of 2007
EMCS	Energy Management Control System
EMS	Environmental Management System
EO	executive order
EPA	U.S. Environmental Protection Agency
EPAct05	Energy Policy Act of 2005
ERDC	U.S. Army Engineer Research and Development Center
ESA	energy security assessment
ESPC	energy savings performance contract
FY	fiscal year
GSA	U.S. General Services Administration
GSHP	ground source heat pump
HVAC	heating, ventilation and air-conditioning
LED	light-emitting diode
MDMS	Meter Data Management System
MOU	memorandum of understanding
MRE	meals-ready-to-eat
NREL	National Renewable Energy Lab
NZEI	Net Zero Energy Installation
OACSIM	Office of the Assistant Chief of Staff for Installation Management
OASA(IE&E)	Office of the Secretary of the Army for Installations, Energy & Environment
ODASA	Office of the Deputy Assistant Secretary of the Army
ODASA(E&S)	Office of the Deputy Assistant Secretary of the Army for Energy & Sustainability
PPA	Power Purchase Agreement
PV	photovoltaic
PNNL	Pacific Northwest National Lab
QRP	Qualified Recycling Program
REM	Resource Efficiency Manager
RFTA	Reserve Forces Training Area
SIR	savings-to-investment ratios
SHW	solar hot water
SRM	Sustainment, Restoration and Maintenance

SVP	solar ventilation preheating
SWAC	sea water air conditioning
UESC	Utility Energy Service Contracts
USACE	U.S. Army Corps of Engineers
WTE	waste-to-energy
WWTP	wastewater treatment plant

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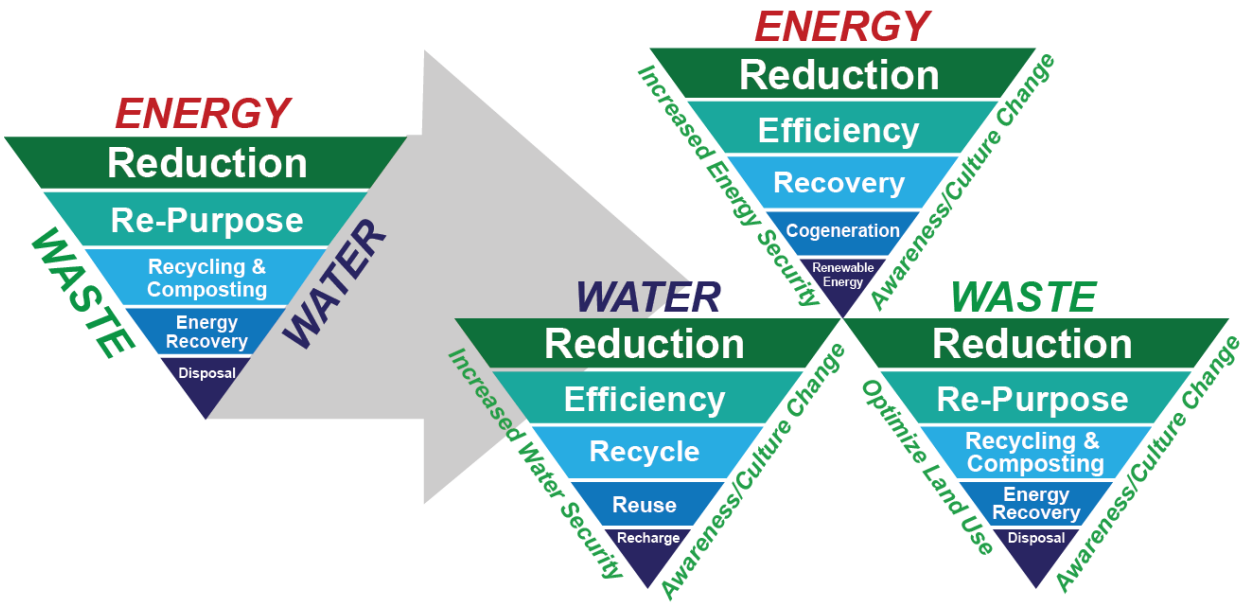
EXECUTIVE SUMMARY

The Army's Net Zero Initiative is built upon the Army's long-standing energy efficiency and sustainability practices. It is a strategy for managing existing federal energy, water, and solid waste programs with the goal of exceeding minimum targets where fiscally responsible, to provide greater energy and water security and increase operating flexibility. Under the Army's Net Zero Initiative, Army installations are focused on achieving broad goals: (1) to produce as much energy on-site as they use annually; (2) to limit the consumption of freshwater resources and return water back to the same watershed so as not to deplete the groundwater and surface water resources of that region in quantity or quality; and/or (3) to reduce, reuse, and recover solid waste streams by converting them to resource values with zero solid waste to landfill.

Since April 2011, the Army has provided technical assistance to 17 pilot installations and one state-wide energy pilot, striving towards Net Zero Energy, Water, Waste or all three. These pilots are serving as test beds to identify lessons learned and best practices to be institutionalized across the Army enterprise. This report provides a summary of the progress to date, identifies best practices in energy, water, and waste, and delineates the next steps to institutionalize Net Zero Army-wide.

Over the last two years of support to the Net Zero Initiative, several significant results have become apparent. The Net Zero hierarchy, the framework for the Net Zero strategy, was refined into subordinate hierarchies for each area of Net Zero. As the Initiative progressed, it became clear that the Net Zero hierarchy applies differently to energy, water and waste, and alternate versions of the Net Zero hierarchy were needed to capture differences. The hierarchies together articulate an overall approach that is not only consistent across installations, but also allows for unique solutions to emerge for each installation in accordance with their specific circumstances. At the same time, the Army has tracked common types of activities occurring at the pilot installations. These best practices became evident as a direct result of the ongoing collaboration between the pilot installations and Army Headquarters through monthly collaboration calls and periodic progress meetings. They will also serve an important role in transitioning Net Zero throughout the Army.

The Army will issue a policy in FY2013 to expand the Net Zero Initiative to all permanent Army installations. Other activities to institutionalize Net Zero will include working with Commands/Direct Reporting Units to effectively implement Net Zero Army-wide and a comprehensive gap analysis to determine appropriate insertion points for Net Zero into existing Army policy and guidance. Institutionalization of Net Zero will take more than incorporating metrics and goals into Army doctrine. Significant change is needed in how Army leaders, Soldiers, civilians, and contractors think, plan, and operate. Fostering a Net Zero ethic will also require the Army to create a culture in which installations recognize the limits of natural resources and where sustainability is embraced and re-energized to support the Army's mission.



1.0 Introduction

The Net Zero Initiative is a holistic strategy for managing energy, water, and waste at Army Installations. Under the Army's Net Zero Initiative, every Army installation will evaluate the feasibility of and implement to the maximum extent practicable:

- producing as much energy on-site as it uses annually;
- limiting the consumption of freshwater resources and returning water back to the same watershed so as not to deplete the groundwater and surface water resources of that region in quantity or quality; and/or
- reducing, reusing, and recovering solid waste streams by converting them to resource values with zero solid waste to landfill.

The Net Zero Initiative is a force multiplier enabling the Army to appropriately steward available resources, manage costs, and provide Soldiers, families and civilians with a sustainable future. Since April 2011, the Army has provided technical assistance to 17 pilot installations and one state-wide energy pilot, striving towards Net Zero Energy, Water, Waste or all three. These pilots are serving as test beds to identify lessons learned and best practices to be institutionalized across the Army enterprise. This report provides a summary of the progress to date, identifies best practices in energy, water, and waste, and delineates the next steps to institutionalize Net Zero Army-wide.

2.0 Background

Net Zero contributes to the Army strategy for sustainability and energy security. Net Zero applies the principles of integrated design to ensure the Army appropriately manages its resources. It is a holistic strategy that builds upon long-standing sustainable practices and incorporates emerging best practices in building and community to manage energy, water, and waste at Army installations. The Army's concept for Net Zero recognizes that more sustainable Army communities are more mission capable, resilient and compatible with local community needs. Net Zero also supports compliance with a variety of Federal mandates and statutes such as those contained in Executive Order (EO) 13514, the Energy Policy Act of 2005 (EPAct05), and the Energy Independence and Security Act (EISA) of 2007.

The Net Zero Initiative was announced in October 2010, and by February 2011, multiple interested installations had nominated themselves to take part. On 19 April 2011, the Army identified 17 pilot installations striving to bring the overall consumption of resources within their respective assigned category down to an effective rate of zero by 2020. The pilot installations (Figure 1) vary in population, are geographically diverse, and include representation from all Army Commands. They range greatly in physical acreage from Fort Bliss with over 1,000,000 acres to Fort Detrick with less than 1,500 acres. They also support a wide range of Army missions from research and testing at Kwajalein Atoll, to education at West Point, to innovation

at Tobyhanna Army Depot, and to training, deployment and sustainment of units and teams for combat at Fort Carson. The pilot installations have and will continue to serve as model communities for sustainability and quality of life.

Net Zero Pilot Installations:

Aberdeen Proving Ground
Camp Rilea
Fort Bliss
Fort Buchanan
Fort Carson
Fort Detrick
Fort Hood
Fort Hunter Liggett
Fort Polk
Fort Riley
Grafenwoehr
Joint Base Lewis-McChord
Kwajalein Atoll
Parks Reserve Forces Training Center
Sierra Army Depot
Tobyhanna Army Depot
West Point

State-Wide Pilot:

Oregon Army National Guard

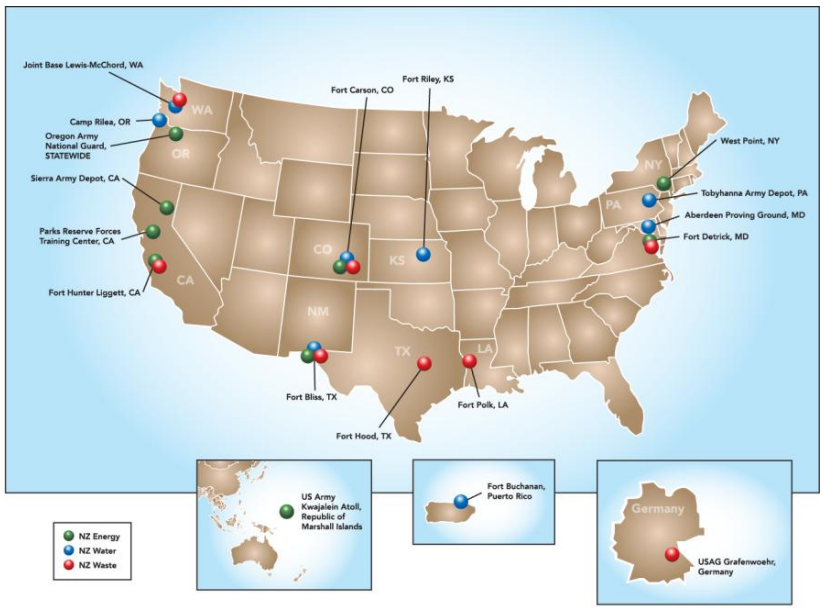


Figure 1. Net Zero Pilot Installations

The cornerstone of the Army's Net Zero Initiative is the Net Zero Hierarchy, comprised of five interrelated steps: reduction, re-purpose, recycling and composting, energy recovery, and disposal (Figure 2). Each step of the Net Zero Hierarchy is a link toward achieving Net Zero in each area of energy, water, and waste. Reduction includes maximizing energy efficiency in existing facilities, implementing water efficiency practices, and eliminating generation of unnecessary waste. Re-purpose involves diverting energy, water, or waste to a secondary purpose. Recycling or composting involves management of the solid waste stream, development of closed-loop systems to reclaim water, or co-generation where two forms of energy (heat and electricity) are created from one source. Energy recovery occurs from energy waste streams, such as exhaust air, condenser heat, cascading return hot water or chiled water streams, boiler stacks, waste water sources, or converting unusable waste to energy. Landfill disposal of waste and building of energy projects are the last of the interrelated steps of the Net Zero Hierarchy, which are to be implemented only after the last drop of water, the last bit of thermal energy, and all other waste mitigation strategies have been fully exercised. The goal is for these interrelated steps to be integrated into the installation's long-term planning efforts, including its master plan, while also evaluating the benefits of installation management actions and projects on a number of variables, including cost.

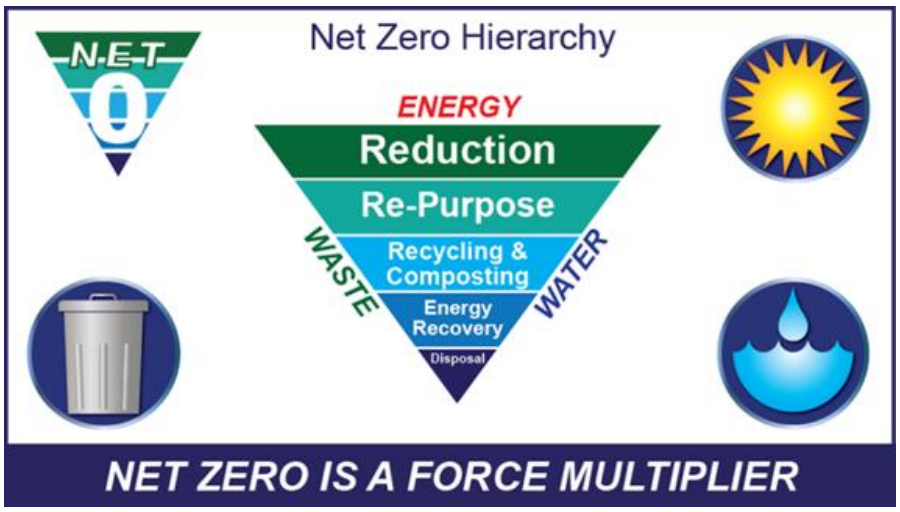


Figure 2. Net Zero Hierarchy

Baselines and Roadmaps

The Office of the Deputy Assistant Secretary of the Army for Energy and Sustainability (ODASA(E&S)) provided support to the Net Zero Pilot Installations in order to conduct baseline assessments and develop roadmaps to guide the installation Net Zero initiatives. Conducting a baseline assessment is a very common and conventional method used to assess the current conditions of a system, project, or organization and develop a snapshot of performance to pinpoint opportunities and analyze future performance. The various baseline methods used for the Net Zero Energy, Water and Waste Pilot Installations are discussed in the respective sections that follow.

Although the concept of a roadmap is also somewhat conventional, ODASA(E&S) personnel developed a framework they believed would be most valuable for the Net Zero Initiative. Generally, a Net Zero Roadmap describes the strategy for achieving an installation's Net Zero goals. The roadmap process compares the current energy use (derived from baselining), water use (established with the water balance), and waste creation (based on waste characterization) with the desired end-state. Using information about the major consumers, the costs of using these resources, alternative sources of water and energy, and alternative methods to waste removal and applicable technologies, various courses of action are described, compared, and prioritized. The roadmap allows installations to conduct planning to reach their goals. Roadmaps also propose likely funding sources and other implementation strategies. The various roadmap methods used in the Net Zero Initiative are also discussed in the sections that follow.

3.0 Net Zero Actions and Activities

3.1 General Net Zero Actions and Activities

Collaboration

Collaboration has been a cornerstone of the Net Zero Installation Pilot Initiative, both internally and externally. To support Net Zero, collaboration has been established at three general levels: monthly collaboration calls, periodic progress review meetings, and collaboration with other federal agencies.

Collaboration calls are held each month to share installation progress toward achieving Net Zero goals, understand and discuss challenges, address specific technical topics, and disseminate information. Participants included the pilot installations, relevant Army organizations (e.g., Army Environmental Command, Installation Management Command, Army Public Health Command), and Army partners (e.g., Defense Commissary Agency, Defense Logistics Agency). Best practices, success stories, and lessons learned were tracked and recorded throughout the calls.

Net Zero Progress Review Meetings were held in June 2011 at Fort Detrick and in January 2012 at a conference center in downtown Chicago, IL. The progress review meetings included brief plenary sessions that included keynote addresses by Honorable Katharine Hammack and other senior Army leaders, and extended break-out sessions for Net Zero Energy, Water and Waste. In July 2012, a Net Zero Waste Progress Review Meeting workshop was held at Joint Base Lewis-McChord that focused solely on Net Zero Waste and included a tour of key elements of the Joint Base Lewis-McChord Net Zero Waste initiative. In September 2012, a similar Water-only workshop was held at Tobyhanna Army Depot that included a tour of key elements of the Tobyhanna Army Depot Net Zero Water initiative, such as leak detection and rainwater harvesting. All progress review meetings provided opportunities for each pilot installation to share and discuss the progress and challenges, and other Army experts and partners to share valuable information to assist the pilot installations in achieving their Net Zero goals. Moreover, the personnel representing the pilot installations were able to form new and stronger relationships that led to increased collaboration.

The Army is also collaborating with other federal agencies in support of the Net Zero Initiative, including the U.S. Department of Energy (DOE), the U.S. Environmental Protection Agency (EPA), and the U.S. General Services Administration (GSA). Based on the 2010 Memorandum of Understanding (MOU) between the Department of Defense (DoD) and the DOE, the DOE labs, including the National Renewable Energy Lab (NREL) and the Pacific Northwest National Lab (PNNL), are providing direct support to Army Net Zero Pilot Installations. NREL conducted assessments and roadmaps of the Net Zero Energy Pilot Installations. PNNL conducted water balance assessments and is still developing water roadmaps for the Net Zero Water Pilot Installations. Based on a 2011 MOU between the two agencies, the Army and EPA are working to identify potential technology demonstration projects at several candidate Net Zero Water Pilot

Installations. The Army actively engaged with the EPA's Office of Research and Development as a part of the Net Zero Water program to conduct joint research projects to support Net Zero. The EPA met with Joint Base Lewis-McChord and Fort Riley to review EPA capabilities and potential projects. Fort Riley will be the host site for several demonstration projects including a social awareness campaign to reduce water use and "sewer mining" using a membrane bioreactor technology to create reclaimed water for use at the installation's central vehicle wash facility. The Army and GSA have developed a plan for the GSA's first Demonstration Research Project with the Army, which will evaluate and implement best practices and strategies for achieving Net Zero Energy, Water, and Waste at Fort Carson, Colorado. The EISA calls for GSA's Office of Federal High-Performance Green Buildings to conduct an annual demonstration project on the green features of Federal buildings, including monitoring and data collection to study their impact on energy use and operational costs. The goal is to ensure that the Federal government learns from its experiences in green building and applies those lessons to current and future programs. Fort Carson is viewed as an ideal location for this joint effort because of its proximity to other military installations and opportunities to develop regional solutions and disseminate best practices.

Outreach, Behavior Change, and Awareness Campaigns

The Net Zero Initiative has re-energized existing sustainability efforts across the Army. Many of the pilot installations have shifted their existing sustainability outreach efforts to support their Net Zero Energy, Water and Waste initiatives. Education and awareness efforts are critical to behavior change. Energy, water, and waste awareness campaigns also promote attention to the use of energy and water resources and creation of waste as a normal part of all activity, including planning, training, and mission execution. Installations have used all facets of traditional and social media to conduct outreach. Some have built new Net Zero web sites and Facebook pages, and are using most of the prevalent social media outlets. Fort Polk has made a particularly strong effort to bolster their awareness campaign, including Public Service Announcements, posters, articles in the base newspaper, and providing "tweets" to the manager of the installation Twitter account. Tobyhanna Army Depot has instituted a water conservation award program to recognize individual exemplary efforts and raise awareness of Net Zero Water goals. Fort Bliss' Residential Community Initiative contractor completed a residential mock billing program and moved to live billing in November 2012 resulting in one third of homes conserving enough energy to qualify for rebates.

Leadership Buy-In and Engaging Existing Knowledge Base

All of the Net Zero pilot installations have command buy-in for and senior level commitment to achieving Net Zero Energy, Water, and Waste goals because leadership buy-in is so important to installation-wide management initiatives. In promoting their Net Zero efforts, the pilot installations have also created interest across diverse communities on their installations. This interest has identified academic, industrial and other unique skillsets that reside outside of the installation's Department of Public Works that can be tapped to support Net Zero Energy, Water, and Waste initiatives. A good example is how West Point created Cadet Energy and

Environmental Officers to encourage the 4,400-plus Corps of Cadets to support the Net Zero Initiative.

Senior leader support for Net Zero has been widespread, providing additional interest in and support for on-going sustainability efforts in other Army program areas. For example, green procurement teams have renewed focus on waste avoidance. Installation-level real property master plans are being updated to incorporate area development concepts, distributed water and waste water, and central utility plants. Net Zero approaches have also been incorporated into base camp design and other aspects of contingency operations.

3.2 Net Zero Energy

The Net Zero Energy hierarchy (Figure 4) updates energy approaches from the initial Net Zero hierarchy (Figure 3). It is first focused on energy reduction through conservation followed by energy efficiency. Once energy use is reduced as much as possible and energy efficient technologies have been implemented, the hierarchy dictates that energy recovery and cogeneration be investigated. Remaining energy loads are to be met with the use of on-site renewable energy sources. Spanning all of the hierarchy steps are "Increased Energy Security" and "Awareness/Cultural Change." The first overarching action acknowledges that achieving Net Zero does not ensure energy security and that additional steps must be taken to achieve both goals. The second overarching action emphasizes the need to integrate awareness and culture change into all Net Zero efforts.

Figure 3. Net Zero Hierarchy

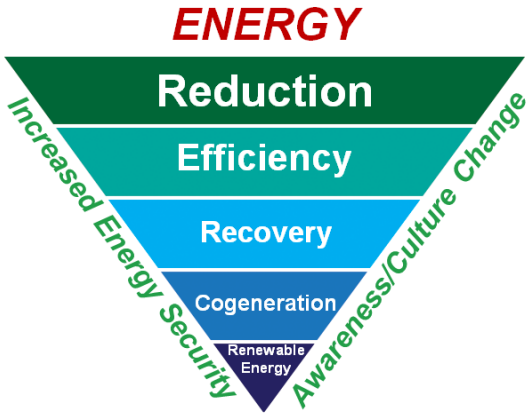


Figure 4. Net Zero Energy Hierarchy

Overarching actions

A number of overarching actions were taken over the past year in support of the Net Zero Energy pilot installations. The Energy Engineering Analysis Program (EEAP) conducted Energy Assessments at the pilot installations to identify energy inefficiencies and wastes in representative buildings, and to propose energy-related projects that could assist the Installation

in meeting its Net Zero Energy goals. The assessment included a Level I/Level II study of energy conservation opportunities including an analysis of building envelopes, lighting, ventilation air systems, controls, and appliances.

Opportunities have been assessed at the pilot installations for increasing energy security through increased energy efficiency and optimized renewable energy strategies. These assessments established the installation's energy baseline, evaluated energy efficiency measures to reduce load, and assessed renewable energy potential to meet the remaining load. The final output of the assessment was used to develop a roadmap of projects and implementation considerations to achieve Net Zero Energy by 2020.

NREL did the assessments above and developed Net Zero Energy Installation (NZEI) roadmaps for the Net Zero Energy Pilot Installations. The roadmaps first establish an energy baseline, or an analysis of the installation's current and predicted energy consumption, using the EEAP reports. The roadmaps then address actions for reducing energy consumption by evaluating energy efficiency measures. Installation-specific renewable energy potential was then assessed to meet the load that would remain after all energy reduction actions are executed. Renewable energy technologies for both thermal and electric loads were technically and economically evaluated. Renewable energy interconnections issues were analyzed and prospective microgrid systems were considered. Then, as the final step of the roadmap, a project implementation timeline was developed that would allow Net Zero Energy to be achieved by 2020.

An energy security assessment (ESA) was also conducted for Fort Hunter Liggett to assess the many ongoing and planned energy projects designed to meet Net Zero and to determine how these energy projects relate to improving energy security. The ESA methodology details eight steps to ensure that energy security is a part of the Net Zero decision-making process and is integrated into energy system infrastructure upgrades. The final outcome was a defined roadmap which details all recommended actions and provides a suggested chronological order in which the actions should be performed to reach a Net Zero Energy goal by 2020. An integrated energy and water security assessment is being developed currently at Fort Bliss.

Hierarchy Actions

1. Reduction

Metering/Monitoring

Fort Carson has begun analyzing facility meter data collected from 238 facilities connected to the Army Meter Data Management System (MDMS) to determine facility energy intensities. Moving forward, this information will help to inform the installation and promote solutions that best support Fort Carson's Net Zero Energy goals. Fort Detrick Energy, Operations, and Maintenance personnel have begun remotely monitoring heating, ventilation and air-conditioning (HVAC), and lighting systems that allows staff to proactively monitor buildings for

service issues prior to emergency situations, and lower energy use for buildings that are not continuously occupied.

2. Efficiency

Energy Efficient Lighting/Retrofits

Parks Reserve Forces Training Area (RFTA) has completed the installation of parking lot light-emitting diode (LED) lights, and the first two phases of exterior LED replacements. West Point is funding LED street lights through sustainment, restoration and maintenance (SRM) funds. Currently West Point has two awarded Energy Saving Performance Contract (ESPC) task orders covering lighting upgrades in various buildings. Fort Carson and Fort Detrick also installed lighting upgrades and retrofits. Fort Hunter Liggett has lighting upgrades underway at this time.

Energy Efficiency Upgrades

Numerous pilot installations have focused on building envelope improvements; these are underway at Fort Hunter Liggett and Kwajalein. Fort Carson is accomplishing these improvements through an ESPC. At West Point, SRM funds are being used to replace exterior door weather-stripping. West Point also used low bid savings to add several energy enhancements to the Science Center project such as: low emissivity glazing, elimination of thermal bridging, lighting controls, and their first ever central chiller plant. The New Cadet Barracks is set to be the Army's most efficient barracks.

Numerous heating and power plant energy efficiency upgrades were completed or are in-process. Fort Carson has installed boiler replacements and based on the results of an ERDC-CERL study, is starting construction of a Net Zero-ready Central Energy Plant (CEP) for the Combat Aviation Brigade (CAB). Fort Detrick installed high efficiency gas-fired boilers to replace an older inefficient centralized steam plant. Anticipated annual savings are approximately $1,500,000 in energy and operating and maintenance costs, a 50% reduction in natural gas consumption, a 10,000,000 gallon reduction in water use, and a savings of 10 tons of greenhouse gases. Kwajalein installed a 1.9 MW generator addition to their power plant that achieves energy savings by following the load more closely with a smaller un-required spinning reserve.

3. Recovery

Army installations will use heat recovery from exhaust air for outdoor air pre-heating/pre-cooling either with new contruction or with renovation projects to reduce need in thermal energy. Exhaust air heat recovery was utilized in West Point's New Barracks design and Scott Barracks retrofit as well as in new construction projects at Fort Carson CAB.

Grey water heat recovery is another way of reducing need in thermal energy. It is cost effective for waste water streams from dishwashers in dining facilities and when possible for waste water streams from showers in large barracks with new construction and major renovation projects.

CEPs with combined heat and power utilize heat from power generation for heating and cooling needs. ERDC has completed analysis for the CEP at West Point, which shows potential to provide heating, cooling and mission critical power to the installation's main area with 80% fossil fuel based energy reduction and become Net Zero Energy when converted from natural gas to biomass boiler synthetic gas in the future. Significant benefits can be achieved by utilization of heat recovered from Caterpillar power generating engines (water cooling circuits and stacks) at Kwajalein. This can be used for absorption cooling and reheat at buildings adjacent to the power plant.

4. Cogeneration

Cogeneration, also known as combined heat and power (CHP) simultaneously generates both electricity and useful heat and several pilot sites are implementing or investigating this technology. Parks RFTA has implemented a solar cogeneration project that will use photovoltaics (PV) to generate electricity while simultaneously providing heat for hot water. Fort Carson has installed a combined heat and power Infinia Sterling Dish. Fort Detrick is exploring potential for cogeneration at its central utilities plant, and West Point is analyzing and planning for major utility infrastructure projects like steam to hot water conversions and district chilling plants to prepare for cogeneration potential.

Kwajalein is exploring the potential to utilize the waste heat from its power plant to provide cooling through an adsorption chiller. Sierra Army Depot has a ground source heat pump system that recovers heat from the earth to increase the efficiency and reduce the operating costs of building heating. The Army is also exploring ventilation air heat recovery for new construction at the Net Zero installations as recommeded by the American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE) 90.1 and 189.1 standards.

5. Renewable Energy

Renewable energy systems were identified and evaluated for each pilot installation in the NREL Roadmap reports. Many of the pilots are investigating renewable energy technologies (blue in table), while some have implemented or are in the process of implementing (red in table) renewable energy. The renewable energy technologies (Table 1) are being considered at each pilot installation.

In addition to the common renewable energy technologies given in Table 1, several pilots are pursuing innovative projects. Fort Hungter Liggett is building a small-scale waste-to-energy (WTE) system through an Environmental Security Technology Certification Program (ESTCP) grant; Fort Detrick is exploring a WTE system at their waste incinerator facility and Kwajalein is

exploring a strategy for a sea water air conditioning (SWAC) district cooling system under an ESPC. Fort Carson has increased renewable energy to nearly 3.5% of its energy use.

Table 1. Renewable Energy Status at Pilot Sites

	Solar PV	Wind	SHW	SVP	GSHP	Biomass/ WTE	Geothermal	Other
Camp Parks	4 MW 25 kW on 1 building 28 kW ESTCP Solar CHP on 2 buildings Solar Street Lights 2 MW in design		8,000 ft^2 Conventional SHW on 2 buildings (550 ft^2) ESTCP Solar CHP 150 kW thermal on 2 buildings	11,000 ft^2	50 tons			
Fort Bliss	30 MW 20 MW system in development 2.3 MW installed		27,000 ft^2 Several systems installed	15,000 ft^2	10,000 tons	10-50 MW WTE	2-4 MW	10-20 MW Concentrating Solar Power
Fort Carson	110 MW PV (Only feasible at significant increased cost) 3 MW 1.5 MW in development	11 MW	53,000 ft^2 2 systems installed	107,000 ft^2 2 installed systems	16,000 tons	45 MMBTU/hr Biomass Heating 50-200 kW Biomass ESTCP		20 MW concentrating solar power (at increased cost)
Fort Detrick	24 MW RFP Issued for system estimated to be 10-20 MW		4,000 ft^2	1,400 ft^2		Potential to utilize medical waste incinerator for energy		
Fort Hunter Liggett	6 MW Solar Street Lights 1 MW Installed 1 MW In Construction 1 MW in Design		13,000 ft^2	1,200 ft^2	200 tons	425 kW WTE Gasification ESTCP Demo		Battery Energy Storage of 1 MWh in Design
Kwajalein	8 MW 60 kW 450 kW in development	9 MW	17,000 ft^2 20 ft^2 (1 building)					Analyzing Sea Water Cooling Options
Oregon NG	0-15 MW 313 kW 90 kW in development	8 MW		Hangars in Salem	Facilities in Climate Zone 5 Installed on 1 facility	3 MW Heating system has design funds	3 MW	
Sierra AD	2-5 MW 300 kW-1000 kW in development		11,000 ft^2	10,000 ft^2	900 tons System installed on 1 Building			
West Point	3-7 MW 100 kW	Viable Large Project/ Resource 10 kW	Appears cost effective; needs further analysis	Appears cost effective; needs further analysis	Conducting additional analysis		10 MW WTE and Biomass Heating	

Evaluated system potential in roadmap

Existing System

Additional systems in progress

PV = Photovoltaic

SHW = Solar Hot Water

SVP = Solar Vent Preheat

GSHP = Ground Source Heat Pump

WTE = Waste-to-Energy

kW = kilowatt

MW = Megawatt

ft^2 = square feet

3.3 Net Zero Water

The Net Zero Water hierarchy (Figure 6) is very similar to the overall hierarchy (Figure 5). It is focused on reduction of water use from all sources followed by improved efficiency. Installation decision makers identify the largest water uses and improve the efficiency of those uses – they seek to perform the same functions with less water. These efforts are a top priority as they should have the greatest effect on reducing *overall* water use. Next, installations maximize water recycling and reuse to reduce the demand on fresh water sources, protecting these surface or groundwater sources for future use. The final step in the hierarchy is focused on recharging the aquifer.

Figure 5. Net Zero Hierarchy

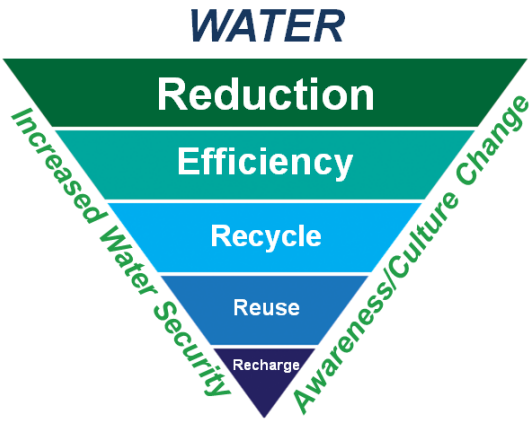


Figure 6. Net Zero Water Hierarchy

<u>Overarching Actions</u>

Several overarching activities were conducted over the past year in support of the Net Zero Water pilot installations. Water balance assessments were prepared for each of the pilot installations. A water balance provides critical baseline information on water use at a pilot installation. PNNL researchers reviewed historical data then conducted a site visit to observe and measure water use at a sample of facility types. This information is balanced with wastewater discharge data so that a complete picture of water use can be provided. The water balance assessments then became the foundation for the water roadmaps, also completed by PNNL. Because the water balance assessments were novel methods of analysis for Army installations, the roadmaps were very different from any previous analyses that have been done. The roadmaps are built upon a deep analysis of water use across the installation, and take into consideration a comprehensive cross-functional view of opportunities to achieve the Net Zero Water goal. Roadmaps were completed for two installations – Fort Bliss and Fort Carson – in FY2012. PNNL is planning to complete roadmaps for the remaining six installations in FY2013.

Net Zero Water actions will also increase an installation's water security. Water security is the assurance that water, potable and non-potable, of suitable quality will be provided at rates sufficient to fully support the Army wherever it has, or anticipates having, a mission in the future. The Army currently does not have an established method for assessing water security risks at installations based on this definition. A draft protocol was developed and tested at Joint Base Lewis-McChord in February, 2012. Lessons learned were incorporated into an integrated protocol for energy and water security, which is being applied to Fort Bliss in 2013.

The Net Zero Water efforts have included active engagement with the EPA's Office of Research and Development to conduct joint research projects to support Net Zero. Fort Riley will be the host site for several demonstration projects including a social awareness campaign to reduce water use and "sewer mining" using a membrane bioreactor technology to create reclaimed water for use at the installation central vehicle wash facility.

Hierarchy Actions

1. Reduction

The first step in the Net Zero Water hierarchy is reduction of water use from all sources. The pilot installations are using several different approaches to reduce total water use. Camp Rilea has been converting turf to native meadows and rain gardens to reduce irrigation needs. Fort Riley's turf grass replacement has helped to reduce irrigation water use by 12 million gallons per year.

Identifying and repairing leaks has occurred at several installations as part of their water use reduction efforts. Tobyhanna Army Depot has an aggressive metering and leak detection program that has helped them achieve a 38% reduction in water use intensity from their baseline. The leak detection system uses acoustic sensors which has helped them identify and fix leaks. Tobyhanna Army Depot is also installing new meters throughout the installation, currently at the rate of one new meter every two weeks. Fort Carson completed a leak detection survey that covered about 30% of the installation. This survey data indicates approximately 6% of the installation's overall use is attributable to leaks which can be fixed. Joint Base Lewis-McChord has an ongoing program to identify leaks and make repairs to the drinking water distribution system. Fort Riley is actively replacing their aging potable water distribution system in the post's historic area.

2. Efficiency

ESPCs are being used to replace plumbing fixtures at Fort Carson, Fort Bliss, Fort Buchanan, and Fort Riley. Water savings also save energy, which enables funding of many water projects that otherwise may not have sufficient savings-to-investment ratios (SIRs). The ESPC contract vehicle has been successfully applied for water conservation and efficiency projects. Fort Carson is using their ESPC to replace thousands of water fixtures with water conserving

fixtures. Fort Bliss recently approved its first retrofit project under an ESPC which will eventually retrofit 13,000 sinks, 7,000 showers, and 9,000 toilets. In order to do this, they need to take advantage of barracks that are empty due to deployments. ESPC projects recently completed at Fort Buchanan include base-wide replacement of water closet fixtures with EPA Water Sense-compliant ultra-low flow water fixtures such as aerators and water restrictors, shower heads, toilets and urinals.

Several installations have implemented or are pursuing irrigation efficiency projects because irrigation at several of the pilots is the primary potable water use. Fort Carson is using a weather-smart irrigation system. The computerized system adjusts irrigation based on weather conditions to improve efficiency. The installation is also in the process of altering design specifications to change the types of irrigation systems put into new construction, so that more efficient systems are installed. In January 2013, Fort Buchanan began installing a new golf course irrigation system using an on-site non-potable well and a 2 million gallon reservoir. The projected daily savings are 70,000 gallons of potable water.

3. Recycle

The pilot installations are seeking to maximize water recycling as part of their Net Zero efforts. Tobyhanna Army Depot uses reclaimed wastewater within their wastewater treatment plants to reduce the amount of potable water used. Several installations have developed proposals to increase the use of treated wastewater, including Fort Bliss (through the El Paso Water Utility), Joint Base Lewis-McChord (through a new WWTP that is currently being designed), and Aberdeen Proving Ground (through its groundwater remediation treatment plant). These proposals are based on the installation of purple pipe systems to distribute the reclaimed water for uses such as irrigation and industrial cooling.

4. Reuse

The installations are also examining ways to enhance their alternate water use. Fort Buchanan has a proposed ESPC project to implement rainwater harvesting on nine buildings and use the water for restroom toilet flushing. Aberdeen Proving Ground has proposed a project to capture rainwater for irrigation. Tobyhanna Army Depot is proposing to collect and use rainwater for industrial cooling tower make-up water.

5. Recharge

The final step in the Net Zero Water hierarchy is to recharge the local aquifer. Low impact development at Aberdeen ensures storm water infiltrates back into the aquifer. Treated wastewater from Camp Rilea's wastewater treatment plant (WWTP) is returned to the groundwater aquifer through rapid infiltration basins. Joint Base Lewis-McChord is considering injecting the treated wastewater into the ground to replenish the water table near its water wells.

3.4 Net Zero Waste

The overall Net Zero hierarchy is representative of Net Zero Waste (Figure 7). Reduction or avoidance of waste all together (the highest level of the hierarchy) is the most efficient strategy for minimizing waste and reaching the Net Zero Waste goal. Re-purposing or re-using waste products and materials is the next most efficient since the complete value of the goods are retained and the re-used goods are substituted for goods that would have been purchased new. Recycling is the next most efficient because it only retains some material value of the goods and materials and requires energy and resources for processing. Composting is a way to recycle organic food wastes. Energy recovery is at the bottom of the Net Zero hierarchy and is the least most efficient because it only retains the thermodynamic value of the materials used in the goods, and also requires energy and resources for processing. Disposal is to be minimized or effectively net zero.

Figure 7. Net Zero Waste Hierarchy

Overarching Actions

While the primary focus of the Net Zero Waste program at the Army headquarters level has been implementing the Pilot Installation Initiative, the ODASA(E&S) has also coordinated policy actions and partnerships with other related programs, such as the Army's Sustainable Procurement Program and the DoD Strategic Sustainability Performance Plan. Key actions that support the Pilot Installation Initiative include: waste stream analysis (Material Flow Analysis installation surveys, and waste characterization studies); research, analysis, and guidance pertaining to technology implementation and other technical solutions; and pilot of a Net Zero Waste roadmap. In FY2012, ODASA(E&S) completed a review of technology solutions that could be applied to challenging materials in installation waste streams. Guidance for implementing composting and digestion solutions for biodegradable organics, a major component of the waste streams, is being developed in FY2013. While these efforts have been focused on the pilot installations, they are applicable to all Army installations.

Developing roadmaps for the Net Zero Waste Pilot Installations was less uniform and straight-forward than developing roadmaps for the Net Zero Energy and Water Pilot Installations. Several Net Zero Waste installations either already had roadmaps that were developed for their existing sustainability efforts or were in the process of developing roadmaps that would be integrated with their Installation Solid Waste Management Plans. Other installations conducted workshop-based planning processes that included a cross-section of personnel from across their installations to weigh-in on opportunities and priorities. Therefore, ODASA(E&S) supported the development of one Net Zero Waste Roadmap, for Fort Polk, that could also serve as a template for non-pilot installations implementing Net Zero strategies. This draft roadmap was developed to be consistent with the Installation Solid Waste Management Plan, but not directly integrated. The final roadmap will be completed in FY2013.

Overarching actions have also been important for installation leadership at the pilot installations. Fort Hood was the first pilot installation to launch Net Zero Waste workgroups made up of personnel and community members from across the installations to support integrated planning for Net Zero Waste initiatives. Fort Hood has held two planning and collaboration workshops in which project ideas and new installation-wide initiatives were developed. Fort Polk emulated the Fort Hood workgroup and workshop process soon after. Installations are also adopting best practices from past sustainability planning efforts, and are integrating their Net Zero Waste efforts with existing planning and performance management systems. Joint Base Lewis-McChord directly leveraged its robust sustainability program which has included a Net Zero Waste goal for the last ten years, and is already integrated with their Environmental Management System (EMS). In addition to leveraging its EMS, Fort Hood leveraged its Environmental Quality Control Council to provide leadership oversight of its Net Zero Waste initiative. Fort Hood and Fort Polk also have drafted installation Net Zero Waste policies.

Hierarchy Actions

1. Reduction

Reduction is the highest level of the Net Zero Waste hierarchy. The most efficient means for keeping waste from being disposed of in a landfill is by eliminating a product or material that becomes that waste. Each of the Net Zero Waste pilot installations are leveraging their existing pollution prevention and sustainable procurement programs, which have been in place for many years. Purchasing is a critical component of eliminating or reducing products and materials, and the ODASA for Procurement launched a new sustainable procurement website in FY2012 that supports the Net Zero initiative. Additionally, the Net Zero Waste collaboration calls periodically include a focus topic on sustainable purchasing. Several Army installations have developed simplified lists of considerations for improving purchasing practices (e.g., Fort Hood, Joint Base Lewis-McChord). The San Antonio Lighthouse for the Blind, which operates the Fort Hood Post Supply and HazMart Store, uses the following list:

- Products that contain post-consumer and pre-consumer recycled content.

- A higher initial purchase cost if the product would require less maintenance or long-term costs over the life of the product or disposal cost.
- Products that contain the verbiage: “Made in the USA”, “Biodegradable”, “Green Seal”, “USDA Organic”, “Energy Efficient”, “Fair Trade Certified”, and “Energy Star Rated”.
- Efficient light products and education of the customer to take expended bulbs to the Classification Yard for disposal.

When a product or material cannot be avoided all together, the Net Zero Waste pilot installations are striving to reduce the products and materials to the extent possible. An example is expanded polystyrene foam (also known as Styrofoam™), which can be easily replaced by other packaging materials in many cases, but not in others such as insulated medical supplies packaging. Installations such as Joint Base Lewis-McChord and Fort Polk are attempting to eliminate all expanded polystyrene foam across their installations.

Other examples of effective waste avoidance include: Fort Polk’s effort to replace actual meals-ready-to-eat (MREs) used in air drop training with simulated MREs that would still meet training requirements; Joint Base Lewis-McChord and Fort Bliss sustainable procurement programs; the use of compostable food service items at a fast food restaurant at Fort Bliss, and in a pilot study at Joint Base Lewis-McChord; a Bring Your Own Bag Campaign at Fort Bliss to reduce use of single-use plastic bags in retail operations; and setting printers across installation networks to double-sided printing.

2. Re-purpose

The second level of the Net Zero Waste hierarchy is the re-purposing of products and materials. Although re-purposing is less focused on purchasing, some pilot installations are coordinating with buyers to connect organizations with stocks of reusable items (e.g., pallets, furniture).

Most of the pilot installations operate some type of free issue initiative for government items, such as used pallets, packaging materials, and even furniture. Installations such as Fort Hunter Liggett even do some level of renovation to furniture before it is offered for re-use. On a larger scale, Fort Carson is working with a regional non-profit organization to donate end-of-life furnishings in lieu of disposal. For non-government (i.e., personal) items, Fort Hood has implemented installation-wide yard sale days in family housing areas. Several installations, including Fort Hood, have implemented mattress refurbishing initiatives utilizing local vendors. Many installations use vendors for cleaning dirty shop rags so that they can be re-used. Joint Base Lewis-McChord has implemented a new agreement with their solid waste hauler, where a subcontract with a state-sponsored 501-(c) 3 charitable organization pays $0.13 to $0.15 per pound for donated clothing and household goods that are collected and brought to them. The proceeds are managed as a part of the installation Qualified Recycling Program (QRP).

Other pilot installation initiatives include the Equipment Containment Site’s effort at Fort Hunter Liggett to re-use expanded polystyrene to ship broken parts back to their supply outlets. Fort

Hood is working with Habitat for Humanity to deconstruct buildings and salvage/donate usable building components. The William Beaumont Army Medical Center at Fort Bliss has implemented two best practices to re-purpose and re-use textiles. When lab coats are lightly soiled (e.g., from pen/ink stains) the coats are dyed blue to obscure the stains. Linens are repaired until they cannot be used anymore, then they are donated to be repurposed at their veterinary clinics or animal shelters.

3. Recycling / Composting

Recycling programs are key diversion programs for the Net Zero Waste pilot installations and will remain a significant diversion program for years to come. Composting and other means of digesting biodegradable organic materials are also considered recycling activities or methods. Most of the Net Zero Waste pilot installations have robust QRPs that include many recent innovations and best practices. Joint-Base Lewis-McChord has a new performance-based solid waste and recycling collection contract that will weigh all containers as they are emptied and logs the information by building number, allowing the installation to work directly with building occupants to improve recycling. Fort Detrick is sorting and removing recyclables from its solid waste stream after the solid waste has been collected from the installation and before ultimate disposal. Fort Hood is implementing single stream recycling with new larger containers for its family housing areas, which will allow for the collection of glass and all seven types of plastic. Fort Hood is also increasing the number of self-service recycling kiosks across the installation. Fort Bliss recently achieved its goal to raise $1 million in QRP proceeds. For many years, Joint Base Lewis-McChord has operated recycling drop-off centers with an extensive list of accepted materials. Fort Polk will operate regular recycling drive-through drop-off hours at its new Net Zero Waste Center. Because a significant amount of potentially divertible materials are disposed during “move-outs”, spring clean-ups, and after the holidays, U.S. Army Garrison Grafenwoehr has implemented special recyclable collection events at these times. Other installations such as Fort Bliss, Fort Carson, and Fort Hood have also implemented move-out recycling support.

Several Net Zero Waste pilot installations have extensive diversion programs for construction and demolition waste streams. Joint Base Lewis-McChord’s “Earthworks” is the largest construction and demolition diversion program, which collects and stockpiles topsoil for reuse, collects and crushes concrete for roadbed and other aggregate, and chips wood waste for mulch and other applications. Fort Polk is recycling old drywall by crushing it for use as a soil amendment. Fort Carson participates in the City of Colorado Springs’ end-of-life porcelain recycling. Fort Carson collects their old porcelain components and fixtures and donates them to the City to be crushed for reuse in roadbed aggregate.

Electronics recycling is an important area within solid waste recycling which has been challenging to address in the past. Although all government property electronic waste is processed through the Defense Logistics Agency Disposition Services, non-government property waste can be significant. Fort Bliss and Fort Carson have initiated partnerships with UNICOR, a subsidiary of the Federal Prison system, to collect and responsibly dispose of

personal electronics. UNICOR does not charge for this service. To address the significant amount of personal electronics in its solid waste stream, U.S. Army Garrison Grafenwoehr has established two electronics recycling points which are supported by the German federal government. Accepted electronics include "everything that is plugged in."

Biodegradable organics is another waste stream the Net Zero pilot installations are striving to reduce or eliminate. Joint Base Lewis-McChord operates the longest-standing and most comprehensive composting program in the Army that processes pre-consumer food waste in addition to yard waste, manure and bio solids. Post-consumer food waste may be added in the near future. Installations such as Fort Hood run composting operations that do not include food waste, but process a significant amount of material and provide useful landscaping products. Most of the pilot installations process wood waste into wood chips and yard waste into mulch for on-Post landscaping projects. With respect to food waste, Fort Polk's solid waste collection contractor is independently diverting pre-consumer food waste from dining facilities that support the training area. Fort Hood conducted a pilot study of and Fort Carson is in the process of acquiring food waste digesters to divert pre-consumer food waste at dining facilities.

4. Energy Recovery

Installation waste that cannot be cost-effectively reduced, re-purposed, recycled, or composted may be a candidate for disposal via waste-to-energy (WTE) technologies to minimize residual waste. Based on the waste stream analyses, the volumes of remaining waste at the Net Zero Waste pilot installations are expected to be significantly smaller after the waste reduction, re-purposing, recycling, and composting efforts are fully implemented. Additionally, the waste stream composition of the reduced waste is expected to be significantly different than the installations' current solid waste composition, and this reduced volume will likely have a lower British thermal unit (BTU) value. Several of the pilot installations are researching WTE technologies that may be capable of treating this lower BTU waste stream composition. The volume and type of residual waste generated by the WTE technology are also being evaluated, with the intent to minimize the volume of residual waste generated and maximize any potential reuse of that material (e.g., incorporation of crushed slag in roadbed aggregate). If suitable cost-effective technologies are identified, a smaller scalable WTE treatment facility may possibly be constructed on Post (using government funding or leveraging a public-private partnership) or a larger-scale commercial off-Post facility may perhaps be used.

5. Disposal

As the Net Zero Waste hierarchy actions are successfully implemented, the volume of solid waste disposed in landfills will significantly decrease. If cost-effective WTE technologies are identified, ultimately only a small volume of residual wastes may require landfill disposal.

In the interim, three of the Net Zero Waste pilot installations (Fort Bliss, Fort Detrick, and Fort Hood) currently operate on-Post solid waste landfills and the other five pilot installations use off-Post facilities. However, all of the pilot installations have made significant efforts to reduce the

volume of waste generated, increase their recycling efforts, and reduce the total volume of waste disposed in landfills (on- or off-Post). Joint Base Lewis-McChord recently modified their solid waste disposal service contract to incentivize recycling and composting over traditional landfill disposal, and the other pilot installations that use commercial solid waste disposal services are using lessons learned from the Joint Base Lewis-McChord contracting action to evaluate their own disposal service contracts.

4.0 Best Practices

Since April 2011, when the Army announced the 17 Net Zero pilot installations the intent of the Net Zero pilot installation initiative was to develop a solid foundation to transition the Net Zero concept beyond the initial set of pilot installations through lessons learned, support technical analysis and roadmap development. Below are some installation-specific best practices gathered to date.

4.1 Net Zero Energy

The goal for Net Zero Energy pilot installations is to produce as much energy on the installation as they use annually. It is important to note that the definition of energy includes both electrical and thermal energy. Energy reduction and efficiency are addressed first, followed by energy recovery, cogeneration and production of on-site power with preference given to the generation of renewable energy. Correctly designed Net Zero initiatives can support greater energy security through these steps as they reduce the reliance on outside fuel sources.

Key best practices documented to date include:

- Conduct thermal building envelope analysis
- Reduce energy use through energy management control systems
- Hire resource efficiency managers
- Pursue alternative financing mechanisms
- Conduct energy master planning

1. Conduct Thermal Building Envelope Analysis

The thermal building envelope is a thermal control layer around the building which encloses the conditioned spaces. Infrared thermography is used to assess the integrity of the thermal envelope by identifying thermal breaks due to un-insulated or inadequately insulated envelope components, and points of infiltration and exfiltration. Reduced thermal building envelope integrity can be a major contributor to high energy consumption.

During the EEAP field investigation effort, thermal images were recorded on sample buildings to determine conditions and identify potential energy conservation measures (ECMs). These images provide the location and amount of heat transfer through the building envelope allowing appropriate mitigation actions to be identified. Air leakage at openings and junctions can be eliminated by improved envelope sealant. Increased insulation will reduce thermal flow through

the envelope as will the replacement of fenestrations to increase thermal resistance. Thermal imaging is a useful tool to incorporate into a building's energy management program.

Because thermography was used in the EEAP efforts, all pilot installations are examples of the use of thermal building envelope analysis. Based on the potential of thermography for further assessing Army facilities, the U.S. Army Engineer Research and Development Center (ERDC) is demonstrating a new technology with the support of the Office of the Assistant Chief of Staff for Installation Management (OACSIM) and the Installation Technology Transition Program at Fort Drum. The technology enables rapid, high-resolution detection of building envelope energy losses. Developed by the Massachusetts Institute of Technology and Eye-R Systems with ERDC's support, the technology combines an innovative vehicle-mounted kinetic super resolution, long-wave infrared imaging system with conventional hand-held thermal imaging.[1]

2. Reduce Energy Use through Energy Management Control Systems

Energy management control systems (EMCSs) provide the ability to control various energy consuming devices. These systems perform data acquisition and control activities and consist of sensors, controllers and controlled devices. Sensors typically measure temperature, pressure and light levels. Once a sensor reading is received, controllers send a signal to the controlled device for action; typical devices that are controlled by the EMCS are fans, compressors, boilers, chillers, air handling units, pumps and lights. EMCSs can control specific systems, entire buildings, or installations. EMCSs can control the length of time that each piece of equipment uses energy such as by scheduling lighting and controlling HVAC systems based on occupancy schedules. They can be used for demand reduction by monitoring load and programming loads to shed prior to exceeding set limits. EMCSs can be used to optimize the energy performance of equipment by conducting ancillary activities such as pre-cooling of buildings, demand ventilation control, and monitoring maintenance requirements and equipment status. EMCSs are being used at Fort Bliss, Fort Carson and Fort Detrick. Fort Hunter Liggett and Camp Parks have active Energy Conservation Investment Program projects to implement EMCSs.

3. Hire Resource Efficiency Managers

Providing dedicated resources to a Net Zero Initiative has a large impact on an installation's ability to achieve Net Zero. For example, a Resource Efficiency Manager (REM) is a contracted staff member hired by an installation to support its resource efficiency program. The REM's primary goal is to bring about reductions in consumption and cost of resource use, and efforts are focused on energy, water, natural gas, fuel oil, and waste disposal. The REMs work with existing staff to enhance conservation efforts and apply a systematic holistic approach to managing resources. This systematic approach involves the interaction with and cooperation of numerous stakeholders throughout the installation and potentially the region. A major

[1] "Diagnostic system provides fast, accurate building leak detection", December 1, 2012, http://www.erdc.usace.army.mil/Media/NewsStories/tabid/9219/Article/9038/diagnostic-system-provides-fast-accurate-building-leak-detection.aspx

advantage of the REM is having a dedicated installation resource to work communications pieces required for stakeholder understanding and cooperation. This can be a critical piece in moving towards an installation's Net Zero goals. Obtaining a funding commitment is necessary to retain this valuable resource who can further the Net Zero Initiative.

Currently, the Oregon National Guard, Fort Bliss, and Fort Carson have REMs or equivalent support. The Oregon National Guard has three REMs; Fort Bliss has one; and Fort Carson uses a contract for support that is similar to the role an REM would serve.

4. Pursue Alternative Financing Mechanisms

Various funding options are available for energy project implementation. Energy Savings Performance Contracts (ESPCs) are already in place at many installations. These enable projects to be implemented without an initial outlay of capital funds. This funding mechanism is based on a partnership between the government and an Energy Services Company which guarantees that implemented projects will generate energy cost savings sufficient to pay for them over the term of a contract. Currently Fort Bliss is employing an ESPC worth over $40 million with annual savings of $4.8 million to fund efficiency measures on post. Also, Kwajalein, Oregon Army National Guard, Fort Carson are all making use of this valuable funding option. All pilot installations have recognized that ESPCs are feasible initiatives that can support the Net Zero Energy initiatives.

Utility Energy Service Contracts (UECSs) allow the installation to partner with their utility who arranges financing for the capital costs of the project. The energy cost savings resulting from project implementation are used to pay off the debt. A common method used for renewable energy projects is to enter into a Power Purchase Agreement (PPA). Under these agreements, a developer pays for and installs the renewable energy system on the installation's property. The installation then enters into a long-term contract with the provider and agrees to purchase the power that the system generates at a certain price. Using private sector funding for these types of projects are attractive because the developers are eligible for Federal and state incentives for which government entities are ineligible. In addition, these projects can be funded directly through agency or budget mechanisms. Fort Carson currently has a PPA for a 2-megawatt solar array, and Fort Bliss is working to develop a similar PPA for a 20-megawatt solar array.

5. Conduct Energy Master Planning

Energy Master Planning is a process to conduct long-range planning while keeping future goals of achieving energy efficiency and sustainability in mind. Energy Master Planning looks beyond managing energy by considering both the opportunities and costs of energy. The planning process begins by establishing a baseline of current energy usage and a clear comprehensive planning vision. Energy efficiency and usage goals are established and a capacity analysis is conducted for renewable energy. Finally, an executable plan is created. For the Net Zero pilot

installation this involves the development of an energy roadmap and funding options for individual project implementation.

Successful Energy Master Planning involves integrated planning by engaging all stakeholders early in the process to develop a common understanding of all project issues, concerns and goals. Involving a multi-disciplinary and cross-functional team allows integrative strategies to be developed that allow synergies to be realized. Energy Master Planning allows installations to forecast, integrate, and guide energy development to ensure current and future mission and energy needs are met. The process reduces inefficient energy development which in turn reduces barriers to achieving Net Zero. A key aspect is the long-term involvement of stakeholders throughout the process.

As a part of the Fort Hunter Liggett Net Zero Initiative, the Master Planning Team of the U.S. Army Corps of Engineers (USACE) supported the development of an Energy and Sustainability Master Plan. By completing the plan, Fort Hunter Liggett became the first Army installation to comply with the updated DoD United Facilities Criteria 2-100-01 on Master Planning, which embraces planning tenets for sustainability, energy efficiency, and compact, mixed–use, walkable community development guided by a regulated set of planning codes. The USACE Construction Engineering Research Laboratory supported West Point in an update to their Energy Master Plan. The update effort will include long range, capital investment strategy, and environmental assessment components.

4.2 Net Zero Water

Goals for Net Zero Water include limiting the consumption of freshwater resources and returning the water back to the same watershed so as not to deplete the groundwater and surface water resources of that region in quantity or quality. In order to pursue a Net Zero Water installation, an installation needs to strive to decrease their freshwater demand while also increasing the use of alternate water sources. Striving toward Net Zero Water will also facilitate meeting EO 13514's mandates for reduction of water use intensity and meeting EISA 2007's requirement for low impact development.

Key best practices documented to date include:

- Maximize the use of xeriscaping
- Implement leak detection on the potable water distribution system
- Maximize water recycling
- Install purple pipe
- Maximize use of alternate water sources

1. Maximize the Use of Xeriscaping

Xeriscaping is landscaping that minimizes or eliminates supplemental watering. There are many landscape techniques that can be used to conserve water. As turf irrigation is one of the most common water demands at Army installations, xeriscaping requires switching to drought

tolerant or native turf grass varieties, or reducing the amount of areas requiring irrigation. Camp Rilea has been converting turf to native meadows and rain gardens to reduce irrigation needs. Grass can be replaced with other types of landscaping materials such as shrubs, stone, or mulch. Artificial turf can also be used, although the cost needs to be evaluated. Irrigation systems can be designed to deliver water only when it is needed and directly where it is needed, greatly increasing efficiency. Xeriscaping eliminates the artificial distinction between "high visibility" and "low visibility." The goal is to minimize all irrigation water use, preferably to not use any water of any type. Improved landscape design also contributes to water reduction.

2. Implement Leak Detection on the Potable Water Distribution System

Most of the Net Zero pilot sites already have strong leak detection programs or they have incorporated leak detection and repair into their efforts. Tobyhanna Army Depot has an aggressive metering and leak detection program that has helped them achieve a 38% reduction in water use intensity from their baseline. The leak detection system uses acoustic sensors which has helped them identify and fix leaks. Although a certain amount of leaking in water distribution systems is tolerated, the water balance studies revealed that pilot site losses are often much more than acceptable industry practice of 2% to 10%. In addition to helping reduce potable water use, there are many other reasons to find and repair leaks. Leaks tend to grow over time, finding and repairing them early reduces the costs and effects of repair when the leak is larger. If leak detection and repair are incorporated into maintenance schedules, this may lower costs associated with unscheduled repairs. Leaks have hidden costs including energy used for delivering the water and chemical costs for treatment. These costs go down when less water is lost.

Appropriate leak detection measures can play a valuable role in employing a rigorous asset management approach to an installation's water infrastructure. There are two main types of leak detection including leak noise loggers and inline detection. The best type of detection depends on size and material of the pipes and the skill of the operator. There are many approaches that can be used, from training in-house personnel to using contracted support. For large installations, it is feasible for only portions of the installation to be surveyed at a time, so regular inspection schedule should be developed. For instance, Fort Carson recently completed a leak detection survey that covered about 30% of the installation. The installation is looking to use a performance contract to fund additional surveys and repairs. Attention to leaks shows an attention to efficiency and communicates the importance of water conservation to the entire installation community.

3. Maximize Water Recycling

Water recycling and reuse can be accomplished in many ways, but all seek to match the water quality to its intended end use. Using potable water for irrigation, industrial purposes, or vehicle wash racks is not the best match of water quality with end use. Non-potable water can be used for some of these purposes, saving the freshwater resource while also reducing treatment costs. Water recycling is defined by the EPA as "reusing treated wastewater for beneficial purposes

such as agricultural and landscape irrigation, industrial processes, toilet flushing, and replenishing a groundwater basin (referred to as groundwater recharge)."[2] Water can be recycled on-site – as in capturing cooling tower water and reusing, or capturing grey water, water from residential, commercial and industrial bathroom sinks, bath tub shower drains, and clothes washing equipment, for irrigation. Recycling water that has been reclaimed from municipal wastewater treatment is another approach. Water may be reclaimed from an on-site treatment plant or procured from a water utility. Tobyhanna Army Depot already reclaims water from its WWTP for use within the plant, reducing the need for potable water for these purposes. Finally, injecting treated wastewater into groundwater is another type of recycling, returning it to replenish the water source for future use again on the installation. Treated wastewater from Camp Rilea's wastewater treatment plant (WWTP) is returned to the groundwater aquifer through rapid infiltration basins. Matching the recycled water quality to potential purposes is critical and information on how to do this is available from the EPA and other resources.

4. Install Purple Pipe

The use of reclaimed water relies on the installation of a purple pipe system to distinguish it from potable water by visually identifying this water as unsuitable for potable water use. Reclaimed water is water treated to domestic wastewater tertiary standards by a public agency suitable for controlled uses.[3] Separate piping is also needed for harvested rainwater and grey water. In order for an installation to successfully recycle water, these parallel distribution systems must be designed, planned for and installed. Several of the pilot installations are developing projects to increase the use of treated wastewater, including Fort Bliss (through the El Paso Water Utility), Joint Base Lewis-McChord (through a new WWTP that is currently being designed), and Aberdeen Proving Ground (through its groundwater remediation treatment plant). Joint Base Lewis-McChord has programmed purple pipe installation with SRM funds in new construction, so that when the reclaimed water becomes available, they will be able to use it.

5. Maximize Use of Alternate Water Sources

In order to reduce the volume of fresh water resources (surface or groundwater with low concentrations of dissolved salts or other solids), water of lower quality – such as rainwater or brackish water – should be used to the maximum extent possible. These alternate sources can be used for purposes that do not require high water quality, such as irrigation. As irrigation can be one of the largest water uses at an installation, options for use of alternate sources needs to be explored. Storm water management requirements may overlap with irrigation needs – ponds can be constructed to capture rainwater and then used as for irrigation source water. Fort Buchanan has a proposed ESPC project to implement rainwater harvesting on nine buildings

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[2] United States Environmental Protection Agency, Region IX (2008) "Water Recycling and Reuse: The Environmental Benefits" EPA 909-F-098-001 (p.1) available at: http://www.epa.gov/region9/water/recycling/brochure.pdf

[3] United States Environmental Protection Agency (2008) "Managing Wet Weather with Green Infrastructure, Municipal Handbook, Rainwater Harvesting Policies: EPA-833-F-010 (p. 3) available at: http://www.water.epa.gov/infrastructure/greeninfrastructure/upload/gi_munichandbook_harvesting.pdf

and use the water for restroom toilet flushing. Tobyhanna Army Depot is proposing to collect and use rainwater for industrial cooling tower make-up water.

4.3 Net Zero Waste

The goal of Net Zero Waste is to reduce, reuse, and recover solid waste streams by converting them to resource values with zero solid waste disposed in landfills. Net Zero Waste has two supporting goals for waste diverted from landfills from previously-established DoD goals for solid waste (i.e., non-hazardous municipal solid waste) and construction and demolition debris. Federal and DoD 'green procurement' and electronics stewardship program goals also support the Net Zero Waste initiative.

Key best practices documented to date include:

- Establish a Qualified Recycling Program
- Characterize and quantify waste flows
- Improve purchasing practices to reduce waste at the source
- Repurpose and reuse waste through free and low-cost opportunities
- Recycle and compost waste through free and low-cost opportunities

1. Establish a Qualified Recycling Program

Every Army installation should establish a Qualified Recycling Program (QRP). At its most basic level, a QRP enables the installation to receive and utilize the proceeds generated from its scrap metal sales via their servicing Defense Logistics Agency Disposition Services (DLADS) office. This level of QRP can be established without additional staff, facilities, or equipment; however, the scrap metal proceeds can then be used to expand the installation's recycling program to collect and sell other recyclables (e.g., aluminum, cardboard) where cost-effective, based on available local and regional markets. The QRP also benefits the installation's Morale, Welfare, and Recreation programs.

Many Army installations have implemented successful recycling programs via a QRP, and have utilized their QRP proceeds to increase the variety of materials collected for recycling, in turn increasing their recycling rates. QRP proceeds can be utilized to purchase additional recycling equipment and establish incentive programs, such as recycling contests between military units and organizations. Recent waste characterization studies show that the recyclable content of installation waste streams can still be high even at installations with the most mature recycling programs.

2. Characterize and Quantify Waste Streams

Periodic waste stream analysis enables the installation to establish its 'baseline' waste composition and to more readily target waste streams for elimination, minimization, or diversion. The DoD Integrated Solid Waste Management Policy (1 Feb 2008) recommends annual waste stream analysis as a best practice for installation solid waste management. Waste stream

analysis can be accomplished using installation personnel or via contractor support, using traditional 'sort and weigh' methods or less labor-intensive visualization methods. A combination of weighing/sorting and visualization may be ideal, if time and resources allow. In any case, the characterization should include building numbers and information about the 'generating activity' for each dumpster. Real Property facility/category codes or building occupant information can be used to determine the 'generating activity' for the waste in the dumpster. Analyzing the waste characterization information by similar 'generating activity' (e.g., clinics, food service, motor pools) may facilitate the installation's efforts to minimize, divert, and recycle the associated waste streams.

3. Implement Sustainable Purchasing Practices to Reduce Waste at the Source

Source reduction is the highest level of the Net Zero Waste hierarchy and should be the first course of action in reducing the installation's waste stream and specific materials within it. Improved purchasing practices can significantly reduce the volume and type of waste generated on Post. For example, supply contracts can be revised to minimize packaging waste, require compostable packaging materials (e.g., Fort Polk's 'say no to Styrofoam' campaign), or include 'take back' clauses for categories of packaging (e.g., pallets, expanded polystyrene). 'Take back' efforts have been successfully implemented in Europe for a wider variety of items beyond packaging, including appliances, modular office components, and tires. Whenever feasible, installations should utilize bulk purchasing (e.g., via an installation HazMart) and bulk dispensing versus individual-use packets (e.g., at dining facilities, food courts, Morale, Welfare, and Recreation food establishments) to minimize waste generation.

The Environmental Protection Agency's Comprehensive Procurement Guideline provides information and guidance on improving purchasing practices. Several Army installations have developed simplified lists of considerations for improving purchasing practices (e.g., Fort Hood, Joint Base Lewis-McChord).

4. Leverage Low-/No-cost Reuse Opportunities

Many reuse and repurposing opportunities require a minimal amount of time and coordination, and are free or low-cost. Numerous opportunities for greater repurposing and reuse can be found in all activities across the installation, and several common best practices have emerged.

- Furniture is a major waste stream with high potential for reuse. Installations have partnered with DLADS, established dedicated storage space, and developed procedures for providing the furniture for on-post reuse. Other installations are donating end-of-life furniture to off-post nonprofit organizations when on-post uses have been maximized and DLADS is not able to process the furniture.
- Food waste is another major waste stream on Army installations, with high potential for diversion. To address part of the food waste stream, some installations have partnered with local nonprofit organizations and/or waste haulers to donate recently-expired food from commissaries and end-of-the-service-day food from service providers.

- In hospitals and clinics, textiles (e.g., linens, garments) make up a significant waste stream that has been addressed through reuse and repurposing in several ways. The William Beaumont Army Medical Center at Fort Bliss has implemented two best practices to re-purpose and re-use textiles.
- Recovery and diversion of usable building components prior to building deconstruction/demolition is another best practice that can be implemented for little to no cost. Fort Hood has worked with Habitat for Humanity to recover building components. Other installations have implemented similar efforts with non-profit organizations.

These examples show that reuse and repurposing can be a low-cost form of waste diversion when personnel invest the time to coordinate and develop the opportunities. Installations are finding and implementing more and more initiatives as a part of their Net Zero Waste efforts.

5. Leverage Low-/No-cost Recycling Opportunities

Most installations have basic recycling programs for the traditional recycling streams (e.g., scrap metal, aluminum, cardboard, paper, plastics, glass), operated either through on-post programs (e.g., a QRP) or their local solid waste hauler. Low-/no-cost opportunities to expand the installation's recycling options may be available from unexpected sources. Personal electronics recycling has been implemented at many installations through partnerships with vendors such as UNICOR, which responsibly recycle and dispose of the electronic components. Collection events are held on post to collect personal electronics and some vendors, including UNICOR, will take the items for free. Fort Carson participates in the City of Colorado Springs' end-of-life porcelain recycling.

5.0 Net Zero Next Steps

5.1 Plans for Institutionalizing Best Practices and Instituting Army-Wide

The Army will issue a policy in FY2013 to expand the Net Zero approach to all permanent Army installations. All installations will be directed to evaluate the feasibility of and then implement, to the maximum extent practicable and fiscally responsible, policies, procedures, and new technology that advances them to meet their Net Zero goals.

Institutionalization of Net Zero will take more than incorporating metrics and goals into Army doctrine. Significant change is needed in how Army leaders, Soldiers, civilians, and contractors think, plan, and operate. Fostering a Net Zero ethic will require creating a culture in which sustainability is embraced with the reality that the Army's resources will always be limited. Through prior sustainability initiatives and the Net Zero Pilot Installation Initiative, this change in culture is evolving and there are additional actions that will be taken both at Headquarters Army

and at the installation-level to further advance Net Zero to support on-going Net Zero and sustainability change efforts.

5.2 FY2013 and Beyond

In FY2013-2014, the Office of the Assistant Secretary of the Army for Installations, Energy & Environment (OASA(IE&E)) will complete the development of foundational Net Zero strategy and policy, continue coordination of the initiative, oversee progress toward incorporating Net Zero approaches into all Army installation resource using activities, and work with Commands/ Direct Reporting Units to effectively implement Net Zero Army-wide. Office of the Assistant Chief of Staff for Installation Management (OACSIM) will create a framework to establish baselines and report performance relative to legal, regulatory, and Presidential requirements. The framework will be revised as needed.

Activities/tasks currently being performed or are in the planning stages that will be completed by the end of FY2014 include those listed in Table 2.

Table 2. Net Zero Activities and Tasks In-Progress

Task	Responsible Agent	Target Timeline
Waste Roadmap	OASA(IE&E)	FY2013
Army-wide Net Zero policy	OASA(IE&E)	FY2013
Integrated Energy and Water Security Assessment	OASA(IE&E)	FY2013
Integrated Energy-Water-Waste Roadmap	OASA(IE&E)	FY2013
Net Zero Implementation Guide	OASA(IE&E)	FY2013
Water Roadmaps	OASA(IE&E)	FY2013
Net Zero progress review meeting	OASA(IE&E) & OACSIM	FY2014
Gap analysis to determine appropriate insertion points for Net Zero into existing policy and guidance	OASA(IE&E) & OACSIM	On-going
Performance measures for assessing Net Zero progress	OASA(IE&E) & OACSIM	FY2014

The Army Commands/Direct Reporting Units will implement the Net Zero policy by striving to exceed, where fiscally responsible, the legal, regulatory, Presidential, Department of Defense, and Army policy requirements for increasing efficiency, reuse, and reducing demand in energy, water, and solid waste. Commands will continually evaluate and implement installation energy/water/waste efficiencies, reductions, and reuse to the maximum extent possible with the available funding and as new technologies/approaches are proven cost-effective. Installations will execute Net Zero where fiscally responsible, leveraging existing resources including alternative financing, for FY2015 and beyond.

6.0 Conclusion

Net Zero is a strategy for managing existing federal energy, water, and solid waste programs, with the goal of exceeding minimum targets where fiscally responsible, to provide greater energy/water security and increase operating flexibility. To date substantial progress has been made in the areas of Net Zero energy, water, and waste. From this, best practices and lessons learned have been identified that can be used to guide these and other installations forward. In FY2013, the Army will start to decentralize Net Zero and embed these practices in standard operating procedures at appropriate Army Commands/Direct Reporting Units and institutionalize an integrated approach of sustainability and resource security to all installation design, planning, service, and investment decisions. Critical components of Net Zero, such as the implementation hierarchy, can support and reinforce existing policy and guidance for the management of Army installations.