

ARMY NET ZERO

Energy Roadmap and Program Summary

Fiscal Year 2013

DISCLAIMER

ACKNOWLEDGMENTS

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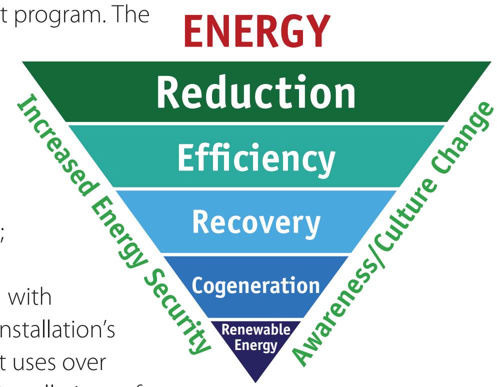
MESSAGE FROM HONORABLE KATHERINE HAMMACK

Photo from U.S. Army 291555

In October 2010, I announced the creation of the Army Net Zero Initiative. Net Zero is a holistic strategy founded upon long-standing sustainable practices and incorporates emerging best practices to manage energy, water, and waste at Army installations. The intent of the Net Zero Initiative is to enhance mission effectiveness and increase installation resiliency. Additional energy-related Federal mandates—including Executive Order 13514, the Energy Policy Act of 2005, and the Energy Independence and Security Act of 2007—further support Net Zero strategies.

The Net Zero Initiative was launched with installation-level pilot programs designed to serve as test beds to gather lessons learned, develop technical analysis and roadmaps, and construct a solid foundation to transition and institutionalize the Net Zero concept throughout the Army. I announced the 17 pilot installations on April 19, 2011. These installations were selected because they volunteered to be pilots and had support from their garrison commanders and higher headquarters. These installations include fifteen Net Zero Energy, water, and/or waste installations and two integrated Net Zero Energy-water-waste pilot installations, along with one statewide Army National Guard Net Zero Energy pilot program. The pilot installations have and will continue to serve as model communities for sustainability and quality of life while the Army takes an even broader approach by decentralizing and applying the Net Zero concept beyond the initial set of pilot installations.



A Net Zero Energy installation reduces overall energy use; maximizes efficiency, energy recovery, and cogeneration opportunities; and offsets the remaining energy demand with the production of renewable energy. A Net Zero Energy installation's goal is to produce as much renewable energy on site as it uses over the course of a year. The Net Zero Energy sites represent installations of different physical sizes, geographic locations, and Army commands.

I am amazed at the progress Army installations have already made to reduce energy and water consumption as well as waste generation. We will all monitor the journey these installations embark on to reach the final Net Zero goal.

Honorable Katherine Hammack
Assistant Secretary of the Army
(Installations, Energy & Environment)
Washington, DC

EXECUTIVE SUMMARY

The U.S. Department of Defense (DOD) has long recognized the strategic importance of energy management to its mission. By reducing energy consumption and developing clean, on-site, renewable energy sources, energy managers at DOD installations enhance energy security, which is defined as the assured access to reliable supplies of energy and the ability to protect and deliver sufficient energy to meet mission-essential requirements. Reduced consumption and on-site production enhance mission effectiveness, benefit the environment, and improve resiliency against grid failures. In addition, renewable energy technologies allow for predictable and potentially decreased energy costs.

The U.S. Army (Army) partnered with the National Renewable Energy Laboratory (NREL) and the U.S. Army Corps of Engineers (USACE) to assess opportunities to increase energy security through improved energy efficiency and optimized renewable energy strategies at nine installations across the Army's portfolio. These Net Zero Energy Installations (NZEIs) demonstrate and validate energy efficiency and renewable energy technologies with approaches that can be replicated across DOD and other Federal agencies, setting the stage for broad market adoption.

The Army's NZEI strategy is to effectively implement the NZEI Initiative Army-wide. This effort includes completing foundational policy development, coordinating the initiative, and overseeing progress toward incorporating Net Zero approaches into all resource-using activities at Army installations.[1]

Figure 1. Nine Net Zero Energy Army installations. *Illustration from U.S. Army*

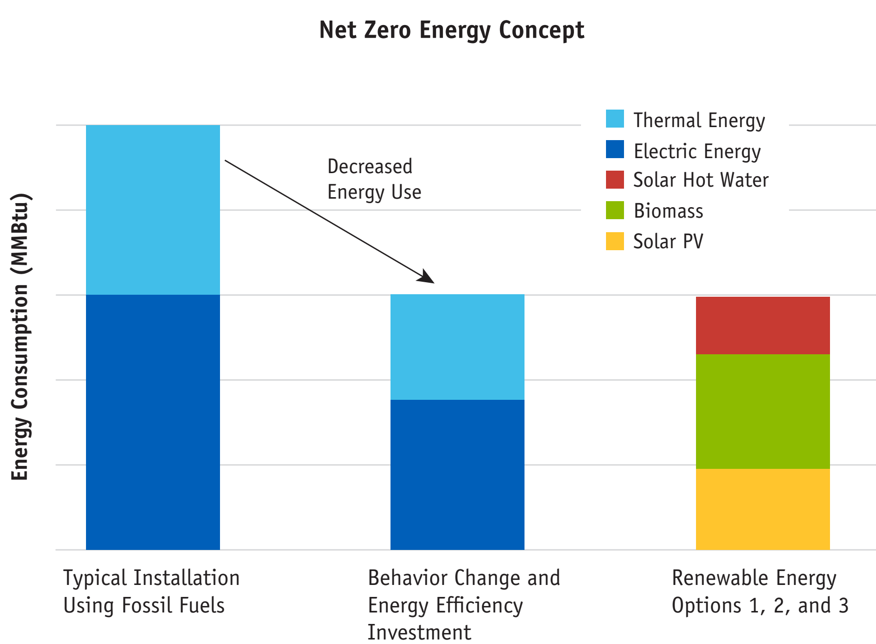


Figure 2. Net Zero Energy concept[2]

[1] "Net Zero Progress Report, Net Zero Pilot Installation Initiative 2012." Assistant Secretary of the Army (Installations, Energy & Environment). May 2013. *usarmy.vo.llnwd.net/e2/c/downloads/296777.pdf.* Accessed July 2013.

[2] Renewable energy options are illustrative and Net Zero strategies could and did include other technology options such as wind and geothermal

In a competitive application process, the Army selected nine installations to pilot Net Zero Energy by 2020. Six pilot NZEIs are focusing solely on Net Zero Energy: Camp Parks Reserve Forces Training Area, Fort Detrick, Fort Hunter Liggett, Kwajalein Atoll, Sierra Army Depot, and West Point. Three other installations volunteered for unique Net Zero Energy Initiatives. Oregon Army National Guard (OR ARNG) is piloting a Net Zero Energy Initiative that includes all of its installations across the state. Fort Bliss and Fort Carson are piloting integrated Net Zero installation programs that comprise energy, water, and waste.

This report summarizes the results of the NZEI project roadmaps, which were developed by NREL in fiscal year (FY) 2012. The progress each installation could make in achieving Net Zero Energy by 2020 is highlighted. Lessons learned and unique challenges met by each installation in FY 2013 are also presented. This report builds on the Net Zero Pilot Installation Initiative Progress Report for 2012 available at *usarmy.vo.llnwd.net/e2/c/downloads/296777.pdf*.

Defining a Net Zero Energy Installation

An NZEI reduces overall energy use; maximizes efficiency, energy recovery, and cogeneration opportunities; and offsets the remaining energy demand with the production of renewable energy. The NZEI's goal is to produce as much energy on site as it uses over the course of a year. In principle, the NZEI should reduce its load through energy conservation and energy efficiency, implement energy recovery and cogeneration opportunities, and then offset the remaining demand with the production of renewable energy from on-site sources. Defining a Net Zero Energy Military Installation is complicated by the need to consider mission-specific energy requirements in addition to energy used by individual buildings, public facilities, and infrastructure.

Table 1. Installation Energy Consumption in FY 2011

Installation Name	Elec. (MMBtu[a])	Thermal (MMBtu)	Total (MMBtu)	Total Cost	Cost Per MMBtu
Camp Parks	26,412	22,479	48,891	$1,329,934	$27.20
Ft. Bliss	883,026	651,750	1,534,775	$17,342,915	$11.30
Ft. Carson	530,470	762,441	1,292,912	$13,148,966	$10.17
Ft. Detrick	486,456	642,264	1,128,720	$16,319,057	$14.46
Ft. Hunter Liggett	43,158	38,430	81,589	$2,566,675	$31.46
Kwajalein	0	876,256	876,256	$21,170,336	$24.16
OR ARNG	47,574	66,935	114,509	$1,809,846	$15.81
Sierra AD	49,641	113,607	163,248	$6,507,493	$39.86
West Point	291,938	751,427	1,043,364	$13,418,348	$12.86

[a] MMBtu is used to mean one million British thermal units.

Net Zero Energy Roadmap Strategy

The Net Zero Energy roadmap describes the strategy and steps for achieving an installation's Net Zero Energy goals. Roadmaps allow installations to conduct planning to reach their goals, identify funding sources, and develop projects. The sections below summarize the main roadmap components.

Establish Baseline Energy Use

The Army NZEI program began in FY 2011 by determining baseline energy use. Table 1 shows energy consumption and costs for the pilot installations when the program began. After analyzing energy consumption and predicting future consumption through estimates of load growth or reduction, NREL validated a baseline for each installation. These NZEI baselines[3] differ slightly from actual use in FY 2011 for some installations for a variety of reasons, such as incorrect or incomplete data in the Army energy reporting system, or significant planned load changes from new construction or demolition. The average difference between FY 2011 data and the NZEI baseline is about 0.4% per installation, with the exception of OR ARNG, which required a 29% increase to correct data errors.

The NZEI baselines serve as a metric for developing a Net Zero Energy strategy. The goal is to reduce the baselines through energy efficiency measures, then replace fossil fuel consumption with renewable energy production. FY 2012 energy consumption data in this report provides updated information and trends in energy use at each installation.

[3] By Army request, NREL created baselines using the most current energy consumption data available rather than the last complete year available (FY 2010). Because analysis was conducted in early FY 2012, FY 2010 energy consumption data was believed to be outdated. This resulted in either a mix of three months of FY 2010 data and nine months of FY 2011 data from the installation (full FY 2011 data was not available during the analysis), or use of FY 2011 utility bills provided by the installation, which varied slightly from the final data reported for FY 2011.

Evaluate Energy Efficiency Measures

The Net Zero Energy hierarchy focuses on energy reduction through conservation and energy efficiency. Energy audits of each installation were managed by USACE and identified opportunities for energy efficiency improvement and investment. The results of the audits for each installation are shown in Table 2.

The audits illustrate varied amounts of energy efficiency potential for each installation. The results vary substantially due to many factors such as past energy projects, energy costs, building age, and the amount of square footage audited.

Once energy use is reduced as much as possible through energy conservation measures (ECMs), including energy recovery and cogeneration possibilities, the next step is to investigate renewable energy projects.

Table 2. U.S. Army Corps of Engineers Installation Energy Audits[a] and Estimated Savings

Installation Name	# of Buildings Audited	Square Footage Audited	MMBtu Savings Per Year	$ Savings Per Year	Potential Savings % of FY11 Energy
Camp Parks	20	415,239	31,839	$448,799	74.60
Ft. Bliss	46	2,029,546	170,023	$7,900,000	28.73
Ft. Carson	57	2,859,881	43,461	$1,181,184	16.32
Ft. Detrick	31	1,516,413	2,134	$166,591	2.97
Ft. Hunter Liggett	78	543,475	52,868	$1,577,522	86.48
Kwajalein	24	721,049	39,300	$3,654,960	13.10
OR ARNG	39	400,098	1,087	$37,775	11.80
Sierra AD	39	1,229,548	2,853	$158,371	4.00
West Point	16	1,951,654	1,377	$43,708	0.30

[a] Data comes from USACE managed energy audits.

Assess Renewable Energy Potential

Renewable energy assessments at the pilot NZEIs identified which technologies have the potential to meet the remaining energy load at each installation; renewable energy strategies should be flexible and evolve as technologies, markets, incentives, and economics change. The assessed technologies, as well as projects already installed or in development, are shown in Table 3.

Analyze Energy Interconnection and Microgrids

Renewable energy interconnections are a key component of project feasibility, and microgrid potential is a key need for energy security. Both interconnection and microgrid design depend on a site's electric distribution system. System infrastructure such as power lines, transformers, protective devices, and capacities were evaluated at a high level in the roadmaps so the team could begin evaluating interconnection solutions and microgrid potential.

Implement Renewable Energy Projects

After identifying viable energy efficiency and renewable energy projects at each installation, the final step was to evaluate financing options such as energy savings performance contracts (ESPCs), utility energy services contracts (UESCs), power purchase agreements (PPAs), as well as DOD's Energy Conservation Investment Program (ECIP) and Environmental Security Technology Certification Program (ESTCP). Key project development considerations include:

- Site—Where will the project be located, has site control been established, and what is the proximity to the grid?
- Resources—How much land is available and will resources such as wind quality need to be validated before securing financing?
- Off-take—Who will buy the power and/or thermal energy, and what are the levelized costs?
- Permits—How will the site handle interconnections and National Environmental Policy Act (NEPA) considerations?
- Technology—What are the technical performance goals (e.g., megawatt-hours per year)?
- Team—Who is the technology partner/developer?
- Capital—What is the ownership structure?

Black text = Evaluated system potential in roadmap
Blue text = An existing system
Orange text = A system in progress

Table 3. Renewable Energy Status at Pilot Sites

	Solar Photovoltaic (PV)	Wind	Solar Hot Water (SHW)	Solar Ventilation Preheating (SVP)	Ground Source Heat Pump (GSHP)	Biomass/ Waste to Energy (WTE)	Geothermal	Other
Camp Parks	4 megawatt (MW) 25 kilowatt (kW) on one building 28-kW ESTCP solar CHP on two buildings Solar street lights 2 MW in design		8,000 ft² Conventional SHW on two buildings (550 ft²) ESTCP solar combined heat and power (CHP) 150-kW thermal on two buildings	11,000 ft²	50 tons			
Ft. Bliss	30 MW 20-MW system in development 2.3-MW installed		27,000 ft² Several systems installed	15,000 ft²	10,000 tons	10-50 MW of WTE	2-4 MW	10-20 MW of con-centrating solar power (CSP)
Ft. Carson	110 MW 3.2 MW 1.7 MW in development	11 MW	53,000 ft² 13 systems installed	107,000 ft² Two installed systems	16,000 tons Four systems installed	45 MMBtu/ hr biomass heating		20 MW of CSP
Ft. Detrick	24 MW 10-20 MW system in development		4,000 ft²	1,400 ft²		Potential to utilize medical waste incinerator for energy		
Ft. Hunter Liggett	6 MW Solar street lights 1-MW installed 1 MW in construction 1 MW in design		13,000 ft²	1,200 ft²	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 ft² 20 ft2 (one building)					Analyzing seawater cooling options
OR ARNG	0-15 MW 313 kW 90 kW in development	8 MW		Hangars in Salem	Facilities in climate zone 5 Installed on one facility	3 MW Heating system has design funds	3 MW	
Sierra AD	2-5 MW 300-1,000 kW in development		11,000 ft²	10,000 ft²	900 tons System installed on one 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	

Solution Summary

A mix of energy efficiency and renewable energy projects contribute to the Net Zero Energy goal at each installation. Table 4 illustrates energy efficiency improvement estimates, as well as thermal renewable energy potential, electrical renewable energy potential, and total potential (a combination of thermal and electrical). The energy efficiency estimates in Table 4 reflect an overall savings estimate for the installation and were developed in parallel with the building-specific audits conducted by USACE (Table 2).

Table 4. Net Zero Energy Solution Summary

Installation Name	Energy Efficiency (EE) Estimate	% Thermal Renewable Energy (RE)	% Electrical Renewable Energy (RE)	% Total
Camp Parks	31%	86%	100%	96%
Ft. Bliss	15%	46%	100%	78%
Ft. Carson	17%	93%	100%	96%
Ft. Detrick	30%	45%	71%	61%[a]
Ft. Hunter Liggett	42%	100%	100%	100%
Kwajalein	25%	NA (all electric)	83%	83%
OR ARNG	50%	100%	100%	100%
Sierra AD	25%	100%[b]	100%	100%
West Point	25%	55%	100%	80%

[a] Includes Fort Detrick and Forest Glen Net Zero Energy estimates

[b] Assumes a renewable energy–powered replacement for warehouse heaters, otherwise the solution is approximately 50%

NET ZERO ENERGY ROADMAPS

The following Net Zero Energy roadmaps summarize FY 2011–2013 energy use status, next steps for project implementation, and unique projects. Average energy costs, consumption, and energy use intensity are identified. FY 2012 data from the Army Energy and Water Reporting System (AEWRS) is provided because it best reflects the installations' current energy consumption. NREL was tasked by the Army to help develop roadmaps and recommend energy projects to meet the Army's Net Zero goals. This report provides summary information, sample projects, and examples. The complete roadmaps for each installation include extensive details.

	Average FY 2012 Energy Costs ($/MMBtu)	FY 2012 Energy Consumption (MMBtu)	FY 2012 Energy Use Intensity (MMBtu/ksf)
CAMP PARKS RESERVE FORCES TRAINING AREA	24.05	45,694	34.25

Camp Parks' Status in FY 2013

The installation is evenly split between electrical and thermal energy with the majority of energy use in office buildings and lodging. Several small renewable energy projects have been installed.

Where Is Camp Parks Headed?

A 2-MW photovoltaic (PV) project funded by ECIP will be built soon. It will provide close to 50% of the installation's electrical energy from a renewable source.

Unique Project

Camp Parks just started a property exchange that will reduce the size of the installation and demolish many buildings, while providing several new buildings with the opportunity for energy-efficient design.

	Average FY 2012 Energy Costs ($/MMBtu)	FY 2012 Energy Consumption (MMBtu)	FY 2012 Energy Use Intensity (MMBtu/ksf)
FORT BLISS	13.57	1,503,281	66.32

Fort Bliss' Status in FY 2013

The installation's energy sources are nearly 60% electricity, 40% natural gas, and 1% propane. Dominant energy use is in office buildings and barracks. Approximately 3 MW of PV and a few small solar hot water (SHW) applications were installed in FY 2013.

Where Is Fort Bliss Headed?

An ESPC project proposed for development may install up to $20 million in energy efficiency improvements, reducing Fort Bliss' energy use by 3%–5%. A 20-MW PV system proposed with El Paso Electric would reduce electricity purchases by 15%.

Unique Project

The Fort Bliss directorate of public works (DPW) is working to support PV on a landfill and pursue the potential of landfill gas from the on-site landfill. Fort Bliss is working with electric and water utility privatization contractors on UESC-type infrastructure improvements.

	Average FY 2012 Energy Costs ($/MMBtu)	FY 2012 Energy Consumption (MMBtu)	FY 2012 Energy Use Intensity (MMBtu/ksf)
FORT CARSON	10.14	1,339,095	104.40

Fort Carson's Status in FY 2013

The base pays about $1.2 million a month to Colorado Springs Utilities for gas and electricity. Fort Carson has installed several solar projects totaling 3.12 MW, including one solar 2-MW PPA. Energy efficiency efforts have reduced energy intensity by 17% from a 2003 baseline.

Where Is Fort Carson Headed?

The base's goal is to cut energy intensity 30% from 2003 levels by 2015, striving for a 50% reduction by 2020, in addition to its NZEI goals. Several avenues have been used to fund energy efficiency projects to include sustainment, restoration, and modernization (SRM), ECIP, and ESTCP demonstrations. In addition, Task Order 1 under an ESPC has implemented projects to reduce energy and water use with future task orders being considered. Life cycle cost-effective renewable energy projects continue to be a challenge as utility rates are low. However, several completed and planned construction projects have included renewable energy technologies such as PV, SHW, GSHPs, and transpired solar walls.

Unique Project

Fort Carson is transforming 1950s-era barracks into modern Leadership in Energy and Environmental Design (LEED) certified office buildings. Renovations resulted in reduced energy use in the building envelope, lighting, plug loads, and heating, ventilation, and air conditioning (HVAC) systems, and also added renewable energy generation.

	Average FY 2012 Energy Costs ($/MMBtu)	FY 2012 Energy Consumption (MMBtu)	FY 2012 Energy Use Intensity (MMBtu/ksf)
FORT DETRICK	12.91	1,150,831	359.00

Fort Detrick's Status in FY 2013

Natural gas for thermal energy is the predominant energy use at the Fort Detrick garrison. Much of the gas is used in the central steam plant, which is in the process of being decommissioned through a UESC. Fort Detrick also has large laboratory and data center energy loads.

Where Is Fort Detrick Headed?

The project with the greatest impact at Fort Detrick is the decommissioning of the central steam plant. The buildings originally served by steam from this plant will have high-efficiency gas heaters installed. This project is expected to save 30% of the gas energy consumption for the garrison. The garrison is also evaluating multiple building ECMs such as occupancy sensors and re-lamping to lower wattage fluorescent lamps.

Unique Project

Fort Detrick is developing a 15-MW PV system through a PPA process. This project is expected to meet 20% of the garrison's electric load. Another project that is currently being evaluated is using heat from the base incinerators to generate steam to produce electricity.

FORT HUNTER LIGGETT	28.50	69,248	60.74

Fort Hunter Liggett's Status in FY 2013

Fort Hunter Liggett has been focusing on reducing the electrical consumption on post with renewable energy and energy efficiency projects. This year's utility consumption decrease reflects reductions in energy consumption from an installation-wide LED lighting project and a 1-MW solar array that has been operational since April 2012. Several small renewable energy projects have also been installed.

Where Is Fort Hunter Liggett Headed?

A 1-MW PV project funded by ECIP has just been completed and will be commissioned soon. There is also a 1.25-MWh battery project that is in final design with construction; this project will allow Fort Hunter Liggett to fully utilize the renewable energy systems and perform peak shaving activities. Between all of the projects that are currently under construction, the installation will be approximately 34% of the way to Net Zero by December 2013.

Unique Project

Fort Hunter Liggett has been awarded an ESTCP to implement a WTE gasification system that will produce a syngas from installation waste. This project has dual benefits, moving the installation toward both Net Zero waste and Net Zero Energy.

	Average FY 2012 Energy Costs ($/MMBtu)	FY 2012 Energy Consumption (MMBtu)	FY 2012 Energy Use Intensity (MMBtu/ksf)
U.S. ARMY KWAJALEIN ATOLL	27.93	855,708	269.26

Kwajalein Atoll's Status in FY 2013

The installation is powered 100% by diesel fuel with the largest load coming from space cooling. There are a few small PV systems on the outer islands and a 60-kW roof-mounted system on Kwajalein islet.

Where Is Kwajalein Atoll Headed?

The installation is in the process of developing an extensive ESPC that includes facilities on Kwajalein, Roi-Namur, and Meck islets. A contractor has been selected and the installation is proceeding with the investment-grade audit. Additionally, the installation is installing a meteorological tower to collect investment-grade wind resource data.

Unique Project

Seawater air conditioning (SWAC) is included in the ESPC. The district chilled water system will be cooled by deep seawater pumped to the surface from a depth of 2,000–3,000 ft.

OREGON ARMY NATIONAL GUARD [a]	15.28	170,071	59.40

Oregon Army National Guard's Status in FY 2013

OR ARNG uses about 14% more thermal fossil fuel than electricity, with the majority of energy use in office buildings, armories, shops, and lodging. Several small renewable energy and energy efficiency projects have been installed or are underway.

Where Is Oregon Army National Guard Headed?

Assessments and projects are underway to replace on-site fossil thermal loads with biomass heat and electric heat pumps. New installations and renovations are being designed to include deep retrofit energy efficiency and small PV. Large, central, economical renewable electric generation projects are being analyzed to offset the overall electric usage, but this is dependent on virtual net metering. Virtual net metering or community solar-type legislation was recently defeated in the Oregon legislature, but there is a sense that this type of legislation will continue to be pushed.

Unique Project

OR ARNG is investigating a possible joint project with the Air Guard to power Kingsley Airfield with geothermal electricity from either an on-site power plant or a planned plant located off-site and supplying the field power through a dedicated power line. The geothermal plant may be owned by OR ARNG or a third party, depending on the procurement and financing mechanism used.

[a] OR ARNG provided corrected data to replace AEWRS data.

	Average FY 2012 Energy Costs ($/MMBtu)	FY 2012 Energy Consumption (MMBtu)	FY 2012 Energy Use Intensity (MMBtu/ksf)
SIERRA ARMY DEPOT	40.59	159,198	30.76

Sierra Army Depot's Status in FY 2013

The predominant energy use at Sierra Army Depot is natural gas (68%), and electricity is 32% of total energy use. The installation is aggressively pursuing energy reduction through energy efficiency measures such as sealing warehouse doors and turning off high mast lights. Energy efficiency measures are being financed through an ESPC. Sierra Army Depot is also working to install a 1-MW PV system on the closed landfill site and skylights in their warehouses.

Where Is Sierra Army Depot Headed?

Sierra Army Depot funded its utility, Plumas Sierra Rural Electric Cooperative (PSREC), to perform an interconnection study. PSREC will look at the impacts of installing 500 kW, 1 MW, or 2 MW of PV on the site. A 2-MW PV system would provide approximately 30% of the Net Zero electric goal. Sierra Army Depot is installing skylights in its warehouses to reduce the electrical energy demand. This project should start in FY 2014. Sierra Army Depot also installed a SHW system to heat its community pool and lighting control measures for the high mast lighting system.

Unique Project

Sierra Army Depot is served by a cooperative utility that would like to pursue an innovative implementation mechanism for renewable electricity. The cooperative utility would finance, own, and operate a renewable electricity system and recover its costs through its capital improvement account with Sierra Army Depot. By partnering with the cooperative utility, the installation can benefit from the utility's ability to access low-cost financing from the U.S. Department of Agriculture (USDA) Rural Utility Service and utilize Federal tax credits as the utility has a for-profit subsidiary with a tax liability.

U.S. MILITARY ACADEMY WEST POINT	12.11	903,886	116.65

West Point's Status in FY 2013

Of the almost 1 million MMBtu of energy used at the installation in 2010, 70% was thermal and 30% was electrical. The installation is increasing its energy footprint with construction of new facilities, but is actively reducing energy use in existing facilities with its ESPC.

Where Is West Point Headed?

There is currently no identified set of renewable energy and energy efficiency projects capable of offsetting garrison annual energy use that are financially feasible. West Point is currently focused on garrison energy reliability, which must be addressed before or in consideration of longer-term energy sustainability goals. West Point is evaluating opportunities to address these concerns with generation capable of being converted to renewable syngas if and when syngas becomes technically and economically viable. This approach, supplemented with other renewable energy projects, works to achieve Net Zero Energy for the installation.

Unique Project

West Point is evaluating refurbishment of its central energy plant and related energy distribution and use infrastructure with a combined heating, cooling, and power facility. This generation upgrade—along with conversion from steam to hot water distributed heating, absorption chillers with cool water distributed cooling, and other ECMs—is predicted to meet 80% of the garrison's energy needs.

COMMON PRACTICES AND LESSONS LEARNED

Much has been learned through the experience of studying and implementing projects to address Net Zero Energy goals. After completing energy assessments and supporting project development at all nine NZEIs, the following lessons were most common.

Starting the NZEI Process:

- Command support is needed for project execution.
- Providing implementation support after the assessment should be part of the up-front project planning and budgeting process.
- Working toward Net Zero Energy requires a diverse and motivated team that includes many people and organizations within an installation such as public works, master planning, environmental, and contracting as well as outside support from commands, Headquarters, Department of the Army (HQDA), and subject matter experts.

KEY TAKEAWAYS

A Net Zero Energy strategy is just the first step on the journey; successfully achieving Net Zero requires a sustained effort from a strong and motivated team to continue to develop, refine, and execute the strategy.

Net Zero is a part of energy security but achieving energy security requires additional effort and resources.

Establishing Baseline Energy Use:

- Difficulties collecting accurate energy use data increase the duration and reduce the quality of a NZEI assessment.

Evaluating Energy Efficiency Measures:

- Energy goals and efficiency mandates require resources, incentives, consequences, and enforcement to be most effective.
- Behavior and culture change are needed in addition to technology upgrades.
- Thermal Net Zero Energy is the most difficult to accomplish because technologies are limited and building specific; installations may need to consider fuel switching.
- Standard construction designs and installation master planning need to change to sync with Net Zero goals.

Assessing Renewable Energy Potential:

- Many installations are good candidates for emerging technologies, but NZEI assessments focus on commercially available technologies.
- Low utility rates and inadequate renewable energy resources make projects difficult at some installations.

Analyzing Energy Interconnection and Microgrids:

- High penetration levels of renewable energy on an installation requires coordination, special contracts, or negotiations with the serving utility to ensure the ability to interconnect systems that exceed existing export limits.
- Storage and microgrids are increasingly necessary to achieve goals.

Implementing Renewable Energy Projects:

- NZEI assessment financials should be viewed as an estimate useful for planning purposes; private sector financing mechanisms may require additional detailed analysis.
- Installations must account for tradeoffs between water, energy, and waste reductions.

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Camp Parks obstacle course. *Photo from SSgt Steve Cline, U.S. Air Force*

CAMP PARKS RESERVE FORCES TRAINING AREA

NET ZERO ENERGY OVERVIEW

Camp Parks can achieve a **96% Net Zero solution by 2020** by implementing energy efficiency and renewable energy technologies. A basic financial analysis illustrates a positive economic return associated with the Net Zero Energy solution and a lower cost relative to the baseline.

QUICK FACTS

Dublin, CA
Location

1.3 million ft^2
Total building square footage

2,478 acres
Installation area

Pacific Gas & Electric Co.
Utility provider

$0.13/kWh, $8.74/MMBtu
Average energy costs in FY 2012 (electricity, thermal energy)

34.25 MMBtu/ksf
2012 reported energy use intensity

PV, SHW, CHP, and Solar Street Lights
Current renewable energy projects

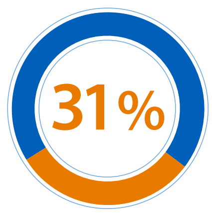
GAME CHANGER

An ability to interconnect PV above the net metering and feed-in tariff limits could allow for 100% renewable electricity in the near future.

[4] NZEI baseline energy consumption data is from FY 2011 utility bills provided by the installation.

KEY ROADMAP RESULTS

Baseline Energy Consumption and Estimated Energy Efficiency Savings



Baseline energy consumption[4]
48,631 MMBtu

Estimated energy efficiency savings
15,219 MMBtu

Sample Recommended Efficiency Improvements

Metering
Lighting retrofits

Sample Recommended Renewables

PV, SVP, SHW
GSHP

UNIQUE PROJECT

A Cogenra ESTCP project will generate hot water and power from a concentrating solar system.

INSTALLATION MAP

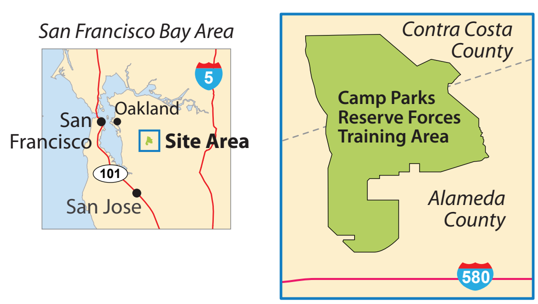


Figure 3. Camp Parks site boundaries

All installation map illustrations are by Dean Armstrong, NREL

Background

Camp Parks (also known as Parks Reserve Forces Training Area [PRFTA]) is a 2,478-acre installation located in Dublin, California. As a component of the Army's Combat Support Training Center, Camp Parks serves as a training area for an estimated 250 reserve components units and 20,000 reservists in northern California.

An NZEI assessment at Camp Parks in 2012 proposed a roadmap of energy projects to achieve Net Zero Energy by 2020. This overview details the energy baseline established for Camp Parks, a roadmap of load reduction and renewable energy projects, and project planning plus financing considerations.

Energy Baseline

An energy baseline is an analysis of current energy consumption at the site, which provides planners and managers a metric against which progress toward Net Zero Energy can be measured. There was a general increase in site electrical usage and a general decrease in site natural gas usage from 2003 through 2012 (Figure 4) as collected from Pacific Gas & Electric Company (PG&E) utility bills. Energy baseline information comes from these utility bills and differs very slightly from reported FY 2011 data.

Monthly peak demands for electrical energy range from approximately 300 kW to 1 MW with typical daily ranges of 400 kW to approximately 800 kW. The average peak load increases in the summer months and is likely attributed to cooling energy (Figures 5 and 6). Site operations, including training schedules, will have an effect on these loads as well.

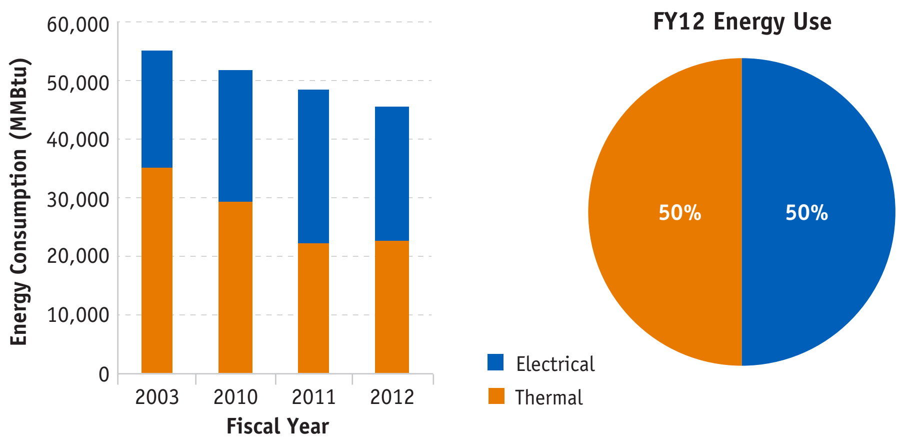


Figure 4. Camp Parks site energy use from 2003 to 2012

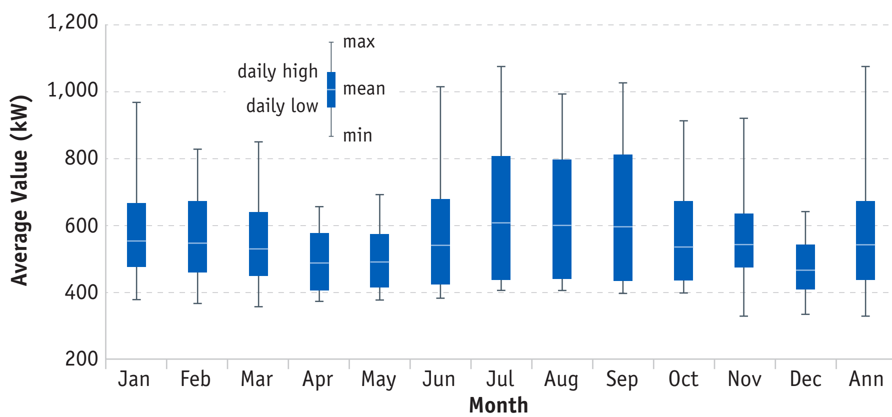


Figure 5. Electrical load profile—primary load monthly averages

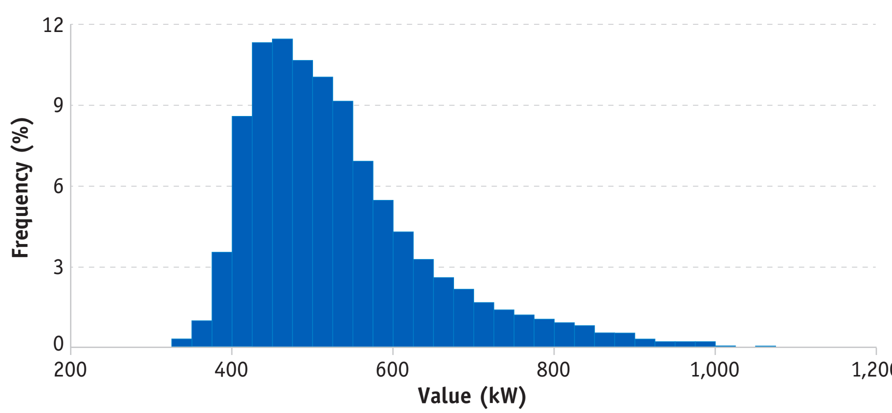


Figure 6. Electrical load profile—primary load peak demand and frequency

Roadmap to Net Zero Energy at Camp Parks

The following is a summary of the analysis for the recommended path toward Net Zero Energy for Camp Parks. This analysis projects that by 2020, Camp Parks will be able to produce 96% of the energy it consumes using on-site renewable sources cost-effectively. The remaining energy usage is associated with thermal energy for space heating, water heating, and process loads such as cooking (Figure 7).

Energy Efficiency Overview

The potential electrical savings amount to 2,921 MWh, or 38.1% of the base electrical load. The base natural gas load reduction is projected to be 52,489 therms, or 23.4% of the thermal load. The total energy reduction for these projects amounts to 15,219 MMBtu, or 31% of the total energy used on site (Table 5).

Through a real property exchange, a private developer will acquire approximately 180 acres (171.5 acres of which belong to the Army) and 24 buildings totaling approximately 250,000 gross square footage (gsf), approximately 23% of total installation building area.[5] In exchange, Camp Parks will gain approximately 152,000 ft^2 of new buildings as well as a variety of road and utility infrastructure construction and improvements.

Camp Parks has also installed a 300-kW natural gas–powered fuel cell that will affect energy use significantly. The project reduces electrical energy purchases from the utility, but increases utility natural gas purchases because the fuel cell uses natural gas to make electricity. Project benefits include cost savings and on-site electrical energy generation.

Table 5. Energy Efficiency Savings Potential

Measure		Savings/ % of Fuel Type		MMBtu Equivalent Savings	% Total Site Savings
SunCal Property Exchange	MWh	808	10.5%	2,757	5.7%
	Therm	23,484	10.4%	2,200	4.8%
Metering	MWh	74	1.0%	253	0.5%
	Therm	2,157	1.0%	216	0.4%
Lighting Retrofit	MWh	1,116	14.6%	3,809	7.8%
	Therm	-	-	-	-
Additional Energy Efficiency Projects	MWh	923	12.0%	3,151	6.5%
	Therm	26,844	12.0%	2,684	5.5%
Total Savings Potential					
Electricity	MWh	2,921	38.1%	9,970	20.5%
Natural Gas	Therm	52,489	23.4%	5,249	10.8%
			Total MMBtu	**15,219**	**31.3%**

Table 6. Proposed Renewable Energy Technologies

Technology	Evaluated Size	Energy Savings (MMBtu)	Simple Payback (years)
SVP	10,700 ft^2	2,287	13
PV	4.0 MW	18,171	22
SHW	7,900 ft^2	3,319	9
GSHP	53 tons	7,005	Needs further analysis[a]

[a] GSHP could be cost effective at Camp Parks, but further analysis is needed to determine financial return and investment decision.

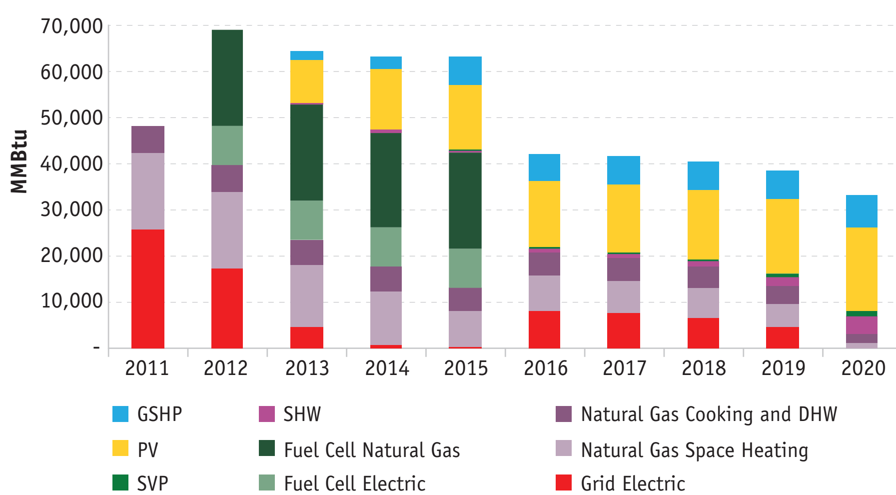


Figure 7. Camp Parks load reduction and renewable energy integration roadmap

[5] Facility space allocations estimated based on the report Space Allocation by Facility for Site 06685: Parks Reserve Forces Training Area, October 2011. This estimate includes all facilities (i.e., property for which the primary unit is square feet) with a real property unique identifier (RPUID).

Figure 8. Cogenra ESTCP
Photo by Caleb Rockenbaugh, NREL

Figure 9. Fuel cell ESTCP
Photo by Caleb Rockenbaugh, NREL

Figure 10. Solar hot water installation
Photo by Caleb Rockenbaugh, NREL

Renewable Energy Project Recommendations

Energy efficiency, SVP, SHW, solar PV, and GSHP technologies all have an estimated payback of fewer than 25 years, with the exception of GSHPs, which are largely cost neutral, but needed in order to come close to achieving Net Zero Energy (Table 6 and Figure 11).

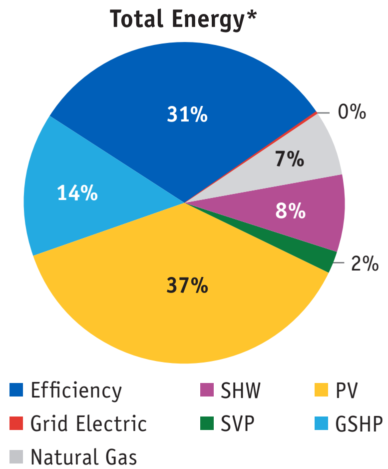
Energy Integration and Microgrid Assessment

Camp Parks had very limited documented information on its electric distribution system infrastructure. Expanding the knowledge of the base's infrastructure will be essential for interconnection and microgrids. Microgrids can ensure energy security for critical loads in the event of a blackout from the local electric utility. The first step toward planning a microgrid is to perform a conceptual design and determine the critical loads, required generation, energy storage, and load shedding schemes. Electrical interconnection of enough renewable energy to get to Net Zero will be a challenge at Camp Parks. The site must work with the utility to overcome barriers to the export of power.

Progress

Camp Parks has undertaken a variety of projects and efforts to help achieve the goal of Net Zero Energy. Completed and ongoing energy projects are described below, along with pictures of several of the projects at the top of the page.

- A 2-MW ECIP PV project in development will handle about 50% of installation electrical load.



*Percentages may not add up to 100% due to rounding.

Figure 11. Camp Parks Net Zero Energy solution breakdown

- A Cogenra ESTCP for a solar cogeneration demonstration project is installed (Figure 8).
- Solar thermal hot water is installed on barracks (Figure 10, different barracks than the Cogenra project).
- Solar PV street lighting is in development.
- Roof-mounted PV and solar thermal is installed on Building 517.
- Phases one and two (out of five) of an LED lighting project are complete.
- A fuel cell ESTCP is operational (Figure 9). Camp Parks expects that maintenance costs outweigh savings in the long term and will likely not continue usage at the end of the contract in FY 2014.
- A real property exchange is in process.

Featured Project: Cogenra ESTCP

Cogenra is demonstrating a new technology to utilize solar power for water heating (144-kW capacity) and electricity production (28-kW capacity) within the same system. The demonstration system is installed on a barracks building and dining facility and produces about 3,000 gal per day of hot water for each building. The project is a 3-year demonstration with funding provided by the DOD ESTCP program. Projected payback is faster than PV or hot water alone. If successful, the system has good potential for replication within DOD.

Key Issues

- There are renewable energy interconnection issues with the PG&E grid for PV.
- Designs planned for new buildings as part of the Camp Parks property exchange risk omission of low-cost efficiency options. Participation in PG&E's Savings By Design program can provide incentives for project design(s) to include energy efficiency measures and should be pursued.
- Additional project financing sources are needed.

Next Steps

Key next steps to implement the Camp Parks Net Zero Energy roadmap include PV project siting coordination with master planning, PV design and construction, electrical systems analysis to determine the upgrades required to interconnect PV into the base distribution system, soil conductivity tests to further examine the potential for GSHP, and the start of the performance contracting process. Camp Parks will also address new building construction from the property exchange, and develop additional energy efficiency and renewable energy projects to meet the Net Zero Energy goal.

Fort Bliss power plant. *Photo from FEMP, NREL 17255*

FORT BLISS

NET ZERO ENERGY OVERVIEW

With ample available renewable energy resources, Fort Bliss can attain **an overall 78% Net Zero solution.** The site can invest in energy efficiency and renewable energy projects through power purchase contracts with private party ownership. Higher costs of energy can be balanced against increased value provided by on-site renewable energy generation.

QUICK FACTS

El Paso, TX
Cantonment area

New Mexico/Texas
Training areas/ranges

21.8 million ft^2
Total building square footage

1.1 million acres
Installation area

El Paso Electric Co., Texas Gulf Coast
Utility providers

$0.06/kWh, $4.90/MMBtu
Average energy costs in FY 2012 (electricity, thermal energy)

66.32 MMBtu/ksf
2012 reported energy use intensity

PV, SHW, CHP
Current renewable energy projects

GAME CHANGER

PV and WTE plants have the potential to meet up to 80% of Fort Bliss' electricity load with residential waste from El Paso. The WTE plant would be sized to cover approximately 65% of the electric load and would be complemented by the proposed geothermal and PV projects to create a mix of renewable energy technologies.

KEY ROADMAP RESULTS

Baseline Energy Consumption and Estimated Energy Efficiency Savings

Baseline energy consumption[6]
1,518,576 MMBtu

Estimated energy efficiency savings
227,786 MMBtu

Sample Recommended Efficiency Improvements

Retro commissioning · Lighting retrofits · Motors

Sample Recommended Renewables

PV, CSP, SVP, SHW · WTE · GSHP

UNIQUE PROJECT

An ESPC contract will implement energy efficiency, water conservation, and smaller renewable energy projects like SHW, GSHP, SVP, and carport and rooftop PV, resulting in $5 million per year savings for an overall payback of 16.6 years.

INSTALLATION MAP

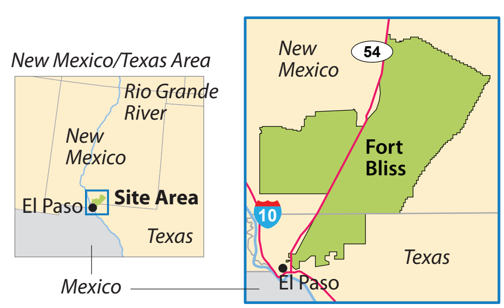


Figure 12. Fort Bliss site boundaries

[6] Based on 2010 and 2011 data provided by the Army for NZEI analysis, which varies slightly from AEWRS data.

Background

Fort Bliss is located on 1,740 square miles in west Texas and southeastern New Mexico. In many ways, this post stands as the forerunner of change in the U.S. Army as it is transformed from the home of the U.S. Army Air Defense Artillery Center to a heavy maneuver division and mobilization center. With approximately 1,119,700 acres, it is one of the largest Army posts in the United States.

The post is striving to become the Army's Center for Renewable Energy and to achieve NZEI status. This overview details the established Fort Bliss energy baseline, a roadmap of load reduction and renewable energy projects, and project planning plus financing considerations.

Energy Baseline

The Fort Bliss energy baseline includes energy use in buildings, facilities, and exterior lighting. All energy use in the cantonment area and training areas on the main installation is included in the baseline. The energy baseline does not include energy use at the New Mexico ranges and installation housing. At Fort Bliss, energy use has increased in recent years along with the square footage of buildings, which grew from approximately 10 million ft^2 in 2005 to 21.8 million ft^2 in 2011, and which is expected to increase another 3 million ft^2 by 2020. Energy consumption in FY 2012 was 1,503,281 MMBtu (Figure 13). The annual electrical load profile averages 35 MW, with a minimum of 22 MW in the spring and fall and a maximum of 63 MW in the summer (the on-peak period is from June to September with cooling as the predominant load).

Currently the post relies on the grid for nearly 94% of its electricity and on Texas Gas Service Company for the majority of its thermal load.

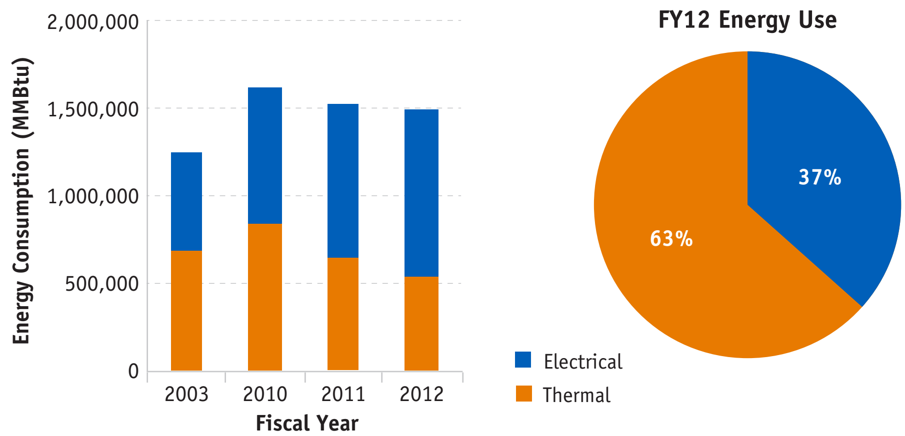


Figure 13. Fort Bliss site energy use from 2003 to 2012

Roadmap to Net Zero Energy at Fort Bliss

The recommended energy efficiency and renewable energy projects for Fort Bliss generate enough power to cover 100% of the electric load and 46% of the thermal load for an overall 78% Net Zero solution.

Energy Efficiency Overview

Many times the most cost-effective way to reduce energy use is through engaging people. Opportunities to do this exist in various forms at any given site. Identifying actions and measures that people can implement at little or no cost can have a significant effect on energy use. For example, using space more efficiently to reduce the amount of building area that is heated and cooled can save energy. Additionally, people can implement measures that include upgrading or replacing existing equipment or control strategies, making modifications to the envelope of a building, or instituting other similar measures.

After behavior change, energy efficiency is typically the most cost-effective energy project investment. USACE was tasked with performing an extensive energy-efficiency assessment of Fort Bliss as part of an Energy Engineering Analysis Program (EEAP) study. This energy optimization assessment looked at 46 representative buildings on the installation and identified 472 conservation measures. The recommended ECMs summarized in Table 7 are estimated to save approximately $944,202 per year (8.9 MWh/yr in electrical energy savings, 28,813 MMBtu/yr in natural gas energy savings, 59,252 total MMBtu/yr in energy savings, and 1,825 kgal in water savings), at an estimated installed cost of $27 million. Proposed, economically viable ECMs include variable speed drives and air handling units, direct digital controls upgrades, and extensive lighting retrofits, including occupancy sensors.

The results of these energy efficiency studies were not available during the Net Zero analysis, so a total 15% reduction was assumed. This number is still believed to be valid because the studies did not cover all buildings or opportunities.

Renewable Energy Project Recommendations

The NREL NZEI assessment process looks at options to cover the minimized electrical energy load through on-site renewable energy generation. This remaining electric

FORT BLISS

load is the total estimated amount of electrical energy use on site after energy efficiency measures have been implemented (Table 7). Fort Bliss expects to generate the majority of this electrical load through a combination of geothermal power, an innovative WTE/CSP application, and a 20-MW ground-mounted PV plant. In addition, the installation is exploring approximately 5 MW of smaller rooftop and carport PV systems (Tables 8 and 9, Figures 15 and 16).

Fort Bliss Net Zero Energy Solution Breakdown

Many of the projects included in the Net Zero Energy solution (Figure 14) are currently not cost-effective compared with grid-delivered energy costs. Fort Bliss would need to accept higher energy costs to improve the installation's energy security and meet the Net Zero Energy goal by 2020. Likely procurement methods include direct appropriations (ECIP, SRM) and alternative financing mechanisms (ESPC and PPA), shown in Table 8.

Energy Integration and Microgrid Assessment

Three PV projects are underway at Fort Bliss. These include a 1.3-MW PV system to be installed adjacent to Commanding General HQ by JCI/General Electric, a roof-mounted 120-kW PV system to be installed on the Infantry Brigade Combat Team Dining Facility by Lockheed Martin, and an ECIP project that will provide PV at the communications center and connect five office buildings, including Garrison Command HQ and DPW Ft. Bliss, into a microgrid.

Progress

- A 20-MW PV plant project is under discussion with El Paso Electric.
- A feasibility study is underway to assess landfill gas production and a PV installation on the cap of the closed Fort Bliss landfill in FY 2014.
- An EEAP report and other energy efficiency and small renewable energy projects, such as SHW, are primed for ESPC project development and implementation in FY 2014.
- The Davis Dome (McGregor Range) geothermal resource assessment is scheduled for a September 2013 completion. In the first quarter of FY 2014, Fort Bliss will identify potential production and begin development of third-party financed procurement of electrical delivery to McGregor Range camps and Fort Bliss if capacity is greater than 2 MW.

Featured Project: WTE/CSP Plant

The main contributor to Fort Bliss' proposed renewable energy generating mix is a 30-MW-plus WTE plant, which could meet up to 65% of Fort Bliss' electric load with residential and commercial waste from El Paso. The recommended WTE plant would be sized to cover approximately 65% of the post's electric load and would be complemented by the proposed geothermal and PV projects to create a mix of energy technologies for Fort Bliss' near Net Zero Energy solution.

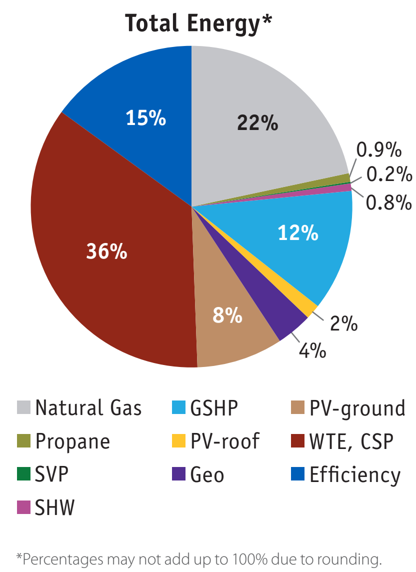


Figure 14. Fort Bliss Net Zero Energy solution breakdown

Table 7. Recommended Energy Conservation Measures from EEAP Report

ECM Group	Estimated Annual Savings						Estimated Implementation Costs ($)
	Electric		Thermal	Water	Totals		
	kWh	MMBtu	Nat. Gas MMBtu	kgal	Total MMBtu	Cost Savings ($)	
No Cost/Low Cost Investment	2,525,054	8,615	8,593	1,825	17,209	292,259	2,003,377
Moderate Investment Cost	2,918,866	9,959	12,588	–	22,547	344,546	3,605,876
Significant Investment Cost	2,819,076	9,619	7,445	–	17,063	256,995	19,597,561
Renewable Energy Technologies	657,993	2,245	188	–	2,433	50,402	1,852,965
Totals	**8,920,989**	**30,438**	**28,813**	**1,825**	**59,252**	**944,202**	**27,059,779**

Note: The dashes in the water column appear because all water reduction measures were low cost and not renewable energy technology.

Figure 15. Carport PV
Photo by Scott Huffman, NREL

Key Issues

Siting of the WTE plant is dependent on the Fort Bliss Programmatic Net Zero Environmental Impact Statement, scheduled for completion in FY 2014.

Discussions with the City of El Paso on its commitment to support WTE development are in progress, and the installation is working with El Paso Electric to deliver WTE energy production to Fort Bliss.

Next Steps

Fort Bliss has set a 2018 deadline for achieving Net Zero Energy. Additional project validation and development work is needed for PV, WTE, and other energy efficiency projects to meet this goal.

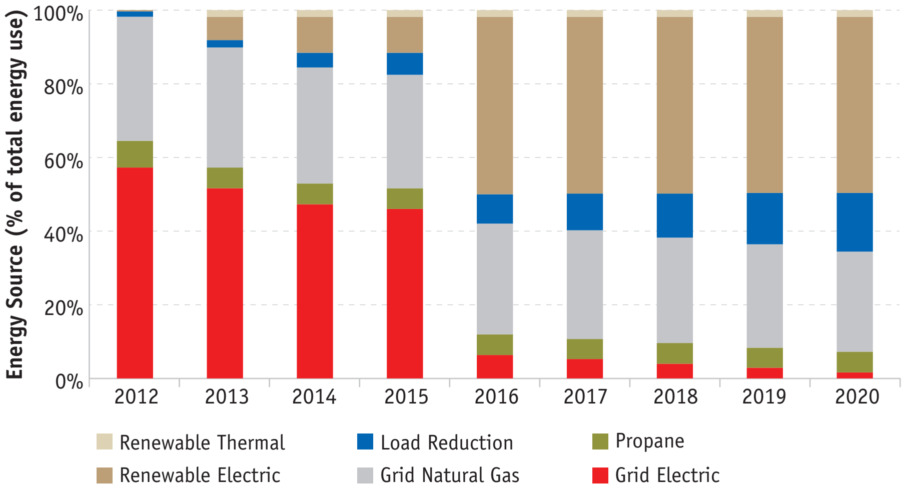


Figure 16. Fort Bliss load reduction and renewable energy integration roadmap

Table 8. Potential Energy Project Implementation Plan

Project	Energy Reduction/ Generation (MMBtu)	Implementation Year	Capital Cost ($)	Procurement Method	% of NZE Goal
Load Reduction (Energy Efficiency)	314,089	2013–2020	41,252,420	ECIP, ESPC, SRM	15.8
Geothermal	76,406	2014	15,000,000	ECIP/PPA	3.6
WTE/CSP	710,373	2016	300,046,000	EPE PPA	36.0
Ground-Mounted PV	172,989	2013–2014	100,000,000	ECIP/EPE PPA	8.7
Rooftop PV	29,889	2013–2015	25,000,000	ECIP/ESPC/SRM	1.5
GSHP	243,080	2013–2018	14,772,000	ECIP/ESPC/SRM	12.2
SHW	14,970	2013–2018	1,105,000	ECIP/ESPC/SRM	0.7
SVP	3,114	2013–2018	224,695	ECIP/ESPC/SRM	0.1
Total	**1,560,910**	**2013–2020**	**497,400,115**		**78.0**

Table 9. Recommended Renewable Energy Technologies for Electric and Thermal Loads

	Size	Energy Production (MMBtu)	% of Load	Levelized Cost of Energy (LCOE)
Electrical load 336 GWh: 100% renewable (with 15% energy use reduction from energy efficiency by 2020)				
McGregor Geothermal	3 MW	72,406	6.3	$0.15/kWh
WTE/CSP	36 MW	710,373	62.0	$0.11/kWh
PV–Ground	25 MW	172,989	15.1	$0.12/kWh
PV – Roof/Carport	5 MW	29,889	2.6	$0.16/kWh
Thermal: natural gas and propane 836,127: MMBtu 46% renewable (w/15% energy efficiency)				
GSHP	9,600 tons	243,080	25.6	$4/MMBtu
SHW	27,422 ft^2	14,970	1.6	$15/MMBtu
SVP	15,254 ft^2	3,114	0.3	$10/MMBtu

A LEED platinum building with on-site solar array. *Photo from Fort Carson*

FORT CARSON

NET ZERO ENERGY OVERVIEW

Net Zero Energy looks promising from a technical perspective, but because of relatively low utility rates for electricity and natural gas, Fort Carson may have to accept higher costs of energy to achieve Net Zero Energy by 2020. A Net Zero solution, with **100% of electrical and 93% of thermal energy from renewable systems,** is possible.

QUICK FACTS

Colorado Springs, CO
Location

13.6 million ft^2
Total building square footage

137,000 acres
Installation area

Colorado Springs Utilities, Western Area Power Administration
Utility providers

$0.06/kWh, $5.19/MMBtu
Average energy costs in FY 2012 (electricity, thermal energy)

104.40 MMBtu/ksf
2012 reported energy use intensity

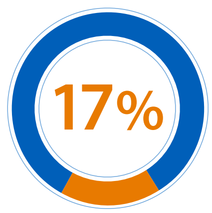
PV, SHW, SVP, GSHP
Current renewable energy projects

GAME CHANGER

Fort Carson is striving for Net Zero at the new Combat Aviation Brigade (CAB). The new CAB buildings must meet American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE) Standard 189.1 specifications. Fort Carson is also developing a request for proposals (RFP) for a central plant that will be natural-gas-fueled, but with the capability to be converted to use biomass fuels.

KEY ROADMAP RESULTS

Baseline Energy Consumption and Estimated Energy Efficiency Savings



Baseline energy consumption[7]
1,292,912 MMBtu

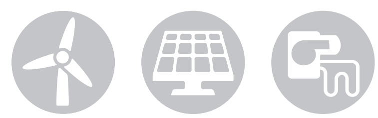
Estimated energy efficiency savings
215,917 MMBtu

Sample Recommended Efficiency Improvements

Boiler retrofit or replacement

Lighting retrofits

Sample Recommended Renewables



Wind

PV, CSP, SVP, SHW

GSHP

UNIQUE PROJECT

Fort Carson is transforming 1950s-era barracks into modern LEED office buildings. Renovations resulted in reduced energy use in the building envelope, lighting, plug loads, and HVAC, and also added renewable energy generation.

INSTALLATION MAP

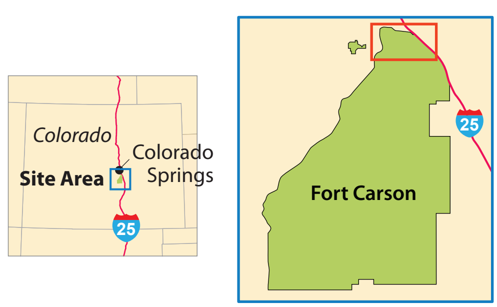


Figure 17. Fort Carson's cantonment area (red outline) contains soldier support facilities; the rest of the installation (green) is the downrange area

[7] Based on FY 2011 utility bills

Background

Fort Carson is south of Colorado Springs and east of the Rocky Mountain Front Range. It comprises approximately 137,000 acres and ranges from 2 to 15 miles from east to west and up to 24 miles from north to south.

Fort Carson supports the living and training requirements of Army personnel stationed at the installation. The cantonment area contains most of the soldier support facilities on Fort Carson such as troop and family housing and administrative, maintenance, community support, recreation, classroom, supply, and storage facilities. The rest of Fort Carson (south of the cantonment area) is the downrange area, which is used for weapons qualification and field training. It includes firing ranges, training areas, and impact areas (Figure 17). Training lands at Fort Carson are actively managed to sustain them for continued use in supporting the Army's training mission.

Energy Baseline

An energy baseline is an analysis of energy consumption at the site, which provides planners and managers a metric against which progress toward Net Zero Energy can be measured. Baseline energy use for Fort Carson was 1,292,912 MMBtu, as reported in FY 2011 utility bills from Colorado Springs Utilities (CSU), Western Area Power Administration (WAPA), and Fort Carson's Solar I PPA provider. Energy use in FY 2011 included buildings, facilities, and exterior lighting.

In FY 2012, energy consumption totaled 1,339,095 MMBtu, comprised of 765,428 MMBtu thermal energy and 573,666 MMBtu electrical energy (Figure 18).

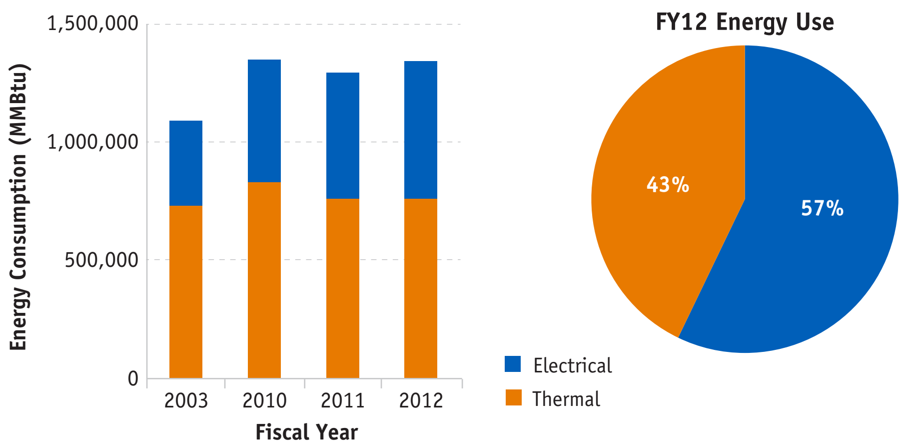


Figure 18. Fort Carson site energy use from 2003 to 2012

Table 10. Recommended Renewable Energy Technologies

	Size	Energy Production	LCOE[a]
Electrical: 100% Renewable			
Wind	11 MW	84,000 MMBtu	$0.08/kWh
PV, Ground	77 MW	398,000 MMBtu	$0.17/kWh
PV, Rooftop	24 MW	126,000 MMBtu	$0.20/kWh
CSP	20 MW	171,000 MMBtu	$0.20/kWh
GSHPs		–38,000 MMBtu[b]	
Thermal: 93% Renewable			
GSHPs	16,000 tons	410,000 MMBtu	$2.80–$4.60/ MMBtu
Biomass	45 MMBtu/h	254,617 MMBtu	$4.30/MMBtu
SVP	107,000 ft^2	32,000 MMBtu	$3.30/MMBtu
SHW	53,000 ft^2	25,000 MMBtu	$6.30/MMBtu

[a] For comparison, Fort Carson's 2011 utility electric rate is $0.058/kWh, and the projected 25-year utility LCOE is $0.061/kWh.

[b] GSHPs provide net energy savings because they significantly reduce thermal energy use, but they require a small amount of electricity to operate; thus, electrical requirements are reflected as a negative number.

Roadmap to Net Zero Energy at Fort Carson

At Fort Carson, NREL recommended a near Net Zero solution with renewable systems supplying 100% of electrical and 93% of thermal energy needs (Figure 22).

Energy Efficiency Overview

In addition to analyzing the potential for renewable energy generation at the installation, NREL reviewed the potential for energy efficiency improvement and sought ways to reduce the electrical and natural gas loads. Compared with 2003, Fort Carson has already reduced energy use by 15%.

Renewable Energy Recommendations

To meet the installation's electrical load, maximizing wind power development within the area of good wind resource on Fort Carson is the first step in cost-effective measures. Remaining electricity could be supplied through a combination of PV (Figure 20) and CSP, which adds energy security with six hours of storage, as long as the system is configured to stay up when the grid goes down. Thermal energy needs are met with biomass, GSHP, SVP, and SHW. Biomass replaces the natural gas used at the central heating plant and GSHPs replace the distributed boilers (Table 10). Natural gas is used for the remaining 7% of thermal loads. The energy mix for near Net Zero Energy at Fort Carson recommends that renewables generate 100% of electric energy and 93% of thermal energy, for an overall 96% renewable energy solution (Figure 19).

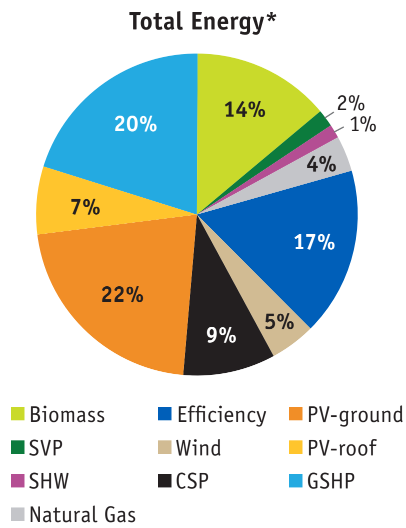


Figure 19. 2020 near Net Zero Energy mix

Energy Integration and Microgrid Assessment

Fort Carson is a large load installation and can integrate large percentages of on-site renewable energy projects without exporting power to CSU's system. The maximum and minimum demands at the site are approximately 37 MW and 15 MW, respectively. For renewable energy projects that will export power to the utility, the Colorado Public Utilities Commission (CPUC) has few regulation policies or incentives for municipal utilities.

Fort Carson installed a microgrid under the Smart Power Infrastructure for Energy Reliability and Security (SPIDERS) program. The microgrid will power critical assets during a grid outage of up to 72 hours. It will be powered by approximately 50% renewable energy (1-MW PV) and 50% diesel fuel, and incorporates plug-in electric vehicle (PEV) battery storage. Incorporating renewable energy and storage defers diesel fuel consumption and extends the time the microgrid can power loads with a finite supply of diesel. The microgrid was installed and completed operational demonstration in fall 2013.

Figure 20. Fort Carson solar array. *Photo from Fort Carson*

Figure 21. Final Building 1219 energy model with PV and shading objects
Image Credit: © 2013 Google Earth, alterations by Matthew Leach, NREL.

Progress

Fort Carson is pursuing many energy efficiency, renewable energy, and energy security initiatives. Current efforts include:

- A contract to replace lighting in 15 facilities.
- A contract to replace old and inefficient boilers in 14 facilities.
- An ECIP project to reduce HVAC energy use in several facilities, replace overhead doors, and improve the power factor for the site by installing large capacitors in key locations.
- An ESTCP project to reduce energy consumption in a dining facility by installing variable speed drives on the fans and sensors on the main kitchen hoods.
- Task Order 1 on an ESPC contract to find ways to cut energy use up to 15%. Energy projects completed to date include window recommissioning, lighting retrofits for 27 buildings, and the addition of variable-speed drives. The site is working to secure approval for additional efforts under Task Order 2.
- The $7 million SPIDERS smart grid project will enable the base to continue to power critical operations during a long-term electrical outage.
- Development of additional ECIP projects to replace additional boilers and install radiant heater systems, transpired solar walls, and a biomass boiler for the main heating plant.

Featured Project: Net Zero Retrofit

NREL conducted a Net Zero retrofit optimization of Building 1219 at Fort Carson (Figure 21) to demonstrate the feasibility of achieving Net Zero Energy performance within the constraints of a retrofit construction project. The optimization considered efficiency measures such as lighting power density reduction, improved lighting controls, daylighting, plug load reduction and controls, building envelope improvements, and HVAC modification, as well as renewable generation. The analysis indicated energy use could be reduced by 58% through cost-effective efficiency measures that resulted in a lower LCC compared with the baseline model. Additional energy to achieve Net Zero could be provided through rooftop PV.

Many of the efficiency strategies evaluated have been incorporated in a retrofit of Building 1219, including:

- LED lighting.
- Controllable plug strips for office workstations.
- Zone-level HVAC (fan coil units).
- High-efficiency computer monitors.
- Multifunction office support equipment.
- Sensor-based lighting control, including daylighting.
- Additional roof insulation and a white roof membrane.
- Renewable generation (solar water heating).

Similar strategies could be considered for office retrofits throughout the Army's portfolio of buildings.

Key Issues

- Life cycle cost-effectiveness of renewable energy systems in a location with very low utility rates.
- Mission impacts from renewable systems such as wind turbines on a site with an aircraft mission.
- A premium for renewables in a budget-constrained environment.

Next Steps

The next steps for Fort Carson involve siting and procurement studies, including PV and CSP, biomass, GSHP, and SVP.

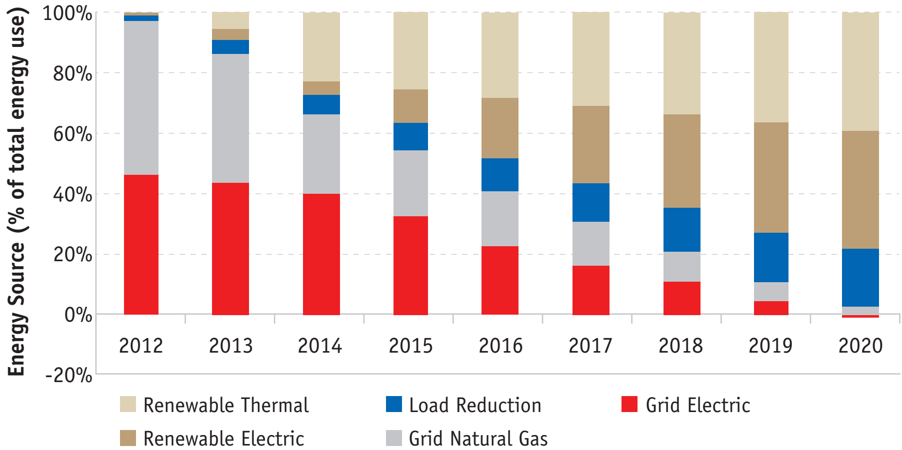


Figure 22. Fort Carson load reduction and renewable energy integration roadmap

Fort Detrick grounds. *Photo from Fort Detrick Public Affairs*

FORT DETRICK

NET ZERO ENERGY OVERVIEW

By FY 2020, Fort Detrick and its Forest Glen annex can achieve **energy reductions of 71% and 40%**, respectively, through energy efficiency measures and renewable energy projects, and a **combined 61% reduction** for both locations. Projects include solar PV developed through a PPA with the Army Energy Initiatives Task Force (EITF).

QUICK FACTS

Frederick, MD
Location

3.1 million ft²
Total building square footage

1,344 acres
Installation area

Potomac Electric Power Co., Potomac Edison, Washington Gas
Utility providers

$0.08/kWh, $4.00/MMBtu *(Frederick)*

$0.10/kWh, $5.69/MMBtu *(Forest Glen)*

Average energy costs in FY 2012 (electricity, thermal energy)

359.00 MMBtu/ksf
2012 reported energy use intensity

PV, ESTCP
Current renewable energy projects

GAME CHANGER

Gas steam plant de-centralization work is underway, with a potential savings of 30% of gas energy and 20% of the total site energy load. This work is being done under a UESC.

KEY ROADMAP RESULTS

Baseline Energy Consumption and Estimated Energy Efficiency Savings

Baseline energy consumption[8]
1,113,621 MMBtu

Estimated energy efficiency savings
334,087 MMBtu

Sample Recommended Efficiency Improvements

Decommission steam plant

Data center upgrade

Sample Recommended Renewables

PV, SVP, SHW

Incinerator electricity

UNIQUE PROJECT

A 15-MW PV system is being developed through a PPA, and electricity generation from incinerator boilers is being evaluated.

INSTALLATION MAP

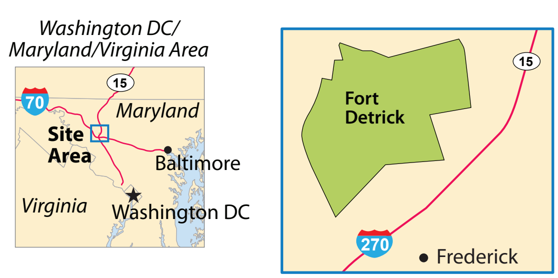


Figure 23. Fort Detrick site boundaries

[8] Based on 2010 and 2011 data provided by the Army for NZEI analysis, which varies slightly from AEWRS data.

Background

Fort Detrick in Frederick, Maryland, is situated on 1,212 acres. In addition to this area, Fort Detrick recently assumed command of the Forest Glen annex (132 acres) and Glen Haven Housing Area (20 acres) in Montgomery County, Maryland. The scope of this project covers Fort Detrick as well as the Forest Glen annex.

Fort Detrick is home to the National Interagency Biodefense Campus (NIBC), which supports research on critical diseases, the threats posed by biological warfare, and strategies for protecting citizens from these threats. This post also supports the critical U.S. Army Strategic Communications Command (STRATCOM), which exercises full control over worldwide Army strategic communications.

The Army Garrison at Fort Detrick takes up 3.1 million ft^2 of building space. Barracks and privatized family housing make up approximately 5% of the total square footage, with labs making up 40% and communications covering 15%. The remaining area (40%) is composed of different building types, including shopping and commercial areas, fitness facilities, gymnasiums, and police and fire stations.

Energy Baseline

An energy baseline is an analysis of energy consumption at the site, which provides planners and managers a metric against which progress toward Net Zero Energy can be measured. Fort Detrick's baseline energy use of 1,113,621 MMBtu was derived from 2010 and 2011 utility bill data.

In FY 2012, energy consumption totaled 1,150,813 MMBtu, comprised of 682,052 MMBtu thermal energy and 468,761 MMBtu electrical energy (Figure 24).

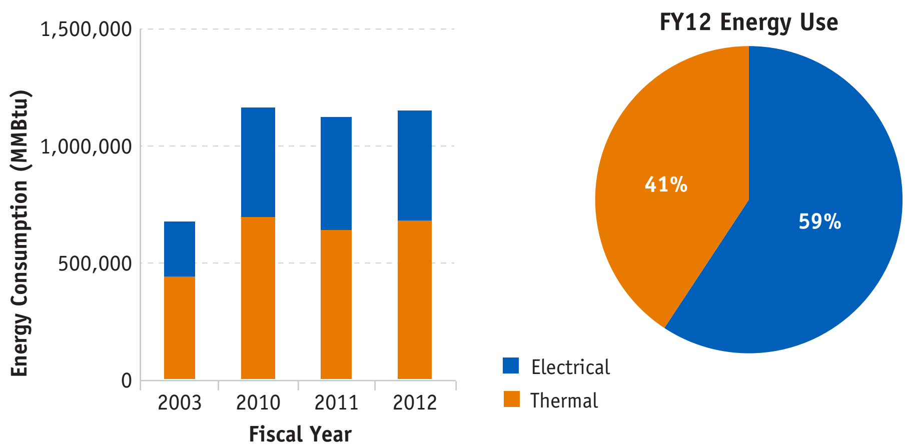


Figure 24. Fort Detrick site energy use from 2003 to 2012

Roadmap to Net Zero Energy at Fort Detrick

Fort Detrick is developing a solar PV project through a PPA in cooperation with the Army EITF. The installation will also look for opportunities in new construction to develop energy efficient buildings that contain renewable energy systems such as PV or SHW. As roofs are replaced and parking lots are built, the installation will review the addition of solar technologies to those projects where appropriate. An ESPC is recommended for implementing the additional energy efficiency projects as well as SVP and SHW.

Energy Efficiency Overview

Two energy efficiency studies were completed at the Fort Detrick and Forest Glen sites, coincident with the NZEI analysis. The EEAP report found that for an estimated investment of $215,000 in energy efficiency projects the base would achieve an estimated lifetime savings of $821,000, with a 6.8-year simple payback. The second study, performed by Pacific Northwest National Laboratory (PNNL), identified 16 ECMs, resulting in 23,154 MMBtu in electrical savings, 2,808 MMBtu in demand savings, and 54,486 MMBtu in gas savings, resulting in annual savings of $2,626,304. With the recommended ECMs, the savings would result in a reduction of 4.97% of the total energy load. With an estimated investment of $7 million, the projects have an estimated simple payback of 2.7 years.

The results of these energy efficiency studies were not available during the NZEI analysis, so a total 30% reduction was assumed. This number is still believed to be valid because the energy efficiency studies did not cover all buildings or opportunities.

FORT DETRICK

Renewable Energy Project Recommendations

An initial assessment identified solar PV, SHW, and SVP as feasible technologies at Fort Detrick and Forest Glen (Table 11 and Figure 28). NREL considered CSP as an option, then excluded it because of site space constraints and the EITF project focus on solar PV. Geothermal power, wind power, and ground source heat pumps were also not considered because there is no usable resource in the region.

The predominant site energy use is natural gas, followed by electricity (Figure 25). The jump in total energy consumption in 2009 is due to the acquisition of the Forest Glen annex.

Energy Integration and Microgrid Assessment

The planned PPA-funded PV project at Fort Detrick will use the nonstate/non-PJM Interconnection process. At the time of implementation, the planned generating facility will be at a nameplate capacity (13 MW or larger) that is too large to qualify for expedited treatment under the small generator interconnection rules. Also, because the facility will not be large enough to generate excess energy from the Fort Detrick metering points, it will not require the PJM process. Fort Detrick planners expect this will be true for each incremental piece of generation installed.

A microgrid assessment was not performed because a recent microgrid study was conducted by the Directorate of Installation Services.

Table 11. Proposed Renewable Energy Technologies

Technology	Evaluated Size	Energy Savings (MMBtu)	Simple Payback (years)
Fort Detrick			
PV – Rooftop	1,717 kW	6,529	Subject to installed cost per watt[a]
PV – Carport	8,208 kW	31,212	
PV – Ground-mounted	12,000–16,000 kW	45,630–60,840	
SHW	32,232 ft²	19,998	18
SVP	32,495 ft²	20,003	13
Incinerator Electricity[b]	2,300 kW	58,450	58
Forest Glen			
PV – Rooftop	1,439 kW	5,472	Subject to installed cost per watt[a]
PV – Carport	2,984 kW	11,348	
LED Lighting	61 kW	894	26
SHW	63,035 ft²	12,833	25
SVP	17,438 ft²	3,925	12

[a] Solar panel prices have been decreasing and can reduce installed cost. At an installed cost of about $2.61/W for a 12-MW plant, the real cost of solar power over 25 years yields a net savings of $2,296,776 compared to the cost of grid-connected power in the business as usual base case.

[b] Ft. Detrick has existing incinerators for medical and solid waste to generate steam. The incinerators do not currently run at full capacity and their output could be increased with additional waste or biomass fuel and the resulting steam used to produce electricity.

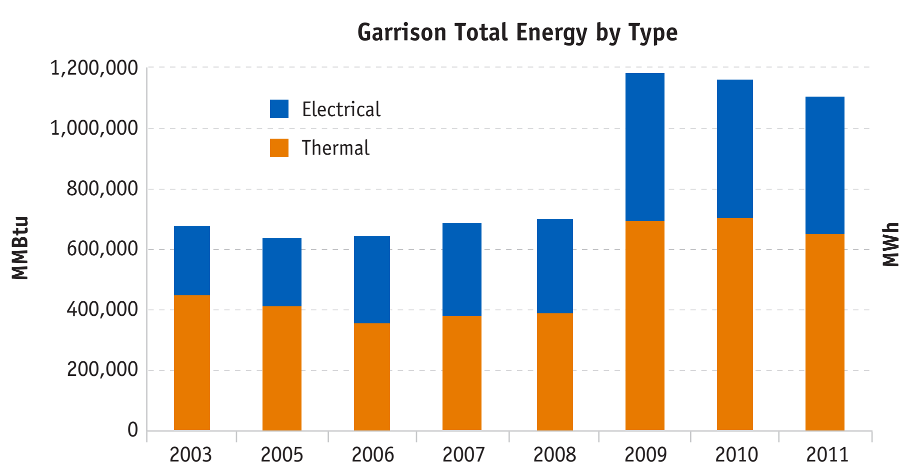


Figure 25. Fort Detrick Garrison energy consumption by type

Figure 26. The NREL team inspects part of the incinerator boiler system
Photo by John Nangle, NREL

Figure 27. The NREL team surveys Area B, the site of the 15-MW PV system
Photo by John Nangle, NREL

Progress

Fort Detrick has undertaken a variety of projects and efforts to help achieve the goal of Net Zero Energy. Completed and ongoing energy projects include:

- A 15-MW PV system (Figure 27).
- An incinerator boiler system (Figure 26).
- Central steam plant de-commissioning.

Featured Projects

A 15-MW PV system is being developed through a PPA. This system is expected to offset 20% of Fort Detrick's garrison electricity load. The developer selection process is currently underway.

Gas steam plant de-centralization work is underway, with a potential savings of 30% of gas energy and 20% of the total site energy load. This work is being done under UESC and is expected to be complete by September 30, 2015 (work can only be done during the summer months).

Electricity generation from incinerator boilers is being evaluated. Additional equipment could be added to the existing incinerators to generate electricity instead of just steam. This would be particularly effective if the boilers operated at their rated output with the addition of more waste or biomass fuel.

Key Issues

A biomass solution could be technically feasible for both Fort Detrick and Forest Glen. However, issues such as site security, fuel transportation, and local community concerns need to be addressed before biomass projects could proceed.

Natural gas consumption remains high at Fort Detrick and Forest Glen. Due to the low cost of gas, conversion to electric water heating, cooking, and building heating systems, which could be powered by renewable electricity, is not cost-effective at current energy prices.

Much of the energy load at both locations goes to laboratory buildings, which have a greater energy use intensity than other buildings. Although some efficiency measures can be implemented, meeting the energy needs of these facilities entirely through energy efficiency and renewable energy projects presents a challenge.

Next Steps

This roadmap is the first step on the path toward increased energy efficiency and use of renewable energy. Next steps toward Net Zero Energy at Fort Detrick include:

- Audits for all laboratory facilities.
- PV siting and procurement study.
- Procurement study for biomass co-firing in incinerators.
- Procurement study of SHW and SVP systems.
- Procurement study for light-emitting diode (LED) lighting.
- Fuel cell partnership with the Army's Construction Engineering Research Laboratory (CERL).
- Additional ESPC or UESC alternative finance contracts.

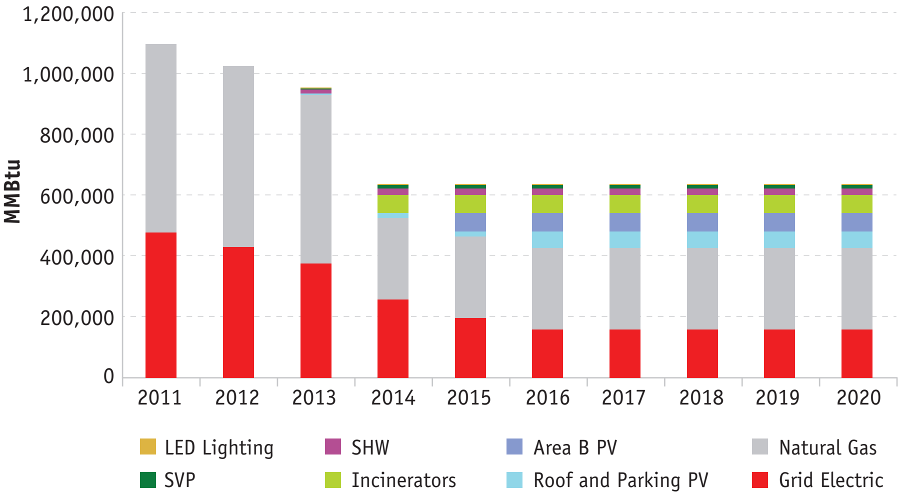


Figure 28. Fort Detrick and Forest Glen load reduction and renewable energy integration roadmap

Headquarters building. *Photo from U.S. Army*

FORT HUNTER LIGGETT

NET ZERO ENERGY OVERVIEW

Fort Hunter Liggett can achieve a **100% Net Zero solution by 2020** through energy efficiency and renewable energy technologies. Due to the high cost of energy at Fort Hunter Liggett, the Net Zero solution can save the installation approximately $25 million over the 25-year analysis period. Some propane may be used for cooking in the dining facility.

QUICK FACTS

Jolon, CA
Location

2 million ft²
Total building square footage

161,900 acres
Installation area

Pacific Gas & Electric Co.
Utility provider

$0.11/kWh, $26.11/MMBtu
Average energy costs in FY 2012
(electricity, thermal energy)

60.74 MMBtu/ksf
2012 reported energy use

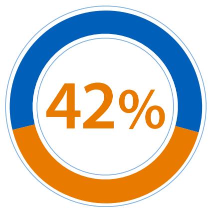
PV, Grid Energy Storage
Current renewable energy projects

GAME CHANGER

The installation utility provider has recently announced that it will upgrade transmission lines to the installation, opening the door for power to be fed onto the grid in times of overproduction. This greatly reduces the installation's need for energy storage, making Net Zero not only feasible, but also economical for Fort Hunter Liggett.

KEY ROADMAP RESULTS

Baseline Energy Consumption and Estimated Energy Efficiency Savings



Baseline energy consumption[9]
81,589 MMBtu

Estimated energy efficiency savings
34,482 MMBtu

Sample Recommended Efficiency Improvements

- Lighting retrofits
- Metering
- Building envelope

Sample Recommended Renewables

- PV, SVP, SHW
- Skylights

UNIQUE PROJECT

Partnering on an ESTCP, Fort Hunter Liggett will soon be producing power from its waste stream. Given the high cost of waste removal at the remote installation, this project will save the installation money on waste disposal fees and from the electricity that is produced.

INSTALLATION MAP

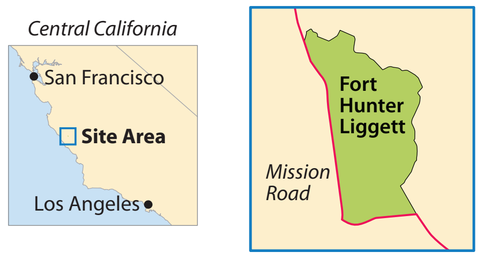


Figure 29. Fort Hunter Liggett site boundaries

[9] Based on FY 2011 AEWRS data

Background

Fort Hunter Liggett is an Army Reserve installation with 161,900 acres of land area located in Jolon, California. The installation has no significantly populated areas near its boundaries.

Fort Hunter Liggett serves as a training center for the Army's Combat Support and Combat Service Support units with ranges, training areas, and facilities to support year-round joint, multicomponent, and inter-agency training. The installation's resources include training bases, military operations on urban terrain (MOUT) sites, a five-mile convoy live-fire course with 360-degree live fire-capability, weapons qualifications ranges, a C-17-capable dirt airstrip, and a 36-pad heliport.

The site also has 28 classrooms and bed space capable of housing more than 1,758 personnel, which includes 84 Army-owned housing units, 2 hotels, and 6 barracks facilities.

Energy Baseline

An energy baseline is an analysis of energy consumption at the site, which provides planners and managers a metric against which progress toward Net Zero Energy can be measured. In FY 2011, the site's baseline energy use was 81,589 MMBtu.

As shown in Figure 30, the site uses nearly equal quantities of thermal i.e., (propane and jet propellant 8 [JP8]) and electric energy. Energy consumption in 2012 totaled 69,248 MMBtu, comprised of 36,036 MMBtu thermal energy and 33,212 MMBtu electrical energy.

Roadmap to Net Zero Energy at Fort Hunter Liggett

The most cost-effective way to move toward Net Zero is by first addressing energy efficiency on the installation, and then using on-site renewable energy generation as an enhancement.

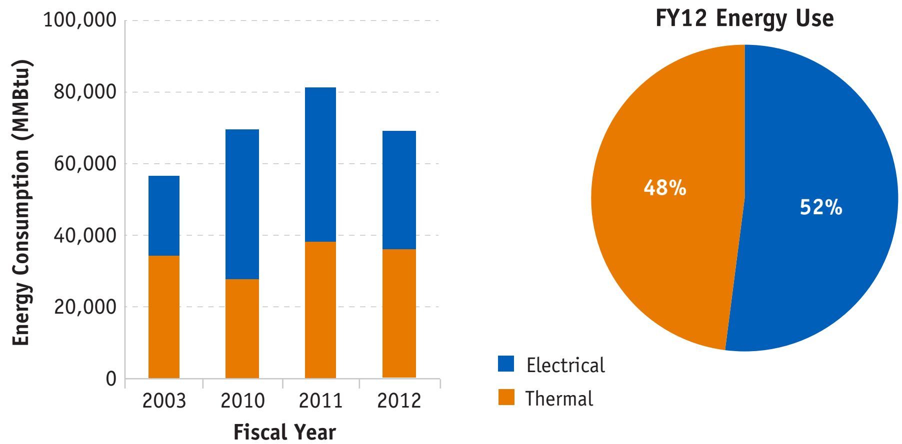


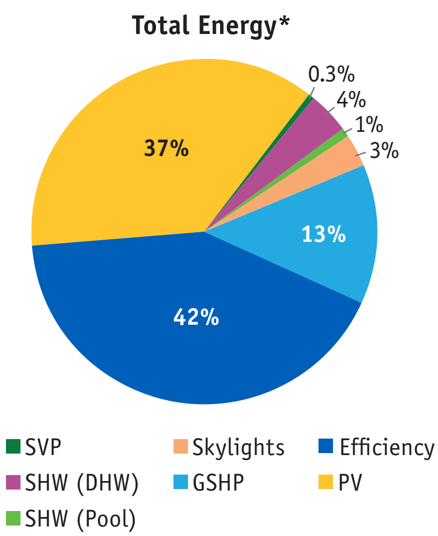
Figure 30. Fort Hunter Liggett site energy use from 2003 to 2012

Table 12. Savings Potential of Current Projects

Measure		Savings		% Total Site Savings
		MMBtu	% of Fuel Type	
New Construction (8 buildings, 511,500 ft²)	Electric	–16,945	–39	–21
	Thermal	0	0	
Building Demolition (150,000 ft²)	Electric	2,917	7	7
	Thermal	2,693	7	
Lighting Retrofit Project	Electric	9,150	21	11
	Thermal	0	0	
Energy Management Control System (EMCS)	Electric	4,369	10	8
	Thermal	2,481	7	
Secondary Wastewater Project	Electric	1,571	4	2
	Thermal	0	0	
4-MW PV System	Electric	20,104	46	25
	Thermal	0	0	
Total	**Electric**	**21,116**	**49**	**32**
	Thermal	**5,174**	**14**	

Fort Hunter Liggett is experiencing extensive change: new buildings are under construction, old buildings are being demolished, and on-site generation construction is under way. Table 12 lists these projects with their corresponding energy use implications. Combined, the current projects result in a 49% electrical energy reduction, a 14% thermal energy reduction, and a 32% total site energy reduction.

FORT HUNTER LIGGETT



*Percentages may not add up to 100% due to rounding.

Figure 31. Fort Hunter Liggett Net Zero Energy solution

PNNL conducted a Facility Energy Decision System (FEDS) analysis that found an additional opportunity for 11.6% electricity reduction and 22.9% thermal reduction through energy efficiency strategies. The efficiency opportunities together with the planned projects served as the formulation of the baseline energy use to be offset with renewable energy technologies.

The roadmap to Net Zero Energy for Fort Hunter Liggett is characterized in Figure 31, which shows the composite energy use assigned to the renewable energy technologies identified previously. Even though the site will not purchase electricity from the grid, there may be some remaining propane use associated with cooking and the remaining domestic hot water (DHW) load that is not offset with the identified SHW systems. Typically SHW systems are not designed to offset 100% of the thermal load because this is not cost-effective; the designed offset is usually about 75% of thermal load.

Energy Efficiency Overview

Potential electrical savings amount to 6,830 MWh or 28.5% of the base energy use and the base thermal load reduction is projected to be 11,177 MMBtu, or 13.7% of the base energy use. The total energy reduction for these projects comes to 34,482 MMBtu or 42% of the total energy used on site.

Renewable Energy Project Recommendations

Table 13 outlines the technology types and technology sizes that resulted in the most favorable life-cycle economics for Fort Hunter Liggett. Because of the high cost of energy and the significant renewable resources that exist at the installation, these solutions result in lower costs than business as usual. Because of the favorable economic case for Fort Hunter Liggett, planners recommend that site managers move forward with these projects as soon as possible.

Energy Integration and Microgrid Assessment

Energy integration issues and microgrid assessment and design are dependent on a site's electric distribution system. Information on the Fort Hunter Liggett electrical distribution system is limited to the data received from PG&E about the grid side of the meter. No documented information exists as to the site's electrical distribution system infrastructure, such as location and technical details of the electric distribution system, transformers, or protective devices' layout and capacities.

Fort Hunter Liggett has planned generation that can be used for operating a microgrid. Having enough generation to match the critical loads at a site is one of the first steps in planning for a microgrid. The generation sources and/or loads must be able to be controlled so changes in the generation or load will not cause the system to go out of frequency or voltage tolerances. The site can be separated into critical loads and noncritical loads so that only the critical loads are powered during microgrid operation.

PG&E, the utility provider at Fort Hunter Liggett, plans to upgrade transmission lines to the installation, opening the door for power to be fed onto the grid in times of overproduction. This greatly reduces the installation's need for energy storage, making Net Zero not only feasible but also economical.

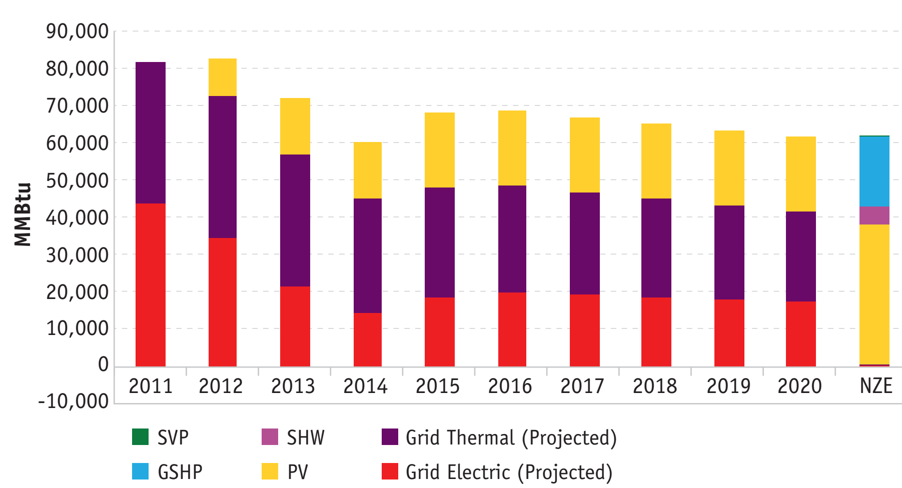


Figure 32. Fort Hunter Liggett load reduction and renewable energy integration roadmap

Figure 33. Phase 1 and 2 PV, solar street lights. *Photo by Lars Lisell, NREL*

Figure 34. Electric vehicle charging station. *Photo by Lars Lisell, NREL*

Figure 35. Power Electronics for the Phase 2 Solar Array. *Photo by Lars Lisell, NREL*

Progress

Fort Hunter Liggett has undertaken a variety of projects and made several efforts to help achieve the goal of Net Zero Energy. The site's completed and ongoing energy projects include:

- A 1-MW ECIP PV project, fully operational since April 2012.
- A second 1-MW ECIP PV project was completed in August 2013 after interconnection negotiations were finalized (Figure 35).
- A third 1-MW ECIP PV project has been awarded.
- A 425-kW WTE system has started construction and will be completed in 2014.
- A 1.25-MWh lithium-ion battery project has been awarded and is nearing the final stages of design.
- Additional solar PV street lights are being installed (Figure 33).
- An electric vehicle charging station was added (Figure 34).
- An installation-wide LED lighting retrofit project is being completed.
- PG&E has announced plans to upgrade the distribution line servicing Fort Hunter Liggett, which will enable feeding power back onto the grid.

Featured Project: ESTCP

Fort Hunter Liggett is demonstrating a new method to turn installation waste into energy using funding awarded through the FY13 ESTCP program. The system produces synthesis gas (syngas) from the installation's non-recyclable waste, which fuels a syngas generator set with a capacity of 425 kW. This will make the installation a Net Zero waste site, and help Fort Hunter Liggett with its Net Zero Energy goal. If this project is successful, the experience will be valuable in deploying the technology elsewhere.

Key Issues

- Overcome the high cost of interconnection for distributed generation projects.
- Identify funding and financing mechanisms.
- Coordinate and control all projects simultaneously—open lines of communication must be maintained to ensure systems will be fully integrated.
- A significant thermal load (48% of the total installation energy use) needs to be addressed; several solutions have been proposed.

Next Steps

Fort Hunter Liggett is making progress in achieving Net Zero Energy and waste. In the near term, coordination between projects and vision for the end products is critical. Securing funding and/or financing for the remaining projects will be a priority. New construction at Fort Hunter Liggett needs to be built to high-performance building standards to ensure that energy consumption does not increase significantly above projections.

Table 13. Summary of Renewable Energy Project Recommendations

Technology	Evaluated Size (variable units)	Energy Savings (MMBtu)	Simple Payback (years)
PV	7,300 kW	36,689	28.2
SVP	1,186 ft^2	261	3.6
SHW DHW	14,138 ft^2	3,876	6.8
SHW Pool	3,571 ft^2	746	6.8
Skylight Area	25,959 ft^2	5,068	21.0
GSHP	215.8 tons	18,741	2.6

Headquarters building on Kwajalein Atoll. *Photo from SSgt Ted Koniares, U.S. Air Force*

U.S. ARMY KWAJALEIN ATOLL

NET ZERO ENERGY OVERVIEW

The U.S. Army Kwajalein Atoll has great renewable energy resources, some with commercially available technologies to harvest these resources. Coupled with energy efficiency, **Kwajalein can reduce its use of diesel fuel by nearly 83% by 2020** by implementing wind, SHW and solar PV projects.

QUICK FACTS

Republic of the Marshall Islands
Location

3.1 million ft²
Total building square footage

1,400 acres
Installation area

Self-generating
Utility provider

$27.93/MMBtu
Average energy costs in FY 2012 (diesel fuel)

269.26 MMBtu/ksf
2012 reported energy use intensity

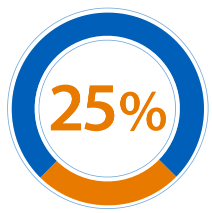
PV, SHW
Current renewable energy projects

GAME CHANGER

Seawater air conditioning (SWAC) could have a significant effect on current energy use on the island of Kwajalein. The SWAC project could reduce the cooling load on the island. Additional mission requirements are estimated to double the current load on Kwajalein.

KEY ROADMAP RESULTS

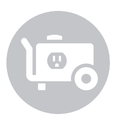
Baseline Energy Consumption and Estimated Energy Efficiency Savings



Baseline energy consumption[10]
905,392 MMBtu

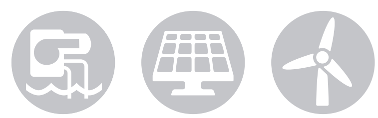
Estimated energy efficiency savings[11]
226,348 MMBtu

Sample Recommended Efficiency Improvements



Diesel generator

Sample Recommended Renewables



Central SWAC

PV, SHW

Wind

UNIQUE PROJECT

Included in the ESPC is a district chilled water system that will be cooled by deep seawater pumped to the surface from a depth of 2,000–3,000 ft.

INSTALLATION MAP

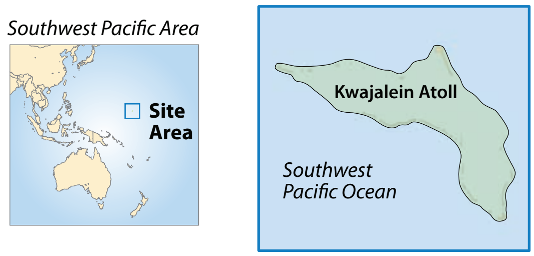


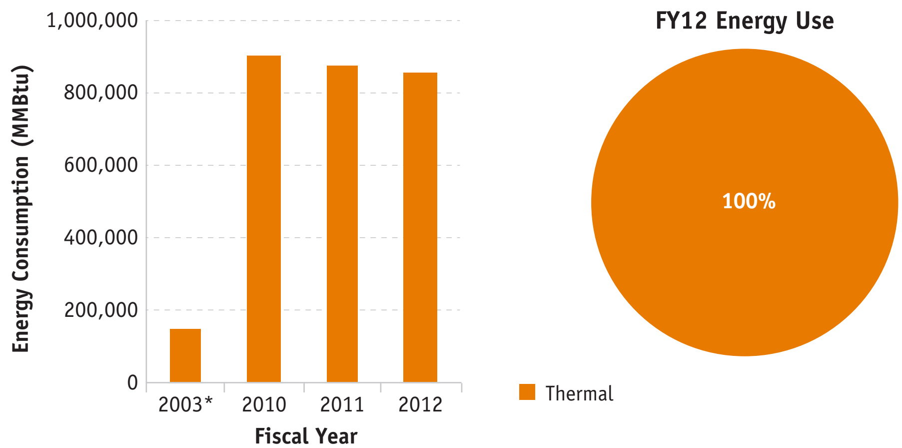
Figure 36. Kwajalein Atoll islands

[10] Based on FY 2011 diesel fuel use data provided by the installation
[11] Energy efficiency savings could be as high as 40%, depending on future energy loads.

Background

U.S. Army Kwajalein Atoll (Kwajalein or USAKA) is part of the Republic of the Marshall Islands and is located approximately 2,000 miles southwest of Honolulu, Hawaii. It hosts Reagan Test Site operations along with National Aeronautics and Space Administration (NASA) and STRATCOM observation and surveillance operations. The Atoll is comprised of nearly 100 small islands that form a ring around one of the world's largest lagoons. Kwajalein Island is the largest within the Atoll in terms of land area and energy use, and is home to approximately 1,500 people. Roi-Namur is home to approximately 200 people, and Meck is operated by a workforce that commutes from Kwajalein.

The main Army infrastructure is located on the island of Kwajalein and additional facilities support operations on Roi-Namur and Meck. Kwajalein, Roi-Namur, and Meck are powered by three independent diesel-fired power plants. For this analysis, NREL collected energy and site data for all three islands, but the detailed analysis is aimed at getting the island of Kwajalein to Net Zero Energy.



*2003 energy data is incomplete

Figure 37. Kwajalein Atoll site energy use from 2003 to 2012

Table 14. Kwajalein Atoll FY 2011 Energy Use from Diesel Fuel Consumption Data

Island	Site Energy Use		
	Gal Diesel	MMBtu	kWh
Kwajalein	4,454,820	581,776	64,356,592
Roi-Namur	2,022,450	264,121	29,314,654
Meck & Carlos	455,573	59,495	5,634,950
Total	**6,932,843**	**905,392**	**99,306,196**

Energy Baseline

The energy baseline for the installation was established using the available diesel fuel consumption data for FY 2011. The total energy consumption for the site decreased slightly between 2010 and 2012 and was comprised of 100% electric energy (Figure 37). The installation produces 100% of its electricity from diesel generators. The energy use data for Kwajalein is recorded in gallons of diesel fuel, which is considered thermal energy, as opposed to purchased electrical energy in kilowatt-hour units. The total NZEI baseline energy usage at Kwajalein Atoll was 905,392 MMBtu. Kwajalein Island consumed 65% of the energy, with a total FY 2011 consumption of 581,776 MMBtu (about 4.5 million gal of diesel) (Table 14).

Roadmap to Net Zero Energy at Kwajalein

Figure 38 assumes that 50% of the recommended PV and SHW is installed soon (operational by the end of 2014) and 50% is installed and operating by 2017 to allow capacity additions as roofs are repaired, upgraded, or replaced. The energy efficiency gains can be accomplished through an ESPC that is assumed to be completed by 2015, with 50% of the savings realized in 2014. The large wind project is assumed to be in full production by 2019, with 50% in production by 2017, and the batteries are deployed over the course of the development period; meanwhile, capacity increases with the renewable energy penetration.

Energy Efficiency Overview

Kwajalein Atoll is in the early stages of developing a comprehensive ESPC that covers facilities on Kwajalein, Roi-Namur, and possibly Meck. In conjunction with the ESPC, the USACE EEAP conducted a detailed energy audit of a selection of 24 buildings on Kwajalein and Roi-Namur. The audit identified 22 ECMs that could save 7,450 MWh/year for Kwajalein and 4,800 MWh/year on Roi-Namur. This equates to an estimated energy savings of just over 40% for the evaluated facilities.

Another potential opportunity for energy savings is to replace existing distributed mechanical cooling systems with a central SWAC system. A rough rule of thumb for estimating the savings from a SWAC system is to assume 90% reduction in cooling energy. For Kwajalein, this equates to a reduction in energy use of approximately 31.5%.

Countering these efforts is the potential additional load of the expanded mission requirement. Initial estimates of the energy demand of these requirements are about 10 MW, or roughly double the peak demand currently seen on Kwajalein.

These energy and mission-related projects could significantly change the current load profile on Kwajalein. At the current stage of development of these projects, it is difficult to estimate the combined effect on the future energy use on Kwajalein. For the purposes of establishing a projected energy use baseline from which to perform the Net Zero Energy analysis, and to encourage energy efficiency improvement, NREL assumed a 25% reduction in energy use throughout this analysis.

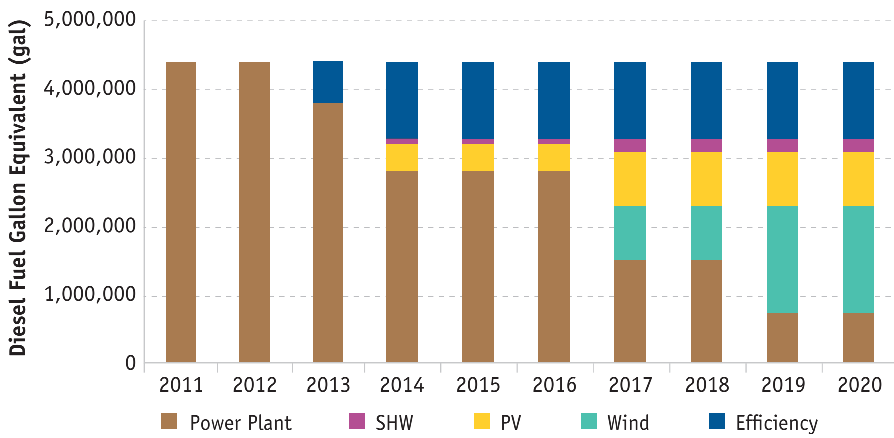


Figure 38. Kwajalein load reduction and renewable energy integration roadmap

Renewable Energy Project Recommendations

Table 15 shows the recommended renewable energy technologies for Kwajalein Island along with the projected annual energy savings, estimated levelized cost of energy (LCOE), and simple payback for energy generated from each technology. The LCOE analysis assumed a 25-year useful life for PV and 15 years for SHW and wind.

Table 15. Recommended Renewable Energy Technologies for Kwajalein Island

Technology	Evaluated Size	Energy Savings (kWh)	Estimated LCOE ($/kWh)	Simple Payback (years)
SHW	17,000 ft^2	3,057,000	0.215 (15 yr)	13.3
PV	8 MW	11,729,436	0.239 (25 yr)	16.6
Wind	9 MW	23,200,026	0.112 (15 yr)	5.3

Energy Integration and Microgrid Assessment

The electrical distribution system on Kwajalein operates at 4,160 V and includes a radial layout with 22 feeders. The distribution system was evaluated to determine the maximum and typical feeder loading, to estimate how much excess capacity lies in the existing distribution system to accommodate interconnection of distributed generation on each feeder. It should be noted that line sizing is reduced toward the end of each feeder, and thus distributed generators must be sited in accordance with the capacity available at the point of connection. Kwajalein's distribution transformers are all three phase; this system architecture benefits future distributed generation deployment because the system's three phases will already be balanced.

PV and wind turbine generators are part of the near Net Zero solution. Large wind turbines will most likely be interconnected directly at the power plant bus, not connected to a single feeder. Several PV systems spread around Kwajalein would most cost-effectively be interconnected to the distribution system where they reside. Kwajalein's distribution system is very lightly loaded and should not present a barrier to renewable energy deployment from a thermal standpoint.

Recommendations for distributed PV deployment on the Kwajalein distribution system are as follows:

- PV penetrations of fewer than 10% should not require any distribution system modification, custom PV inverters, or power factor compensation hardware.
- PV penetrations of up to 30% might not require any modifications or custom hardware; however, power factor compensation could be required near large inductive loads, and generator ratings for reactive power limits should be verified before proceeding with further installation above 10% penetration.
- A thorough dynamic stability study is recommended for PV penetrations greater than 15%, where the minimum monthly power factor drops below 0.85.

Figure 39. Meteorological tower instrumented with anemometry
Photo by Dan Olis, NREL

Progress

Kwajalein staff has been focusing on a large ESPC that includes both energy efficiency and renewable energy technologies, and is planned to cover facilities on Kwajalein, Roi-Namur, and Meck. ECMs to be investigated during the investment grade audit for the ESPC include:

- Rooftop and ground-mounted PV.
- SHW systems.
- SWAC.

In addition to the ESPC, a meteorological tower is being installed to collect investment-grade wind resource data (Figure 39). A site on one of the outer islets has been identified to host the met tower and data acquisition equipment.

A cooling load study was conducted to locate and quantify the cooling loads on Kwajalein. It will provide a better understanding of the baseline energy use for the ESPC and provide data for the evaluation of the SWAC proposal. The cooling load study results indicate that approximately 40% of the energy on Kwajalein is used for space cooling with over 10% of the cooling load coming from two facilities that provide temperature and humidity controlled storage.

Featured Project: Seawater Air Conditioning

SWAC was included in the preliminary assessment phase of the ESPC and has shown initial promise for technical and economic feasibility. The basic design concept includes a large diameter pipe to run from the surface down to a depth of approximately 3,000 feet, a heat exchanger to cool the district chilled water, and an exhaust pipe to discharge the warmed seawater. A district chilled water loop cooled by the seawater could provide chilled water to facilities throughout the island.

Key Issues

- Finding site(s) for the development of large wind project(s).
- Interconnection of significant renewable energy with the existing power plant and distribution system.
- Environmental assessment for the SWAC pipe and district chilled water system.

Next Steps

Next steps at the Kwajalein Atoll installation include further development of promising energy efficiency and renewable energy projects:

- Continue to develop the ESPC contract to finalize analysis of savings opportunities.
- Operate the meteorological tower for at least one year to validate wind resource. This will be necessary for private sector financing.
- Conduct a more detailed analysis of potential electrical system issues resulting from the integration of PV and wind projects.

Colonel James Nesmith Readiness Center. *Photo from U.S. Army*

OREGON ARMY NATIONAL GUARD

NET ZERO ENERGY OVERVIEW

Oregon Army National Guard can achieve **a nearly 100% Net Zero solution by 2020** by implementing energy efficiency and renewable energy technologies. A basic financial analysis illustrates a positive economic return associated with the Net Zero Energy solution and a lower cost of energy relative to the baseline.

QUICK FACTS

Oregon
Location

3.4 million ft^2
Total building square footage

48
Installation sites statewide

15 electricity, 4 natural gas and propane
Utility providers

$0.08/kWh, $9.26/MMBtu
Average energy costs in FY 2012 (electricity, thermal energy)

59.40 MMBtu/ksf
2012 reported energy use intensity

PV, Wind, GSHPs
Current renewable energy projects

GAME CHANGER

A possible Oregon virtual net metering or community solar law would allow large renewable energy generation projects to credit energy meters at smaller installations. OR ARNG's ability to achieve NZEI status depends on crediting geographically dispersed electric meters with centrally produced renewable electricity.

KEY ROADMAP RESULTS

Baseline Energy Consumption and Estimated Energy Efficiency Savings

Baseline energy consumption[12]
160,879 MMBtu

Estimated energy efficiency savings
80,439 MMBtu

Sample Recommended Efficiency Improvements

Lighting retrofits
Retro commissioning

Sample Recommended Renewables

PV, SVP
Wind
Geothermal electricity

UNIQUE PROJECT

OR ARNG is investigating a possible joint project with Air Guard to power Kingsley Airfield with geothermal electricity from an on-site power plant or a planned plant located off-site and supplying the field power through a dedicated power line. The geothermal plant may be owned by OR ARNG or a third party, depending on the procurement and financing mechanism.

INSTALLATION MAP

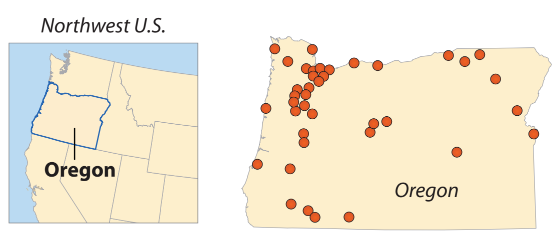


Figure 40. Oregon Army National Guard installation locations

[12] Based on 2010 and 2011 utility bills

Background

OR ARNG has 48 sites across the state of Oregon. Installations include Joint Forces Headquarters, readiness centers, workshops for refurbishing military equipment, educational missions, and drilling armories. These installations are located in urban and nonurban areas, DOE climate zones 4 and 5. OR ARNG serves in several diverse capacities including military training and readiness, natural disaster community support, and refurbishment and remanufacturing of military equipment. It has ranges, training areas, and facilities to support year-round joint, multicomponent, and interagency training.

Currently, OR ARNG has approximately 3.4 million ft^2 of building area and is experiencing a period of growth. New buildings are slated for construction or expansion over the next few years and new installations are transferring to OR ARNG management such that by the year 2020, expected building area under management will be about 3.9 million ft^2.

Installations in three cities (Warrenton, Clackamas, and Salem) account for 60% of electricity use and 51% of natural gas and propane use. The rest of the installations are smaller armories, readiness centers, warehouses, and education buildings. All installations are primarily day use (except for a few multiday trainings a year at Camp Rilea), so thermal loads (natural gas and propane) are considered to be space conditioning with little water heating demand.

Energy Baseline

The NZEI baseline energy use of 160,879 MMBtu was derived from 2010 and 2011 utility bill data. Energy use at OR ARNG for FY 2012 was 170,071 MMBtu; 57% thermal and 43% electrical energy (Figure 46). Total building energy use intensity for OR ARNG in FY 2012 was 59.40 MMBtu/ksf.

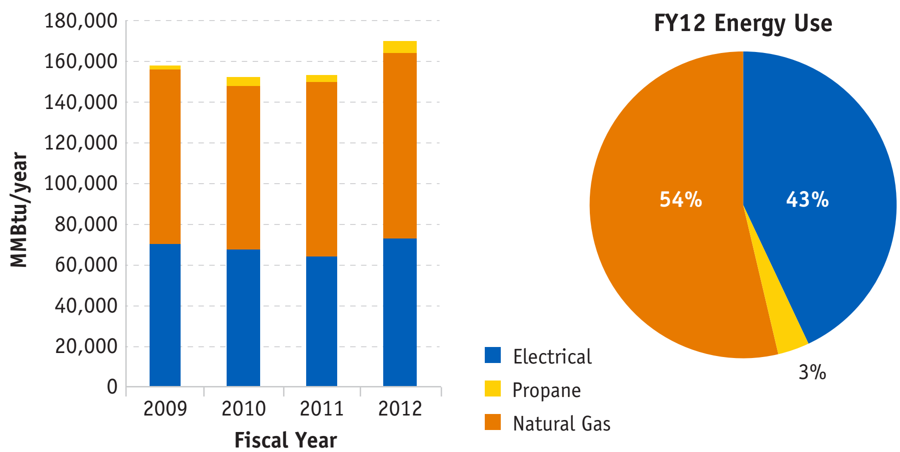


Figure 41. Oregon Army National Guard site energy use from 2003 to 2012

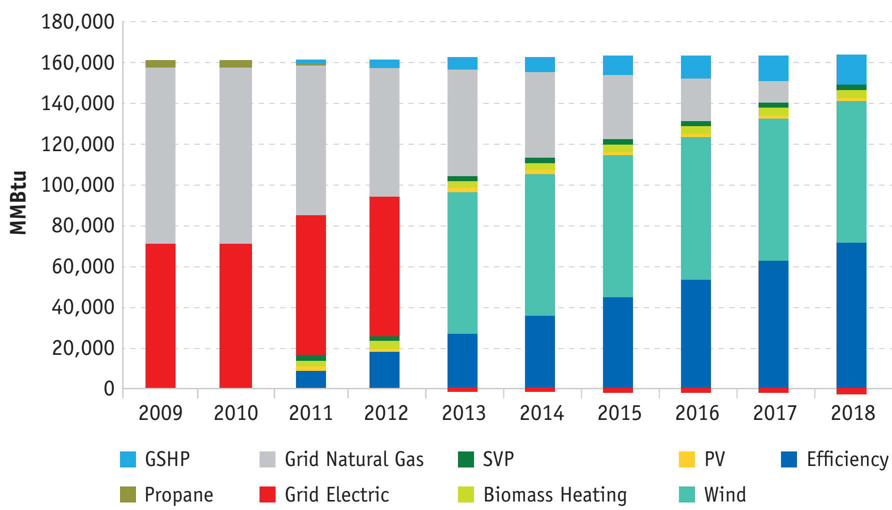


Figure 42. OR ARNG load reduction and renewable energy integration roadmap

Roadmap to Net Zero Energy at Oregon Army National Guard

The recommended path toward Net Zero Energy for OR ARNG consists of 50% energy savings through energy efficiency and implementation of renewable energy generation technologies to balance the required energy to meet the remaining load. On-site renewable thermal and electric technologies can offset natural gas and propane use while larger centralized renewable electricity generation projects can offset electricity usage since it is economically not feasible to achieve NZEI status at each individual installation across the state. This analysis projects that by 2020, OR ARNG could cost-effectively produce nearly 100% of the energy it consumes using centralized renewable sources. The remaining energy use would be thermal energy for process loads such as cooking.

Figure 42 characterizes the 2012 Net Zero roadmap for OR ARNG, showing the composite energy use assigned to the renewable energy and energy efficiency technologies identified. The mix of technologies used to meet energy demand is changing and adjusting as due diligence and feasibility analysis is continuing on the large renewable electricity-producing projects. Grid-purchased electricity is negative because estimated wind production is in slight excess of estimated electric load in 2020—each wind turbine produces a large increment of annual energy and the last turbine added to the project produces a little more than the estimated need. Although the natural gas load is shown to be zero, it is possible that some natural gas use will remain for cooking, domestic hot water (DHW) load, and hot water process loads at workshops for equipment repair and maintenance. The hot water process loads identified at workshops were for pressure washing equipment, which required higher temperature water for short intervals and sporadic use, which does not make it a good match with solar thermal technology. The GSHP portion is energy savings from GSHP units (i.e., not energy use) and is subtracted from the energy efficiency column.

Energy Efficiency Overview

Potential energy savings amount to 80,439 MMBtu, or 50% of OR ARNG's projected 2020 energy load (Table 16).

Renewable Energy Project Recommendations

SVP, biomass heating, and air-source heat pump (ASHP) and GSHP technologies all have an estimated payback of fewer than 25 years and are proposed to meet on-site thermal loads and offset present fossil fuel use (Table 17).

There were a number of renewable electric generation technologies that were evaluated for economic feasibility. Table 18 lists the type of projects analyzed in order of ascending energy cost ($/kWh). The large centralized projects that use third-party ownership were the only ones that had estimated electricity costs near what OR ARNG currently pays. The smaller distributed systems that would be owned by the installation have electric costs that are estimated to start at about three times the present utility rate.

Table 16. Energy Efficiency Savings Potential

EE Measures	% Savings	MMBtu Savings
Low-Cost & Behavioral	8	12,870
Standard Retrofit – Lighting	12	19,305
Standard Retrofit – Retro Commissioning	6	9,653
Standard Retrofit – Controls	10	16,088
Deep Retrofit - HVAC[a]	9	14,479
Deep Retrofit – Envelope	5	8,044
Total	**50**	**80,439**

Table 17. Proposed On-Site Renewable Energy Thermal Technologies

Proposed Projects	Evaluated Site	Energy Savings (MMBtu)	Simple Payback (years)
SVP	Aviation hangar at Salem AASF	2,659	14.4
Biomass heating	Four installations that use propane	3,706	15.9[a]
ASHP	Installations in climate zone 4	72,794[b]	12.6[c]
GSHP	Installations in climate zone 5	13,918[b]	12.5–14.5[c]

[a] Based on data in "Feasibility Assessment For Biomass Heating Systems At Oregon Army National Guard Facilities," Craig Volz.
[b] Assumes all natural gas use for respective sites is replaced with indicated electric technology. Based on 2011 use.
[c] Simple paybacks are estimated across all installations in a climate zone based on high-level analysis of multiple locations in the zone.

Progress: Planned Major Projects and Acquisitions

OR ARNG has planned several construction projects and installation acquisitions over the next few years. New readiness centers will be constructed in the city of The Dalles and in Polk County.

Based on resource energy manager initial audits, the installation has set an energy efficiency target for 2020 at 50% of the 2003 energy use intensity. Based on a calculated managed square footage of 3,930,723 ft^2, the target energy use intensity for 2020 is 23.5 kBtu/ft^2, which will translate to annual energy use of 92,539 MMBtu/yr. New construction will be reviewed for energy-efficient design.

OR ARNG has undertaken a variety of projects and made several efforts to help achieve the goal of Net Zero Energy:

- Awarded the technical energy audit portion of a proposed statewide $11 million ESPC with the goal of at least 50%

Figure 43. The Dalles Readiness Center under construction
Photo from U.S. Army

Table 18. Renewable Electric Technologies Analyzed

Technology	Capacity (MW)	Annual Energy (kWh/MMBtu per year)	Estimated First Year PPA Price ($/kWh)	Estimated Army LCOE ($/kWh)
Large Wind: Rilea (GE 1.6 xle)	8.0	20,423,815 / 69,706	0.0701	0.0790
Large PV: Christmas Valley (with Oregon business energy tax credit [BETC])	5.762	9,032,232 / 30,827	0.0840	N/A
Geothermal Electricity	3.1	20,500,000 / 69,967	0.0980	0.0910
Large PV: Christmas Valley (without BETC)	11.0	19,870,911 / 67,819	0.1083	N/A
Biomass Electricity	3.0	22,338,000 / 76,240	0.1390	0.1580
Large PV: Camp Withycombe Highway Bypass-Bond funded	3.5	3,783,861 / 12,914	N/A	0.1944
Distributed Generation PV: Salem (JFHQ & ARC)	0.35	385,818 / 1,317	0.2078	0.2689
Small Wind: Rilea (NW100 21m)	0.10	125,038 / 427	N/A	0.2693
Distributed Generation PV: Camp Withycombe	0.50	521,236 / 1,779	0.2197	0.2843

energy savings within a 20-year payback period.

- Achieved LEED Gold certification at the Colonel James Nesmith Readiness Center; the Center has an energy use intensity target of 25.7 kBtu/ft^2 and features a 36-kW PV system (see image on page 40).
- Assessing SVP for Redmond and sites east of the Cascades.
- Implementing biomass heating to replace propane use at Redmond and Bend sites.
- Installing met tower at Camp Rilea for a year-long assessment of wind resource.
- Renovating Milton-Freewater Armory to achieve a target energy use intensity of 31.2 kBtu/ft^2.
- Reducing electricity consumption by an estimated 700,000 kWh/yr with the Camp Withycombe lighting project.

Featured Project: The Dalles Readiness Center

The new Dalles Readiness Center (Figure 43) was designed with low- to no-cost passive energy features that save energy, reduce loads, last for the life of the building, and reduce equipment sizing, making it cheaper to implement high-efficiency mechanical equipment. Some of the passive design features include building orientation, daylighting, solar gain, natural ventilation, and airtightness. These passive features are augmented with energy-efficient lighting, selective glazing, system controls, GSHPs, and increased insulation. This efficient building will also have a 90-kW PV system and is set to be Oregon's first locally developed site to demonstrate a 30-kW to 36-kW innovative concentrating PV system.

Key Issue

There are barriers to wheeling electricity or crediting electricity production from central renewable-electricity generation systems to geographically dispersed electric meter locations.

Next Steps

Key next steps for implementing the roadmap include wind data analysis at Camp Rilea, geothermal electric resource and project evaluation at Klamath (Kingsley Field), energy model development for Joint Forces headquarters, analysis of district heat and possible CHP at Umatilla, and assessment of SVP for Redmond and sites east of the Cascades.

Open space for PV. *Photo by Kari Burman, NREL*

SIERRA ARMY DEPOT

NET ZERO ENERGY OVERVIEW

Sierra Army Depot could achieve **100% NZEI status by 2020** by implementing energy efficiency and renewable energy technologies. A basic financial analysis illustrates a positive economic return associated with many projects, and presents challenges with replacing some of the current natural gas use in a cost-effective manner.

QUICK FACTS

Herlong, CA
Location

5.1 million ft^2
Total building square footage

32,056 acres
Installation area

Plumas Sierra Rural Electric Cooperative
Utility provider

\$0.18/kWh, \$35.42/MMBtu
Average energy costs in FY 2012 (electricity, thermal energy)

30.76 MMBtu/ksf
2012 reported energy use intensity

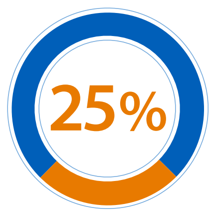
PV, SHW, and Skylights
Current renewable energy projects

GAME CHANGER

By supersizing or expanding the development of a utility-owned PV system, the installation can meet all of its electrical consumption (kilowatt-hours). As the current PV project in development is a first of its kind for the utility, a successful initial PV project could open up the door for additional PV development in its portfolio.

KEY ROADMAP RESULTS

Baseline Energy Consumption and Estimated Energy Efficiency Savings



Baseline energy consumption[13]
162,930 MMBtu

Estimated energy efficiency savings
40,732 MMBtu

Sample Recommended Efficiency Improvements

Building envelope
Metering
Lighting retrofits

Sample Recommended Renewables

PV, SHW, SVP
GSHP

UNIQUE PROJECT

Unique projects at Sierra Army Depot include warehouse skylights funded through an ECIP, and a 1- to 2-MW PV system on a landfill funded through a utility contract.

INSTALLATION MAP

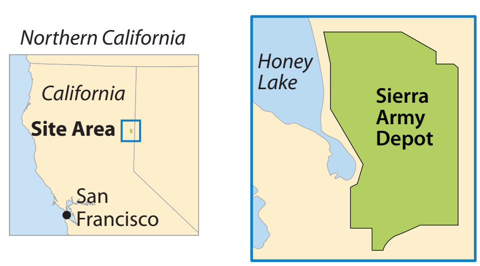


Figure 44. Sierra Army Depot site boundaries

[13] Based on 2010 and 2011 data provided by the Army for NZEI analysis, which varies slightly from AEWRS data.

Background

Sierra Army Depot is located near Herlong, California, within the Honey Lake Valley in Lassen County in a high desert plain at the intersection of the Cascade Mountains and Sierra Nevada mountain range. Approximately 55 miles northwest of Reno, Nevada, and approximately 40 miles southeast of Susanville, California, the main depot covers more than 32,056 acres.

Since the area has moderate summer and winter temperatures and is relatively arid, Sierra Army Depot is an ideal location for storing equipment and vehicles. Sierra Army Depot provides a complete range of logistics support to the Army including storage, repair, shipping, and maintenance for vehicles and other equipment.

Through this initiative, the Army—in collaboration with NREL and with support from DOE FEMP—performed an NZEI assessment at Sierra Army Depot in FY 2012 and 2013 and proposed a roadmap of energy projects to achieve Net Zero Energy by 2020. This overview details the energy baseline established for Sierra Army Depot, a roadmap of load reduction, renewable energy projects, project planning, and updates. FEMP is funding Sierra Army Depot NZEI technical support in FY 2013 and FY 2014.

Energy Baseline

The NZEI baseline for this assessment used the FY 2011 energy consumption data available from the Army at the time of analysis. This energy baseline was 162,932 MMBtu.

As shown in Figure 45, the total energy for the site remained relatively steady between 2010 and 2012, with very little fluctuation between electric and thermal energy usage. The total energy usage at Sierra Army Depot declined slightly in FY 2012 from 162,930 MMBtu in 2011 to 159,198 MMBtu in 2012. Energy use was dominated by thermal loads, primarily met with natural gas. The natural gas blended price includes several fees that do not change with increased use of natural gas (such as financing, connection, and maintenance charges). These fees could end in 2018 if Sierra Army Depot decides to buy and maintain the natural gas system.

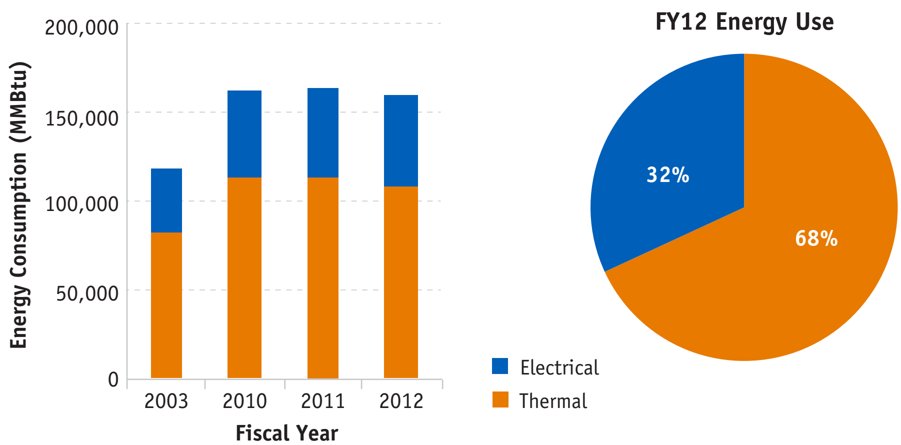


Figure 45. Sierra Army Depot site energy use from 2003 to 2012

Table 19. Recommended Energy Conservation Measures from EEAP Report

Proposed Projects	Annual MMBtu Generated or Saved (electric)	Annual MMBtu Generated or Saved (thermal)	Contribution of projects to NZEI (% from 2011 baseline)
Heating	1,295	6,388	2.30%
Lighting	5,160	(2,367)	1.71%
Building Envelope	1,893	22,963	15.26%
Total	**8,348**	**26,984**	**19.27%**

Roadmap to Net Zero Energy at Sierra Army Depot

The following summarizes the recommended path toward Net Zero Energy for Sierra Army Depot, including energy efficiency and renewable energy opportunities.

Energy Efficiency Overview

USACE performed the energy efficiency assessment and its findings are documented in EEAP reports. The findings included up to a 19% reduction in energy from lighting, hot water, heating, and building envelope improvements. Table 19 summarizes the projects from the EEAP report for the Sierra Army Depot, CA, May 2012. Sierra Army Depot is currently implementing energy efficiency projects through an ESPC. The results of these energy efficiency studies were not available during the NZEI analysis, so a total 25% reduction was assumed. This number is still believed to be valid because the energy efficiency studies did not cover all buildings or opportunities.

Renewable Energy Project Recommendations

Renewable energy opportunities include PV, SHW, SVP, and heating load reduction using GSHPs (Table 20). Additionally, reduction in lighting could be achieved with skylights in the warehouses. High mast outdoor lighting could be replaced with energy efficient LED lights. On-site geothermal electric generation was considered, as well as the use of a direct line from the nearby geothermal plant.

Roadmap of Energy Project Recommendations

The initial recommended roadmap for Sierra Army Depot to reach NZEI status is illustrated in Figure 46. The NZEI path begins with a 25% reduction of 2011 baseline energy use through an array of energy efficiency measures. The electrical load in the original roadmap is offset with a combination of off-site (but directly connected) geothermal electric generation and on-site PV.

To offset the thermal load, hot water is replaced with SHW production and building heat is replaced with SVP and GSHPs. Reducing heat energy to Net Zero would require GSHPs for several of the warehouses currently heated with natural gas radiant heaters. On the thermal side, it will be difficult for Sierra Army Depot to reach Net Zero because of current constraints with the natural gas contract, which are in effect until 2018. As a result, it is difficult to implement cost-effective thermal energy measures based on the pre-2018 gas contract and contemporary natural gas prices. However, to assist the transition to Net Zero Energy, NREL does not recommend any additional warehouses be retrofitted with natural gas–fired heaters.

Energy Integration and Microgrid Assessment

A hybrid strategy includes development of an on-site PV system and interconnecting the existing off-site Amedee geothermal electric plant to Sierra Army Depot. With this strategy, the Amedee geothermal plant would utilize the already constructed, but currently non-operational, direct distribution line from Amedee to Sierra Army Depot (approximately 1.5 miles in length). This 12-kV power line is owned by a utility company that no longer serves Sierra Army Depot. The Amedee geothermal concept does not appear to be economically viable in FY 2014; however, NREL recommends that Sierra Army Depot revisit this option in another year.[14]

In January 2013, renewable energy project planning shifted from geothermal electric to PV technology. PSREC is supportive of adding solar PV at Sierra Army Depot, especially through relatively small incremental steps in order to monitor rate

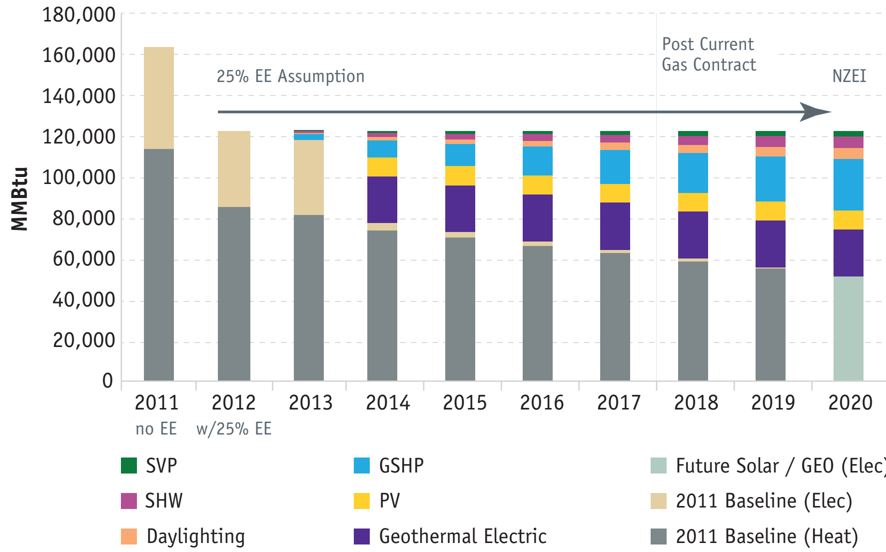


Figure 46. Sierra Army Depot Roadmap to NZEI

Table 20. Army Net Zero Renewable Energy Projects

Proposed Projects	Annual MMBtu Generated or Saved (electric)	Annual MMBtu Generated or Saved (thermal)	Contribution of projects to NZEI (% from 2011 baseline)
SVP (9,950 ft²)	-	3,600	2.2%
SHW (14,200 ft²)	-	4,600	2.8%
Skylight (63,600 ft²)	12,923	(6,100)	4.2%
GSHP (1,100 tons)		85,000	Needs further analysis[a]
PV (2.5 MW)	12,105		7.4%

[a] GSHPs could be cost-effective at Sierra Army Depot and have shown good performance on one building, but further analysis is needed to determine financial return and investment decision.

[14] To become viable the geothermal plant would need to sell power to the installation or its utility at competitive rates, and utilize the existing line or other means to transfer power to the installation.

Figures 47 and 48. SHW at the community pool in August 2013. *Photos from Sierra Army Depot*

Figure 49. Solar railroad crossing lights. *Photo from Sierra Army Depot*

impacts as well as grid challenges. PSREC offered to do an interconnection study to look at the impact on their distribution system with various sizes of PV systems. This study should be coordinated with upgrades made to the substation near the landfill. PSREC also noted the opportunity to use their in-house financing capabilities and allow for low cost of capital (estimated at a 2.2% interest rate for co-ops) and a simplified financing mechanism.

Progress

Sierra Army Depot has undertaken a variety of projects and made several efforts to help achieve the goal of Net Zero Energy. Completed and ongoing energy projects include:

- An ECIP awarded for the skylight project on the warehouse roofs; installation is expected to start in FY 2014.
- B671 envelope upgrade shows spray-on foam insulation, @ R23 value, and was completed in Spring 2013 (Figure 51). Occupants said portable swamp coolers weren't needed that summer.
- High mast lighting controls were installed and will only allow each mast to be energized by hand during hours of darkness with auto shut-off at sunrise (Figure 50).
- Solar rail-road crossing lights added in 2013 to avoid additional power consumption from the grid (Figure 49).
- Army Environmental Command is working on the National Environmental Protection Act (NEPA) report for PV on the landfill (see photo on page 44).
- An interconnection study is being conducted by PSREC.
- A SHW system was installed on the community pool in April 2013 (Figures 47 and 48). Several weeks after the SHW installation, the propane furnace hadn't operated because the water temperature of the pool met the required specification of approximately 85°F.

Figure 50. High mast lighting (12 kW)
Photo from Sierra Army Depot

Key Issues

Renewable energy interconnection is being studied by PSREC. This interconnection study will determine the infrastructure upgrades required for three sizes of PV systems (500 kW, 1 MW, and 2.5 MW). Initial results indicate that a PV system of 2 MW or less would not cause major technical complications of the utility's system.

Another issue is Sierra Army Depot's current natural gas utilities privatization contract. About 80% of the installation's natural gas bill is comprised of finance upgrades and maintenance charges to heat its warehouses. It's difficult for Sierra Army Depot to economically reach Net Zero at current gas prices. After the expiration of the current natural gas contract, nearly 50% of fixed charges should be retired. This scheduled cost reduction will allow for increased thermal measure opportunities while also capping total thermal expenditures below pre-2018 levels.

Next Steps

Key next steps to a Net Zero Energy roadmap include:

- Complete the interconnection study and develop an RFP for a third-party installation of PV.
- Add control sensors for high mast lighting and track usage of mast lights and associated energy expenditures.
- Develop and refine mock gas and electric invoices for buildings and warehouses; create a spreadsheet with usage and cost graphs that update automatically and update the mock invoices.
- Train energy managers to use invoices to report to the commander on NZEI progress, and encourage energy-saving behavioral measures supported by education cost and consumption metrics.

Figure 51. Insulation installed in warehouses
Photo from Sierra Army Depot

Aerial campus view. *Photo from USMA West Point*

U.S. MILITARY ACADEMY WEST POINT

NET ZERO ENERGY OVERVIEW

NREL based its renewable energy analysis on assumptions of energy load growth of 15% due to new facility additions and efficiency gains of 25% at West Point by 2020. NREL's assessment and recommendations present a roadmap to **100% site Net Zero electrical energy by 2020**, dependent on mission, security, and community considerations.[15]

QUICK FACTS

West Point, NY
Location

7.7 million ft^2
Total building square footage

16,068 acres
Installation area

Central Hudson Gas & Electric, Orange & Rockland Utilities
Utility providers

$0.07/kWh, $7.16/MMBtu
Average energy costs in FY 2012 (electricity, thermal energy)

116.65 MMBtu/ksf
2012 reported energy use intensity

PV, Wind
Current renewable energy projects

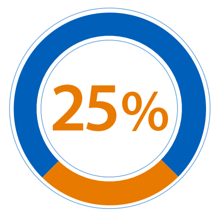
GAME CHANGER

If the financial benefits provided by on-site electricity generation at West Point—including relief for the utility's strained electric transmission system—were monetized, energy generation projects could become more financially viable.

[15] Growth and efficiency gains were hypothetical and only utilized for NZEI analysis purposes. Realization and implementation of any and all roadmap goals and energy measures is contingent on funding and subject to mission constraints. West Point anticipates continuing dependence on conventional energy sources for energy security.

KEY ROADMAP RESULTS

Baseline Energy Consumption and Estimated Energy Efficiency Savings



Baseline energy consumption[16]
1,067,081 MMBtu

Estimated energy efficiency savings
266,770 MMBtu

Sample Recommended Efficiency Improvements

CHCP
Building envelope

Sample Recommended Renewables

WTE
Wind
PV, SHW, SVP

UNIQUE PROJECT

Potential projects researched separately by CERL include: Conversion of the central energy plant to natural gas–fueled "tri-generation" (electricity generation, heat utilization for heating, and absorption cooling), conversion of the heat distribution and building systems infrastructure from steam to hot water, and possible future conversion to synthesis gas (syngas) or a natural gas/syngas mixture as primary fuel.

INSTALLATION MAP

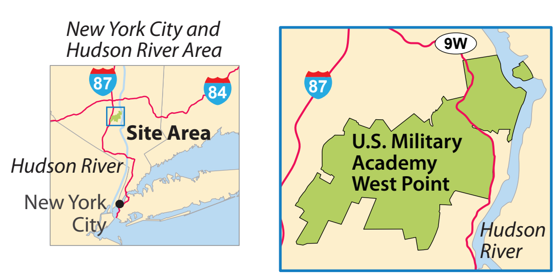


Figure 52. Location of West Point Military Academy

[16] Based on 2010 and 2011 data provided by the Army for NZEI analysis, which varies slightly from AEWRS data.

Background

West Point is the home of the U.S. Military Academy (USMA), located on 16,068 acres of high ground along the western banks of the Hudson River approximately 50 miles north of New York City. USMA was founded in 1802, making it a regional historic landmark and the focal point for the U.S. military; the building inventory is unique among Army installations because many buildings are classified as historic and the entire cantonment area is considered a national historic landmark (USMA National Historic Landmark). West Point maintains its status as an accredited four-year undergraduate program with about 4,500 cadets who reside on campus.

Energy Baseline

An energy baseline is an analysis of current energy consumption at the site, which provides planners and managers a metric against which progress toward Net Zero Energy can be measured.

There has been a general decrease in both site electrical usage and site natural gas usage from 2003 through 2012 at USMA West Point (Figure 53). The detailed energy data available for NREL's study were nine months of FY 2011 and three months of FY 2010 data. These data were utilized to establish the energy baseline.

Roadmap to Net Zero Energy at West Point

NREL analysis projected that by 2020 USMA could cost-effectively produce 100% of the electrical energy and 55% of the thermal energy it consumes using renewable

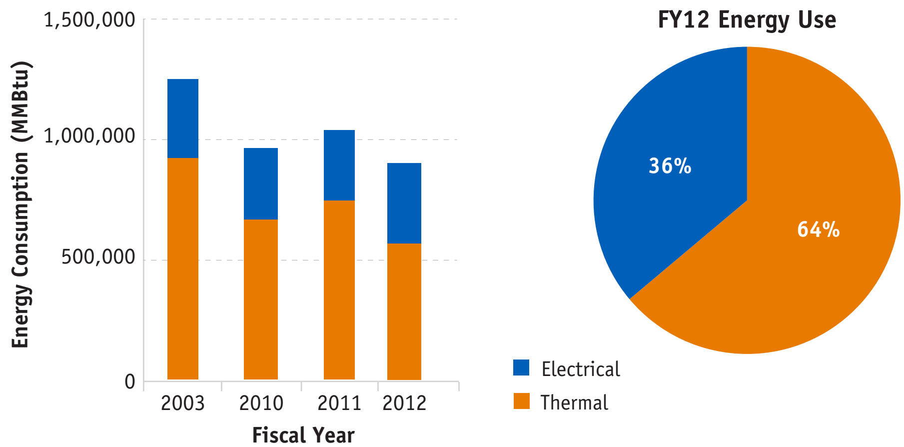


Figure 53. West Point site energy use from 2003 to 2012

sources. Several concepts were evaluated to make up the thermal shortfall, but they are currently considered infeasible. They include GSHPs and use of heat from a WTE facility.

Energy Efficiency Overview

Total annual electrical and thermal loads were estimated to decrease by 25% from investments in energy efficiency technologies such as lighting, HVAC improvements, and building controls.

Projected 2020 Energy Consumption

Due to aggressive ongoing efforts toward implementation of efficiency improvements and cost-effective renewable energy projects, the overall trend of decreasing energy use at West Point is expected to continue through 2020 despite the planned addition of new facilities (Figure 56). New facilities additions were calculated to add 15% to the FY 2011 baseline through FY 2020.

If realized, the efficiency improvements (despite the assumed load growth) would lead to net reduction in energy use at the garrison of 10,146 MWh of site electrical and 36,018 MMBtu of site thermal energy per year. The energy efficiency and load growth assumptions were hypothetical based on information available in FY 2012, were used only for NZEI analysis, and were understood to be subject to change. West Point currently continues to use best-available up-to-date information to support actual energy planning decisions.

Renewable Energy Project Recommendations

Table 21 summarizes the FY 2011 baseline and assumed FY 2020 electrical and thermal energy consumption amounts for West

Table 21. Projected 2020 Annual Energy Load

	Electrical (MWh)	Thermal (MMBtu)
FY 2011 Baseline Annual Energy Use	101,462	720,182
Growth Assumption (2011–2020)	15,219	108,027
Efficiency Improvement (2011–2020)	(25,366)	(180,046)
Assumed FY 2020 Annual Energy Use	**91,316**	**684,164**

Table 22. Annual Energy Production for Proposed Renewable Technologies

	Electrical (MWh)	Thermal (MMBtu)
WTE	74,460	
Wind	15,715	
Biomass		376,145
PV	5,256	
SHW		47
SVP	-0.649	81
Total	**95,431**	**376,273**

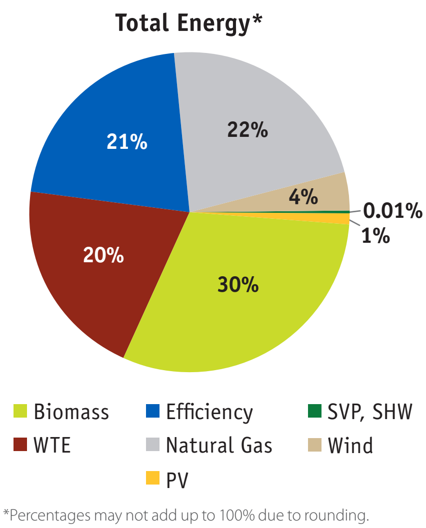


Figure 54. Proposed 2020 Net Zero Energy strategy, including projected load growth

Point. Table 22 lists the technology opportunities that were identified and considered economically feasible[17] to contribute toward a Net Zero Energy scenario along with their respective projected annual energy production figures. Figure 54 shows percent contributions to the net conventional energy consumption at the garrison, offset by each technology evaluated and the assumed energy efficiency improvements (including projected load growth, which reduces energy efficiency from 25% to 21% of the total energy strategy).

The technologies and capacities selected for evaluation were initially selected with West Point DPW after evaluating on-site resources, the proximity of resources to primary load centers (in the cadet area), and available space for deployment of renewable generation on the installation.

Energy Integration and Microgrid Assessment

Sandia National Laboratory (SNL) is conducting an energy security study that is expected to provide guidance for enhancing the West Point distribution system. The study has identified four microgrid configurations to support six energy surety areas. NREL is working with West Point DPW and others providing service to West Point to integrate SNL, NREL, and CERL recommendations.

Progress

A number of the renewable energy technologies were identified in the 2012 NZEI Roadmap Report as likely to be economically feasible but as having mission, security, and environmental concerns. These technologies were included in the NZ roadmap in the interest of supporting Army planning and policy development. On a practical level, however, there is no plan at West Point to deploy these technologies.

Roadmap technologies that faced concerns and are not planned at this time are:

- WTE—WTE would involve multiple truckloads daily of tons of municipal solid waste onto or near to the installation. This is incompatible with mission security and could face community opposition as well.
- Wind—There was concern over Federal Aviation Administration clearance for a wind project given the proximity of Steward Airport. West Point also lies in the scenic Hudson River Valley viewshed, and it was thought community opposition might arise to deployment of large wind turbines on the ridgeline.
- Biomass—As with WTE, security and transportation related concerns were significant.
- GSHP—The terrain around West Point consists largely of granite just below the soil surface which can be expected to make the installation of ground coils impractical or prohibitively expensive.

Support for these technologies has appropriately been excluded from the scope of NREL's ongoing project development support at West Point in favor of support for short- and medium-term installation energy portfolio efforts, such as immediate efforts toward installation energy reliability and security. These efforts are considered precursors to efforts toward renewable technologies, which still enjoy robust backing at the installation.

These four identified technologies account for a large percentage of the projected alternative energy production in the Net Zero roadmap but are not under consideration for deployment. Success of Net Zero and NREL support efforts warranted consideration of the CERL-proposed combination of technologies. This combination consists of conventional generation along with aggressive energy efficiency approaches, and the possibility of future conversion to renewable fuel.

Featured Project: Tri-Generation

NREL has collaborated with CERL in the evaluation and validation of complimentary energy generation and heating and cooling technologies. CERL analysis indicates that collectively the tri-generation (electricity, heating, and cooling) could meet approximately 80% of the projected 2020 source energy needs of the garrison. Natural gas would fuel the generation initially, and NREL has provided a high-level evaluation of the potential future economic feasibility of conversion to syngas fuel from biomass.

The proposed tri-generation scenario encompasses:

- Building renovation and new construction projects currently being planned and implemented utilizing third-party financing approaches
- Central energy plant conversion from steam generation to heat recovery electrical generation providing hot water to buildings and absorption chillers
- Peak heating provided by existing natural gas steam boilers feeding steam to hot water heat exchangers
- Construction of three area chiller plants
- Hot water storage tanks for load balance
- Chilled water storage tanks for load balance and electrical demand reduction

[17] See Progress section for a technology feasibility update.

Figure 55. South wall of Hollender Center, a potential SVP building
Photo by Dylan Cutler, NREL

- Renovated barracks chillers served by absorption and centrifugal chillers in a central chiller plant
- Building HVAC and DHW systems using steam converted to hot water use
- Improved building envelope for buildings requiring new hot water radiators and/or unit heaters, including increased wall and roof insulation and new or added high efficiency windows.

Key Issues

Model parameters for the cost of electricity and natural gas utilized in NREL's analysis were based on actual utility bill information shared with NREL by USMA DPW and AEWRS data. Since 2012, a few factors have come to light that impact energy planning and decision making at the garrison and inform NREL's ongoing support strategy:

- **Natural gas contracts**—West Point is re-negotiating contracts and there is price uncertainty as a result.
- **Natural gas rate structure**—A 'blended' rate for natural gas was used in the NREL analysis. The rate structure the utility is using to invoice USMA for natural gas has a relatively small commodity price component, and a relatively large demand or delivery component. This diminishes the expected value of renewable energy in displacing natural gas consumption at USMA.
- **Strained electric transmission system**—Much of USMA receives electric utility service via a single, often overloaded transmission line. During system peak conditions, transmission line capacity limits are approached, but the ECMs have alleviated this situation somewhat.

Energy reliability and security issues, which are expected to become more critical as USMA brings new buildings online, are the first priority. USMA is actively working with its serving utilities supported by New York State entities, NREL, and non-government entities to resolve them. Development of renewable energy projects is secondary. With USMA's utility energy contracts subject to renegotiation and/or restructuring, and with on-site base load generation under consideration, the cost-of-energy assumptions that informed NREL's 2012 analysis are subject to change. Renewable energy project development has been delayed until there is greater certainty around the cost of conventional energy at USMA.

Renewable Energy Projects Still Under Consideration

Three remaining technologies, PV, SHW, and SVP (Figure 55), are still under consideration and will be evaluated for their potential to sustainably supplement CERL's proposed combination of technologies beyond the projected 80% of current source energy savings.

Next Steps

Verify assumptions and refine analysis for the tri-generation project. Use the tri-generation analysis plus the garrison's work with New York authorities and utility providers to continue to refine the Net Zero Energy strategy. Because it was not possible to factor these considerations into the original roadmap recommendations, proposed next steps are:

- Continue work with CERL and West Point to refine analysis of the tri-generation scenario ECMs together with the renewable energy measures likely to be feasible at West Point.
- With CERL, present results with recommendations to DPW and team with DPW to validate and refine assumptions for integration of projects into West Point energy planning and then project development, proposal, procurement, and implementation.
- Engage in ongoing support of energy project development at USMA West Point.

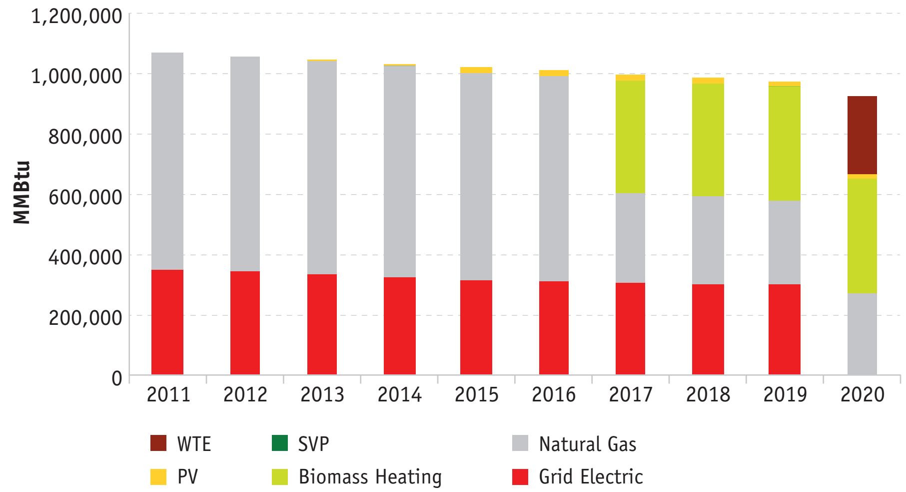


Figure 56. West Point load reduction and renewable energy integration roadmap[18]

[18] Reflects NZ roadmap analysis development in FY12 but not current installation net zero strategy.

CONCLUSIONS

The Army's Net Zero Energy pilot program is an ambitious effort to identify best practices and strategies to lead the way in energy sustainability efforts at Army installations. The roadmaps summarized in this report are a first step on the journey to Net Zero for each installation. In many ways, the process of working toward Net Zero Energy is just as important as the end goal. The nine pilot installations have already made substantial progress in identifying, developing, and executing energy efficiency and renewable energy projects in the first years of the program.

> **If all nine of the Army Net Zero Energy pilot installations achieve Net Zero Energy, they will replace approximately 8% of the Army's current total installation energy use with renewable energy. This replaces about 6 trillion Btu of fossil fuel–generated energy with renewable energy sources.**

Each of the Net Zero Energy pilot installations has great potential for energy efficiency. If all nine of the installations were to reach Net Zero Energy they would replace approximately 8% of the Army's current total installation energy use with renewable energy. This would replace about 6 trillion Btu of largely fossil fuel–generated energy with renewable energy sources, increasing the Army's energy security and reducing its environmental footprint. It would also support the Army's overall renewable energy goal of utilizing 25% renewable energy by 2025. If all Army installations worldwide were to achieve a 25% reduction in energy consumption, like most Net Zero Energy installations can, the Army would save approximately 20 trillion Btu and about $300 million annually.

Implementation of these projects and a sustained effort will be required to fully meet the Army's Net Zero Energy goals. The pilot installations have strong and motivated energy teams and we look forward to their continued progress on their journey to Net Zero Energy over the next several years.

ABBREVIATIONS AND ACRONYMS

AC . . . . air conditioning
ARC . . . . Army Reconnaissance Course
ASHP . . . . air-source heat pumps
ASHRAE . . . . American Society of Heating, Refrigerating, and Air-Conditioning Engineers
AEWRS . . . . Army Energy and Water Reporting System
BETC . . . . business energy tax credit
Btu . . . . British thermal unit
CAB . . . . Combat Aviation Brigade
CERL . . . . Construction Engineering Research Laboratory
CHCP . . . . combined heating, cooling, and power
CHP . . . . combined heat and power
CPUC . . . . Colorado Public Utilities Commission
CSP . . . . concentrating solar power
CSU . . . . Colorado Springs Utilities
CY . . . . calendar year
DHW . . . . domestic hot water
DOD . . . . U.S. Department of Defense
DOE . . . . U.S. Department of Energy
DPW . . . . directorate of public works
ECIP . . . . Energy Conservation Investment Program
ECM . . . . energy conservation measure
EE . . . . energy efficiency
EEAP . . . . Energy Engineering Analysis Program
EITF . . . . Energy Initiatives Task Force
EMCS . . . . energy management control system
ESCO . . . . energy service company
ESPC . . . . energy savings performance contract
ESTCP . . . . environmental security technology certification program
FEDS . . . . Facility Energy Decision System
FEMP . . . . Federal Energy Management Program
ft^2 . . . . square feet
FY . . . . fiscal year
gsf . . . . gross square footage
GSHP . . . . ground source heat pump
GWh . . . . gigawatt-hour
HQ . . . . headquarters
HQDA . . . . Headquarters, Department of the Army
HVAC . . . . heating, ventilation, and air conditioning
JCI . . . . Johnson Controls, Inc.
JFHQ . . . . joint force headquarters
JP8 . . . . jet propellant 8
kBtu . . . . one thousand British thermal units

ABBREVIATIONS AND ACRONYMS (cont.)

ksf . . . . one thousand square feet
kW . . . . kilowatt
kWh. . . . . kilowatt-hour
LCC . . . . life cycle cost
LCOE. . . . . levelized cost of energy
LED . . . . light-emitting diode
LEED . . . . Leadership in Energy and Environmental Design
MMBtu. . . . . one million British thermal units
MOUT. . . . . military operations on urban terrain
MW . . . . megawatt
MWh. . . . . megawatt-hour
NASA . . . . National Aeronautics and Space Administration
NEPA. . . . . National Environmental Policy Act
NIBC . . . . National Interagency Biodefense Campus
NREL . . . . National Renewable Energy Laboratory
NZEI . . . . Net Zero Energy installation
OR ARNG. . . . . Oregon Army National Guard
PEV . . . . plug-in electric vehicle
PEPCO . . . . Potomac Electric Power Company
PG&E. . . . . Pacific Gas & Electric Company
PNNL . . . . Pacific Northwest National Laboratory
PPA . . . . power purchase agreement
PRFTA . . . . Parks Reserve Forces Training Area
PSREC. . . . . Plumas Sierra Rural Electric Cooperative
PV . . . . photovoltaic
RE. . . . . renewable energy
RFP . . . . request for proposal
RPUID. . . . . real property unique identifier
SHW . . . . solar hot water
SNL . . . . Sandia National Laboratory
SRM. . . . . sustainment, restoration, and modernization
STRATCOM . . . . U.S. Army Strategic Communications Command
SVP . . . . solar ventilation preheating
SWAC . . . . seawater air conditioning
UESC. . . . . utility energy services contract
USACE . . . . U.S. Army Corps of Engineers
USAKA . . . . U.S. Army Kwajalein Atoll
USMA . . . . U.S. Military Academy
V. . . . . volt
WAPA . . . . Western Area Power Administration
WTE . . . . waste to energy

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