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Targeting Net Zero Energy at Marine Corps Base Hawaii, Kaneohe Bay

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WREF 2012: TARGETING NET ZERO ENERGY AT MARINE CORPS BASE HAWAII, KANEOHE BAY

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ABSTRACT

In 2008, the U.S. Department of Defense's U.S. Pacific Command partnered with the U.S. Department of Energy's (DOE's) National Renewable Energy Laboratory (NREL) to assess opportunities for increasing energy security through renewable energy and energy efficiency at Hawaii military installations. DOE selected Marine Corps Base Hawaii (MCBH), Kaneohe Bay, to receive technical support for net zero energy assessment and planning funded through the Hawaii Clean Energy Initiative (HCEI). NREL performed a comprehensive assessment to appraise the potential of MCBH Kaneohe Bay to achieve net zero energy status through energy efficiency, renewable energy, and hydrogen vehicle integration. This paper summarizes the results of the assessment and provides energy recommendations.

The analysis shows that MCBH Kaneohe Bay has the potential to make significant progress toward becoming a net zero installation. Wind, solar photovoltaics, solar hot water, and hydrogen production were assessed, as well as energy efficiency technologies. Deploying wind turbines is the most cost-effective energy production measure. If the identified energy projects and savings measures are implemented, the base will achieve a 96% site Btu reduction and a 99% source Btu reduction. Using excess wind and solar energy to produce hydrogen for a fleet and fuel cells could significantly reduce energy use and potentially bring MCBH Kaneohe Bay to net zero. Further analysis with an environmental impact and interconnection study will need to be completed. By achieving net zero status, the base will set an example for other military installations, provide environmental benefits, reduce costs, increase energy security, and exceed its energy goals and mandates.

1. INTRODUCTION

In 2008, the U.S. Department of Defense (DoD) and the U.S. Department of Energy (DOE) began a joint initiative to address military energy use by identifying specific actions to reduce energy demand and increase use of renewable energy at DoD installations. The initiative directed early attention toward the possibility of the net zero energy military installations (NZEIs). NZEI is defined as "a military installation that produces as much energy on-site from renewable energy generation or through the on-site use of renewable fuels, as it consumes in its buildings, facilities, and fleet vehicles."[1]

NREL was asked to perform NZEI assessments for multiple military installations and to create a template to explain the methodology for performing the assessments. Defining a net zero energy military installation is complicated by the need to meet the energy demands of the facilities without interfering with the energy used for mission (e.g., for tactical fuel demands and various forms of transportation). A net zero energy analysis for DoD must also consider impacts on mission, security, site resources, federal energy mandates, and cost of energy.

This paper gives a brief overview of NREL's net zero energy assessment strategy, focusing on the analysis and recommendations at MCBH Kaneohe Bay. Details of this assessment are provided in *Targeting Net Zero Energy at Marine Corps Base Kaneohe Bay, Hawaii: Assessment and Recommendation*.[2]

2. NET ZERO ENERGY ASSESSMENT APPROACH

The Net Zero Energy Assessment and Planning Approach is outlined below. The basic approach developed for this assessment includes seven steps, which are briefly summarized here and addressed in detail for the MCBH Kaneohe Bay assessment.

(1.) **Establish Energy Baseline:** Identify the installation mission, geographic boundaries, and any special energy requirements (e.g., reliability, performance in emergency situations, etc.). Summarize annual (source) energy used and associated costs by all identified sources supporting the mission, as well as its type and means of distribution. Become familiar with energy projects already planned on-site.

(2.) **Demand Reduction through Human Action:** Identify approaches to minimizing wasted energy while maintaining or improving the quality of mission execution.

(3.) **Perform an Energy Efficiency Assessment:** Identify specific on-site energy efficiency (EE) project opportunities and their effect on installation energy consumption.

(4.) **Perform a Renewable Energy and Load Reduction Assessment:** Identify project opportunities exploiting on-site renewable energy (RE) or renewable fuels for electricity and/or heat production.

(5.) **Perform a Transportation Assessment:** Identify projects to reduce and replace fossil fuel use in fleet vehicles.

(6.) **Perform an Electrical Systems Assessment:** Identify the impacts of recommended on-site RE projects on the installation's electrical infrastructure. Outline the characteristics of a microgrid to support emergency operations in the event of a public grid outage by considering load control and storage.

(7.) **Make Energy Project Recommendations:** Demonstrate how the recommended projects can be implemented to produce energy savings, with attention to technical feasibility, life cycle economics, and financing options.

3. MCBH KANEOHE BAY ENERGY BASELINE

The first step in conducting a net zero energy assessment is to establish the boundaries of the installation's baseline for energy consumption and related greenhouse gas emissions. The energy baseline is used to identify areas for improvement and to measure progress toward NZEI goals. Collecting the appropriate data to calculate the baseline is important to an accurate assessment. Data collection can present a significant challenge due to limitations in metered or historically collected data.

3.1 Site Description

MCBH Kaneohe Bay is located on the eastern side of Oahu, Hawaii. The base is on the Mokapu Peninsula between Kaneohe Bay and Kailua Bay. MCBH Kaneohe Bay is separated from the Honolulu area by the Ko'olau Mountain Range. This coastal region is referred to as "windward" Oahu, since it is exposed to northeasterly trade winds.

3.2 MCBH Kaneohe Bay Boundary

This study focused on MCBH Kaneohe Bay only and did not include Camp H.M. Smith, Marine Corp Training Area Bellows, the Manana Housing area, or the Puuloa Training Facility, which are often associated with this installation. Figure 1 is a map from the MCBH Master Plan 2006 and shows the boundary area of MCBH Kaneohe Bay addressed in this study.

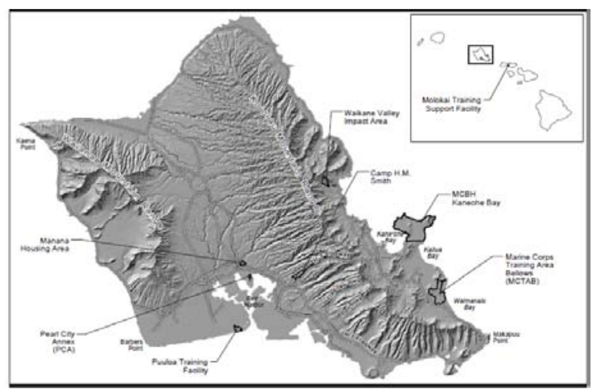

Fig. 1: MCBH Kaneohe Bay properties

3.3 Energy Consumption Baseline

Working with MCBH Kaneohe Bay, NREL determined an energy boundary for the MCBH Kaneohe Bay baseline that includes all on-site buildings and facilities, and fleet vehicles. An energy baseline provides an analysis of current energy consumption on base, as well as a metric against which to measure progress. Baseline energy consumption for MCBH Kaneohe Bay is shown in Table 1.

TABLE 1: KANEOHE BAY ENERGY BASELINE

Baseline Annual Energy Usage Information 2009			
Energy Use	Site Energy, Variable Units	Site Mbtu	Source Mbtu
Electricity (kWh)	107,088,800	365,387	1,432,317
Propane (Mbtu)	18,890	18,890	21,724
Gasoline (Gallons)	181,802	20,744	23,855
Diesel (Gallons)	93,967	13,860	15,939
Total Energy Use		418,881	1,493,835

The site's total energy use in 2009 was 418,881 million British thermal units (Mbtu). These site Btu values were converted into source Btu utilizing conversion factors developed by NREL (3.92 source Btu/site Btu electricity and 1.15 source Btu/site Btu fuel). The total source Btu is 1,493,835 Mbtu. Electricity accounts for 95.88% of the source Btu, and fuels account for the remaining 4.12%.

3.4 Electrical Baseline (Grid Connected)

NREL obtained MCBH Kaneohe Bay's load profile from 15-minute metered data from the Hawaiian Electric Company (HECO) website databases for 2009. The daily-load profile shows electricity use peaks around noon and tapers off around 7 p.m. The annual load profile shows an annual peak load of 18 megawatts (MW) that occurred in August and October.

3.5 Propane Baseline

Propane use at MCBH Kaneohe Bay was provided to NREL for Fiscal Year 2009. This data was used to establish the annual propane baseline of 18,890 Mbtu. Propane is used for hot water in the MCBH Kaneohe Bay barracks boiler plants, officers club, laundry, gym, and clinics.

3.6 Transportation Baseline

NREL personnel visited MCBH Kaneohe Bay in early 2010 and in March 2011 and were able to obtain basic information about the total fuel consumption on the base. MCBH Kaneohe Bay provided tactical jet fuel (JP-8), gasoline, and diesel fuel use data for 2009. The breakdown of fuel use by gallon is shown in Table 2.

TABLE 2: KANEOHE BAY TRANSPORTATION ENERGY BASELINE

Baseline Annual Fuel Usage Information	
Total Gasoline (gallons)	181,802
Total Diesel (gallons)	93,967
Total JP-8 (gallons)	9,335,777

JP-8 is reserved exclusively for tactical use and represents the majority of the fuel consumed on the base; thus tactical use accounts for the bulk of the transportation-related baseline. The amounts of fuel used for tactical operations are outside of the control of the installation energy managers. Although there are opportunities for future analysis examining the potential to reduce the use of fuel in training operations, this project did not include tactical fuel use reduction.

4. REDUCING ENERGY WITH HUMAN BEHAVIOR

Security, economic, and environmental objectives support a DoD-wide—and national—transition to clean energy that may be viewed, in part, as a culture change, requiring individual awareness of energy costs, new habits related to energy use, and continuing creative attention to ways of reducing energy demand. In conjunction with an NZEI analysis, DoD leaders should institutionalize ways of engaging peoples' ingenuity to reduce energy demand. It should be emphasized by the superiors/management that wasting energy goes against the values and goals of DoD's mission and therefore all personnel are required to conserve. This assessment does not attempt to quantify energy reductions due to behavior changes but rather outlines a recommended approach.

5. ENERGY EFFICIENCY ASSESSMENT

Energy efficiency is typically the most cost-effective energy project investment. Prior to conducting further analysis of the renewable energy generation technologies, the potential for energy efficiency improvement potential should be evaluated. Energy efficiency and conservation analysis were conducted first, as they will reduce the electrical and propane fuel loads at the base and decrease the sizes of the renewable energy systems required.

MCBH Kaneohe Bay has several projects already planned to increase the efficiency of its building portfolio. The NREL team was not able to include all of these measures in the analysis of efficiency improvement potential for the base. The savings outlined in this report reflect the energy efficiency measures that were identified at the time of the site visit.

The energy efficiency measures proposed below were done on a high level with very general base information. These calculations should not be considered investment-grade calculations and should not be used for determining the economics of a potential investment. The recommendations should only be used for planning and for identifying energy conservation measures (ECMs) for further investigation.

5.1 Summary of Proposed Energy Efficiency Projects

It was beyond the scope of this project to conduct detailed energy audits of the approximately 163 installation facilities at MCBH Kaneohe Bay. However, based on discussion with base personnel and a walk-through of several of the facilities on base, the NREL team determined that the savings potential for energy efficiency at MCBH Kaneohe Bay could be estimated by auditing a few representative buildings. Measures include retro-commissioning, computer energy management, and installation of lighting occupancy sensors and water heater boilers. The savings estimates are shown in Table 3.

TABLE 3: MCBH ENERGY EFFICIENCY SAVINGS

	Mbtu Savings	% Site Savings
Electricity (MWh)	62,211	15.9%
Propane (Mbtu)	1,251	0.6%
Total (Mbtu)	63,462	16.5%

The desired outcome from this analysis is a quantitative estimate of energy reduction potential. The intent is to minimize the energy consumption prior to the sizing of RE or other generation technologies.

6. RENEWABLE ENERGY AND LOAD REDUCTION

After reducing the energy use through conservation measures, the remaining energy needs of an NZEI are met through renewable energy generation. NREL began the analysis of the renewable energy generation potential of MCBH Kaneohe Bay by examining the high-level resource and project potential. The analysis includes MCBH Kaneohe Bay's specific solar and wind resource maps. The renewable energy resource maps were provided by the NREL Geographic Information System (GIS) Team. Overall, the resource maps indicate good solar and wind resource potential, moderate geothermal potential, and poor biomass potential.

In addition to the basic resource assessment, the NREL team conducted an initial assessment of the renewable energy opportunities for MCBH Kaneohe Bay based on high-level energy data provided by MCBH Kaneohe Bay and the Navy staff, using resource potential and NREL's Renewable Energy Optimization (REO) software tool. The initial REO screening evaluated the following technologies:

Further load reduction—

- Daylighting
- Solar hot water

Renewable energy generation—

- Photovoltaics (PV)
- Wind energy

Based on the resource assessment, REO screen, and discussions with MCBH Kaneohe Bay, the following technologies were eliminated from further analysis: concentrated solar power, biomass, and geothermal/ground source heat pump.

Technologies to be considered further include daylighting, solar hot water, PV, and wind turbines.

6.1 Solar Resource

The solar resource map for PV indicates that all of MCBH Kaneohe Bay falls in the 5.75–6.00 kWh/m^2/day category for horizontal tilt at latitude, which indicates a good resource. The direct-normal solar resource is also significant at 5.50–6.00 kWh/m^2/day. Direct-normal radiation excludes scattered light that results from humidity and atmospheric particles. It is a measure of only the direct, or shadow-casting, sun rays. High direct-normal radiation levels are good for systems that focus or concentrate the sun's rays on a central collector or pipe.

6.2 Wind Resource

The wind resource is good at MCBH Kaneohe Bay, and NREL has wind-speed data that was monitored over a year-long period (August 1, 2009–July 31, 2010). The analysis indicated that MCBH Kaneohe Bay has areas that are Class 3 wind regime (300–400W/m^2). More detailed information is available in the *Kaneohe, Hawaii Wind Resource Assessment Report*.[3]

6.3 Further Load Reduction

Solar daylighting and solar hot water are considered renewable energy technologies and are analyzed further as additional load reduction.

6.3.1 Daylighting

Technology overview—A complete daylighting system consists of apertures (skylights) to admit and distribute solar light and a controller to modulate artificial light in order to achieve energy cost savings. The initial NREL assessment balances savings from reduced electric light usage against the cost of installing a daylighting system and the expense of heat loss through the skylights.

Planned projects—Skylights have been installed in some of the buildings at MCBH Kaneohe Bay, so a detailed assessment of the office building and warehouses would need to be done to determine whether more energy savings could be achieved with additional daylighting measures. *Economic analysis*—The annual electric savings was calculated to be 2,092,540 kWh/year, with cost savings of $377,745/year and an 11.4-year payback period. The system production, along with the economics for the entire base, can be seen in Table 4.

TABLE 4: MCBH KANEOHE BAY DAYLIGHTING SAVINGS

Non-Office Skylight Area (ft^2)	99,123
Annual Electric Savings (kWh/year)	2,092,540
Daylighting Capital Cost ($)	$4,320,360
Daylighting Cost Savings ($/year)	$377,745
Daylighting Payback Period (years)	11.4

Recommendations—The analysis for daylighting considered warehouse-type buildings and offices only; it did not include housing. NREL does not recommend retrofitting daylighting in most existing buildings on the base, as it is not generally cost-effective. There are retrofitting opportunities in warehouse-type buildings, however, because roofs are often metal and uninsulated. Since daylighting can be incorporated at no additional cost in the design stage of a building, NREL recommends that all new construction at MCBH Kaneohe Bay incorporate daylighting strategies.

6.3.2 Solar Hot Water

Technology overview—The NREL team evaluated the feasibility of installing solar water heating systems on 28 of the buildings at MCBH Kaneohe Bay. The system utilizes an insulated flat-plate collector that preheats water before entering the existing water heater, thus reducing the amount of fuel that must be used to heat the water.

Economic analysis—The system production, along with the economics for the entire base, can be seen in Table 5.

TABLE 5: MCBH KANEOHE BAY SOLAR HOT WATER SAVINGS

Solar Water Heating Area (ft^2)	257,509
Solar Water Heating (Mbtu/year)	9,589
Solar Water Energy Savings (Mbtu/year)	11,239
Solar Water Utility Cost Savings ($/year)	$254,713
Payback Period (years)	14

6.4 Renewable Energy Generation

6.4.1 Photovoltaics

Technology overview—Photovoltaics are semiconductor devices that convert sunlight into electricity. The amount of energy produced by a panel depends on the efficiency. This depends on the type of collector, the tilt and azimuth of the collector, the temperature, and the level of sunlight. PV panels must be mounted in an unshaded location: rooftops, carports and ground-mounted arrays are common options. PV systems are very reliable and last 20 years or longer.

Planned projects—MCBH Kaneohe Bay provided NREL with the proposed sites for solar PV projects. These sites include selected carports and rooftops areas. More than 24 carports were selected as potential sites for PV. The estimated power production from these sites is 2.72 MW. The total estimated rooftop area is 745,066 ft^2, with estimated power production calculated to be ~7.45 MW peak. The total amount of power that can be generated from the selected carports and rooftop sites is ~10.2 MW peak.

Economic analysis—NREL considered savings from the proposed 10 MW PV projects, and the results of the analysis are presented in Table 6.

TABLE 6: MCBH KANEOHE BAY PV SAVINGS

PV Size (MW)	10
Annual Electric Savings (kWh/year)	15,432,643
PV Capital Cost ($)	$60,000,000
Annual Cost Savings ($/year)	$2,193,144
PV Payback Period (years)	24.9

6.4.2 Wind Turbine Energy Generation

Technology overview—Wind turbines consist of rotating blades that convert the momentum of the wind to electric power. They have several moving parts and require regularly scheduled and unscheduled maintenance. Turbines range from as small as 250 watts to as large as 5 MW, with the larger ones being most economical. Wind turbines work best when installed in areas of wide open space.

Some of the challenges as wind turbines get larger involve the logistics of deploying them to islands. Roads and transmission infrastructure are often not available at the sites. The blades are often too large for transporting into remote areas on small roads. Cranes are often required to mount the wind turbines and perform maintenance. Installation and maintenance can increase the cost dramatically for wind turbines in Hawaii. NREL factored these extra costs into the capital cost of the wind turbines.

A new technology that is being used in the Caribbean is a wind turbine designed by a French company, Vergnet. It is a small, lightweight turbine with a two-blade rotor, teetering hub, light foundation, and guyed tower. This type of wind turbine can be lowered during hurricanes. Traditional turbines, on the other hand, use three-blade rotors and have heavy towers and large, deep foundations. The Vergnet turbines are smaller (275 kW–1 MW) than the traditional 2- to 5-MW wind turbines.

Planned projects—The only planned wind turbine at this time is a small 2.4-kW Skystream turbine being installed at the base school. Initial screening suggests MCBH Kaneohe Bay's strong wind resource could result in wind turbine capacity factors of 30% –35%.

Economic analysis—The economics are highly favorable for wind turbines. A 1.5-MW turbine was modeled using the HOMER[4] software tool, and the cost assumptions are shown in Table 7. The number of wind turbines needed to offset all the on-site electricity is 19, for a total of 28.5 MW. The economics show a favorable payback of 2.78 years.

TABLE 7: MCBH KANEOHE BAY POTENTIAL WIND SAVINGS

Wind Turbine Size (MW)	28.5
Annual Electric Savings (kWh/year)	92,879,232
Wind Capital Cost ($)	$57,000,000
Annual Cost Savings ($/year)	$13,172,577
Wind Payback Period (years)	2.78

Further analysis looked at a hybrid system of PV and wind tied to the grid to get to net zero. Installing the planned 10 MW of PV would provide 13% of the annual required energy production. An additional 24 MW of wind would provide 65%, leaving 22% of the power from the grid.

The economic renewable energy analysis indicates that the installation of 28.5 MW of wind generation is the most cost-effective solution. Wind power alone tied to the grid could reduce the levelized cost of energy from $0.20/kWh to around $0.05/kWh. Adding the 10 MW of PV would further increase on-site production and reduce the amount of electricity purchased from the grid. Though adding PV to the hybrid solution for NZEI slightly increases the levelized cost of energy ($0.09/kWh) from wind generation alone, The PV will diversify the power generation. Often there is wind resource at night when solar resource is not available, complementing the renewable production.

The overall potential renewable energy savings for both electrical reduction and heating reduction is summarized in Table 8.

TABLE 8: MCBH KANEOHE BAY POTENTIAL RE SAVINGS

Project Name	Size	Savings	Source Btu Savings (Mbtu)
PV	10 MW	15,432,643 kWh	206,412
Wind Turbines	28.5 MW	92,879,232 kWh	1,242,263
Daylighting	99,123 ft2	2,092,540 kWh	27,988
Solar Hot Water	257,509 ft2	11,239 Mbtu	12,925

6.5 Net Zero Energy Potential

MCBH Kaneohe Bay can achieve net zero electrical energy through the installation of renewable energy technologies and investment in energy efficiency. Net zero energy status can be met with various combinations of efficiency, wind turbines, and solar power.

It is not economical at this time for MCBH Kaneohe Bay to pursue net zero thermal energy. MCBH Kaneohe Bay's current thermal energy source is propane. Approximately half of the propane usage on base can be replaced with energy efficiency measures and solar hot water systems. If MCBH Kaneohe Bay wanted to become a full NZEI, it would need to replace its propane-powered systems with hydrogen or electrical power created by renewable energy. As systems reach the end of their useful life and need to be replaced, it is recommended that this option be examined.

7. TRANSPORTATION ASSESSMENT

NREL personnel visited MCBH Kaneohe Bay in early 2010 and were able to obtain basic information about MCBH Kaneohe Bay's fleet fuel consumption, including a fleet list and estimated driving usage; however, the NREL team did not obtain data on staff commuting patterns. NREL is presently working with the energy management team at MCBH Kaneohe Bay to complete this analysis. When NREL visited the base in March 2011, it was brought to the team's attention that a portion of MCBH Kaneohe Bay's fleet is being converted to hydrogen vehicles by 2015. The data gathering and analysis is presently being updated.

Although fleet fuel consumption is a small component of the total fuel consumption at MCBH Kaneohe Bay, it is relevant because this fuel is subject to various statutory and Executive Order (EO) requirements, including EO 13423, EPAct 2005, and EO 13514. As fleet fuel consumption data was available, NREL was able to establish an NZEI transportation baseline for the fleet (see Table 2 in section 3.6, Transportation Baseline).

7.1 Analysis

NREL recommends that MCBH Kaneohe Bay fully commit to B20 use 100% of the time in its diesel vehicles. This will require working with its diesel supplier to obtain B20. Mixing diesel fuel and biodiesel fuel in engines and storage tanks will have adverse affects on diesel vehicle performance, so fleet users should avoid mixing biodiesel and diesel in vehicle engines and thoroughly clean storage tanks before replacing diesel with biodiesel. If poor results with biodiesel use are experienced, MCBH Kaneohe Bay should consider switching fuel suppliers. There are biodiesel specifications in place that guarantee a certain quality of biodiesel fuel, so diesel vehicles at MCBH Kaneohe Bay should perform as well using biodiesel fuel as they would if they were using diesel fuel.

The recent addition of an E85 fueling station to MCBH Kaneohe Bay gives the base the ability to replace a large portion of the fleet's fossil fuel with ethanol. NREL obtained the general composition of the fleet and an estimate of fleet gasoline usage and used this data to estimate the gasoline savings that could be achieved by switching certain classes of fleet vehicles over to E85. By completely phasing out gasoline-powered vehicles for E85 vehicles, the base could realize fossil fuel savings of 63,029 gallons/year.

Using hydrogen in conjunction with fuel cell vehicles gives the base the ability to produce its own fuel without relying on infrastructure. At the moment, hydrogen vehicles are prohibitively expensive, but if prices fall, MCBH Kaneohe Bay may want to consider changing over to hydrogen fueled vehicles, since they will be generating their own fuel primarily from renewable technologies. The potential gasoline savings from changing 100% of light- and medium-duty vehicles to hydrogen is 78,785 gallons/year.

NREL understands that MCBH Kaneohe Bay is converting some of its fleet to new hydrogen fueled vehicles. It is also procuring electrolysis equipment to produce hydrogen on-site. The hydrogen vehicle fleet is presently three sedans that use 4 kg of hydrogen per tank and 12 kg/week. The electrolysis equipment produces 1 kg/hr or 168 kg of hydrogen per week. If the price comes down on hydrogen vehicles, an additional 13 sedans could be purchased to replace gasoline vehicles.

These measures would help MCBH Kaneohe Bay work toward petroleum reduction requirements under EO 13514, EPAct 2005, and EO 13423, and begin developing a culture that emphasizes the use of alternative fuels.

8. ELECTRICAL SYSTEMS ANALYSIS

Prior to the final determination of the recommended energy projects, NREL conducted an assessment of the existing electrical system. This evaluation determined whether the site electrical infrastructure at MCBH Kaneohe Bay is robust enough to accommodate the proposed new RE generation systems.

8.1 Grid-Connected Impact Assessment

Under grid-connected operation, the site maintains an electrical connection to the area power system. Generally, the connection to the local grid simplifies analysis by providing a stable voltage and frequency reference. However, in cases such as MCBH Kaneohe Bay, located on an island, the site may make up a large percentage of the total utility system load. Thus, the impact of the proposed RE projects on the grid should be evaluated in a detailed interconnection study. For this analysis, NREL performed a high level analysis on the electrical system.

MCBH Kaneohe Bay is served by Hawaiian Electric Company (HECO) at a single substation. Transmission is via a 138-kilovolt (kV) line with two 46-kV feeders to the three transformers in the main substation. The three HECO transformers have 12.5-millivolt (MV) capacities. There are three substations that are fed from the main substation. Substation 1 distributes power to the east side of the base, which includes the housing district and supports approximately half the base load. Substation 2 provides service to the central part of the base, including many of the operations facilities. Substation 3 provides power to the airfield and tactical facilities. The output of the PV array and wind turbines will be stepped up via separate transformers that tie into the 12.47-kV primary distribution system. The higher voltage (69 kV) is considered (sub) transmission level and supplies the substation transformer. To ensure safety and meet utility operating requirements, transmission lines are typically not accessible to renewable energy system operators. Voltage connection levels are dictated by the existing utility system. Large distributed generation (DG) systems generally interconnect with the distribution system and then tie back to a substation, which is fed by a transmission line.

To maintain the integrity of the reconfigurable distribution system, each feeder must not only be able to support the DG that is proposed to be connected to that feeder, but also be able to support the DG that could be switched onto the feeder via reconfiguration.

The feeder capacities obtained by NREL show that the large utility-size wind turbines could tie into some circuits. However, the total capacity and individual feeder capacity fall short of the proposed wind turbine installation capacities of 20–28 MW. Turbine choice and the exact sites that are deemed constructible will dictate which circuits may prove economical for interconnection.

8.2 Islanded Microgrid Assessment

If independence from the grid is important to MCBH Kaneohe Bay, then a microgrid assessment should be performed. Using the assessment done thus far for the net zero energy analysis, the site should decide which loads are critical and consider the expectations surrounding the operations of the microgrid. Considerations that are integral to these decisions include load shedding capability/demand response management and existing generation capability for emergency backup. Ability to dispatch RE generation should be evaluated. Since the PV and wind generators are not dispatchable, additional thought must be given to energy storage options (hydrogen or batteries) and dispatchable generators.

The output from the microgrid analysis will be identification of critical loads; determination of the microgrid size and area; examination of existing backup power systems; analysis of load profile to determine coincidence between RE and critical loads; analysis of the most economical electric hybrid system with generators, storage, demand response, and RE sources; a basic overview of potential microgrid operation and control methods; and an assessment of the required system changes for a microgrid and their approximate costs.

9. IMPLEMENTATION PLAN

MCBH Kaneohe Bay has several options for implementing energy projects, including energy savings performance contracts, utility energy services contracts, power purchase agreements, and appropriated funds. Government-owned projects funded through appropriations reduce contractor financing and markup fees but require up-front capital and would prevent MCBH Kaneohe Bay from receiving federal tax incentives. Government-owned projects would also place an operations and maintenance (O&M) burden on MCBH Kaneohe Bay. By contrast, privately owned projects would allow MCBH Kaneohe Bay to implement renewables without any up-front capital, and with reduced O&M responsibility. Privately owned projects would also allow MCBH Kaneohe Bay to take advantage of federal tax credits, although some of the money gained in tax credits would go toward contractor financing and mark-up fees.

Federal energy projects require funding to generate results. Carefully matching available financing mechanisms with specific project needs can make the difference between a stalled, unfunded project and a successful project that generates energy and cost savings. The Federal Energy Management Program supports federal agencies in identifying, obtaining, and implementing alternative financing to fund energy projects.

10. CONCLUSION

NREL's net zero analysis evaluated opportunities for energy efficiency, renewable energy, and transportation fuel reduction at MCBH Kaneohe Bay. The analysis shows that MCBH Kaneohe Bay has the potential to make significant progress toward becoming a net zero installation. If the base implements the recommended energy projects and savings measures, it would achieve a 96% site energy reduction and a 99% source energy reduction. By achieving this status, the base will set an example for other military installations, provide environmental benefits, reduce costs, increase energy security, and exceed its energy goals and mandates.

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