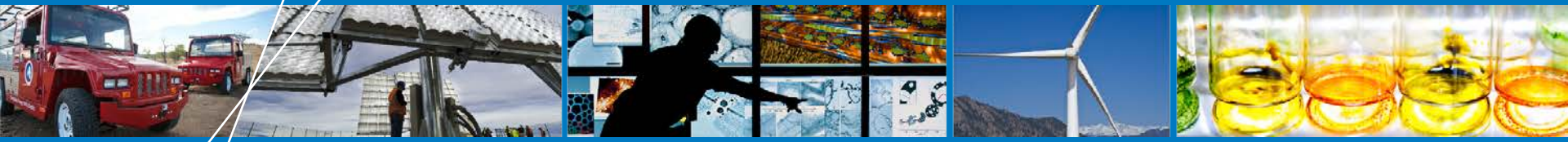
NREL
NATIONAL RENEWABLE ENERGY LABORATORY

Targeting Net Zero Energy for Military Installations



World Renewable Energy Forum
Denver, Colorado

Kari Burman

May 14, 2012

NREL/PR-7A40-55214

NREL is a national laboratory of the U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, operated by the Alliance for Sustainable Energy, LLC.

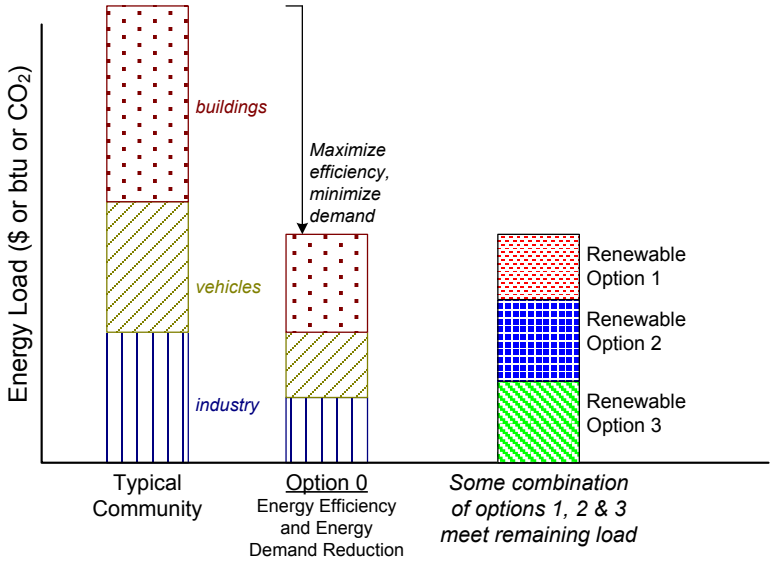
Overview

- A net zero energy installation (NZEI) is one that produces as much energy from on-site renewable sources as it consumes
- NZEI assessment provides a systematic approach to energy projects
- Analysis includes efficiency, renewables, transportation, and grid
- Goal of analysis is to lead to project implementation
- Full Report for MCBH-Kaneohe Bay:

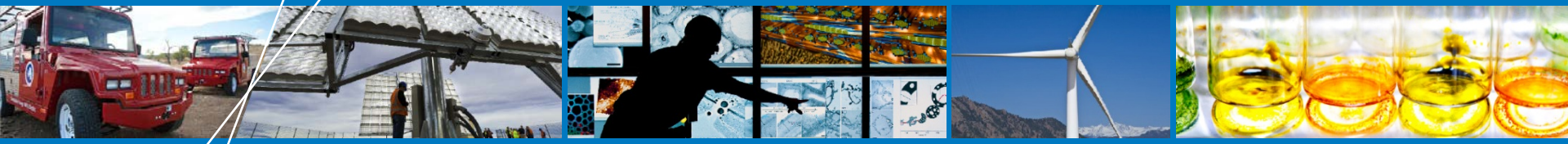
Targeting Net Zero Energy at Marine Corps Base Kaneohe Bay, Hawaii: Assessment and Recommendations http://www.nrel.gov/docs/fy12osti/52897.pdf

Assessment Outline

- **Baseline**
  - Current energy consumption
- **Energy Efficiency Measures**
  - Retrofit improvement potential
  - New construction design improvement and optimization
- **Renewable Energy**
  - Deployment of renewable energy
- **Transportation**
  - Reduce and replace fossil fuel use
- **Electrical Systems**
  - Interconnection and microgrid
- **Implementation**
  - Savings & Utility Contracts
  - Enhanced Use Lease



NREL
NATIONAL RENEWABLE ENERGY LABORATORY



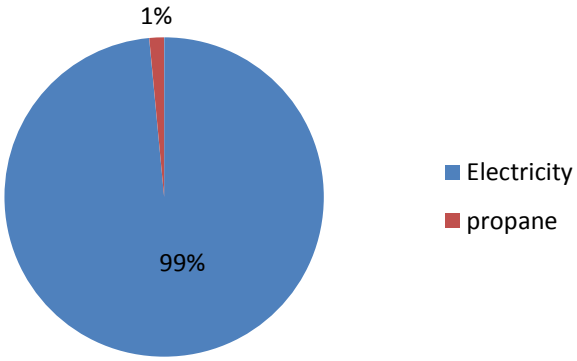
Marine Corps Base Hawaii-Kaneohe Bay

Baseline

- **Determine installation energy boundary**
  - MCBH-Kaneohe Bay is located on the eastern side of Oahu, HI
  - The energy boundary includes all on-site buildings and facilities and fleet vehicles
- **Data**
  - NREL collected data for the most recent full year, 2009.
  - Electrical, thermal and transportation
  - The metrics used is source Btu

MCBH- Kaneohe Bay Baseline

Energy Use Breakdown for buildings % of Total Source MMBtu



Baseline Annual Energy Usage Information 2009 (Source MMBtu)	
Electricity (kWh)	419,788,096
Propane (MMBtu)	21,723

Baseline

Energy Source	*2009 Energy Use*		
	Site Energy (Variable units)	**Site Energy (MMBtu)**	**Source Energy (MMBtu)**
Buildings and Facilities			
Electricity	107,088,800 kWh	365,387	1,432,317
Propane	206,900 gallons	18,890	21,724
Total Building Energy Use		**384,277**	**1,454,040**
Fleet Fuel			
Gasoline	181,802 gallons	20,744	23,855
Diesel	93,967gallons	13,860	15,939
Total Fleet Energy Use		**34,604**	**39,794**
Total MCBH Kaneohe Bay Energy Use		**418,881**	**1,493,835**

Note: 95.88% of source Btu's are from electricity and 4.12% from fuels

*Source Btu analysis allows for the accounting of the energy required to transport fuel to the base and the energy losses due to inefficiencies in the electrical generation process. Conversion factors developed by NREL (3.92 source Btu/site Btu for electricity and 1.15 source Btu/site Btu fuel)

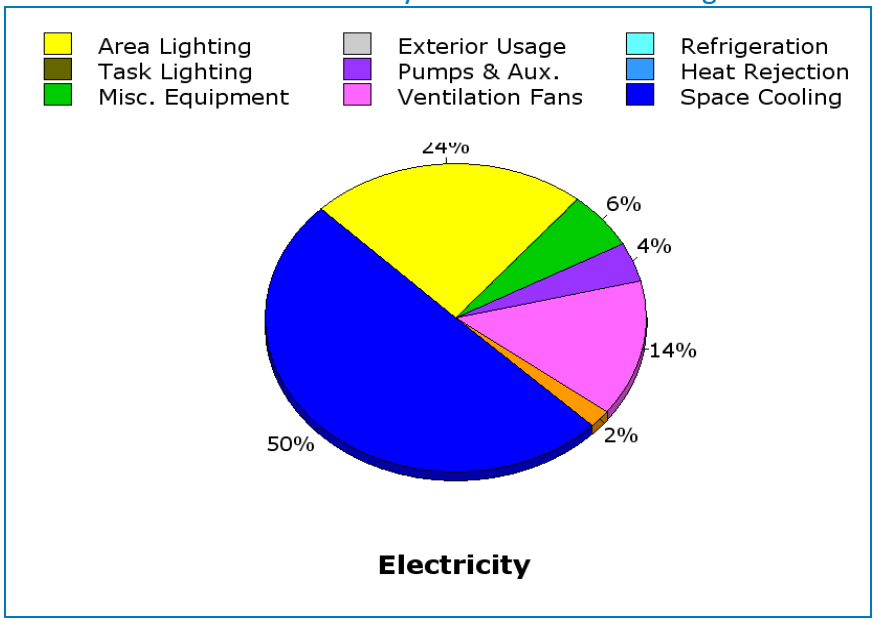
Energy Efficiency

Determine efficiency reduction potential

- **MCBH- Kaneohe Bay has an Energy Savings Performance Contract in place**
- **Specific Main Base Facilities Modeled**
  - Offices
  - Commissary
  - Barracks
  - Main Gym
- **Base Wide ECMs**
  - Lighting Occupancy Sensors
  - Computer Energy management
  - Water Heater Boilers
- **Analysis Tools and Methods**
  - Efficient building retrofits
    - Building audit / walkthrough
  - Building modeling **e-Quest**

Sample Results from MCBH-Kaneohe Bay

Modeled electricity end use office buildings



- Installation details
  - 6.1 M square feet and 800 facilities
- Average Energy Use Intensity ~ 50 kBtu / sq. ft.
- Efficiency reduction potential = 73,169 MMBtu
  - 20% reduction in office buildings

Energy Efficiency

Measure	*Savings (% of fuel type)*			*MMBtu Equivalent Savings*	*% Total Site Savings*
		Specific Base Facilities			
Commissary (32% reduction)	MWh	1,401	2.4%	4,780	2.1%
Barracks (40% reduction)	MWh	7,497	12.8%	25,587	11.4%
Offices (43% reduction)	MWh	3,215	5.5%	10,972	4.9%
Gym (52% reduction)	MWh	467	0.8%	1,593	0.7%
Mess Hall (40% reduction)	MWh	1,310	2.2%	4,470	2.0%
		Base Wide ECMs			
Retro-commissioning	MWh	2,023	3.5%	6,904	3.1%
Lighting Occupancy Sensors	MWh	935	1.6%	3,190	1.4%
Computer Energy Mgmt	MWh	1,387	2.4%	4,732	2.1%
Water Heater Boilers	MMBtu	1,251	4.8%	1,251	0.6%
		Total			
Electricity	MWh	18,233	17.03%	62,211	15.9%
Propane	MMBtu	1,251	6.62%	1,251	0.6%
			Total MMBtu	**63,462**	**16.5%**

Total electrical reduction = 18,233 megawatt-hours (MWh) or 62,221 MMBtu (17.03% electrical load reduction)
Total propane reduction = 1,251 MMBtu (6.62% propane load reduction)

Total reduction = 63,462 MMBtu (16.5% total reduction)

Renewable Energy

- **Tools used in RE assessment**
  - **GIS resource screening tools**, Renewable Energy Optimization (REO), PV Watts, HOMER.
- **Daylighting**
  - Assessment restricted to warehouses
  - MCBH Kaneohe has installed some skylights
- **Solar Projects**
  - Solar resource is good
  - MCBH Kaneohe has task orders scheduled for 10 MW of PV (rooftop, carport & ground mount)
- **Wind turbines**
  - Wind resource is excellent. NREL completed a wind resource study
  - Wind turbines most economical form of renewable energy
  - Small 2.4 kW wind turbine being installed now
- **Solar Hot water (Thermal load)**
  - NREL team evaluated the feasibility of installing solar water heating systems on 28 of the buildings and swimming pool

64 kW Rooftop PV at K-Bay

Potential wind turbine sites at K-Bay

Renewable Energy

After conservation and energy efficiency improvements are accounted for, the balance of energy consumption is met with renewable energy to reach NZEI electric & thermal
(Note: solar hot water & daylighting are considered renewable energy**)**

Project Name	*Size*	*Savings*	*Source Btu Savings MMBtu*	*% of Total MMBtu*
Electrical Reduction				
PV	10 MW	15,432,643 kWh	206,412	14%
Wind Turbines	28.5 MW	92,879,232 kWh	1,242,263	86%
Daylighting	99,140 ft^2	2,092,540 kWh	27,988	2%
Thermal Reduction				
Solar Hot Water	257,509 ft^2	112,389 therms	12,925	59%

Total electrical reduction = 110,403 MWh or 1,476,663 MMBtu (102% electrical load reduction)
Total Thermal reduction = 12, 925 MMBtu (59 % propane load reduction- not fully net zero)

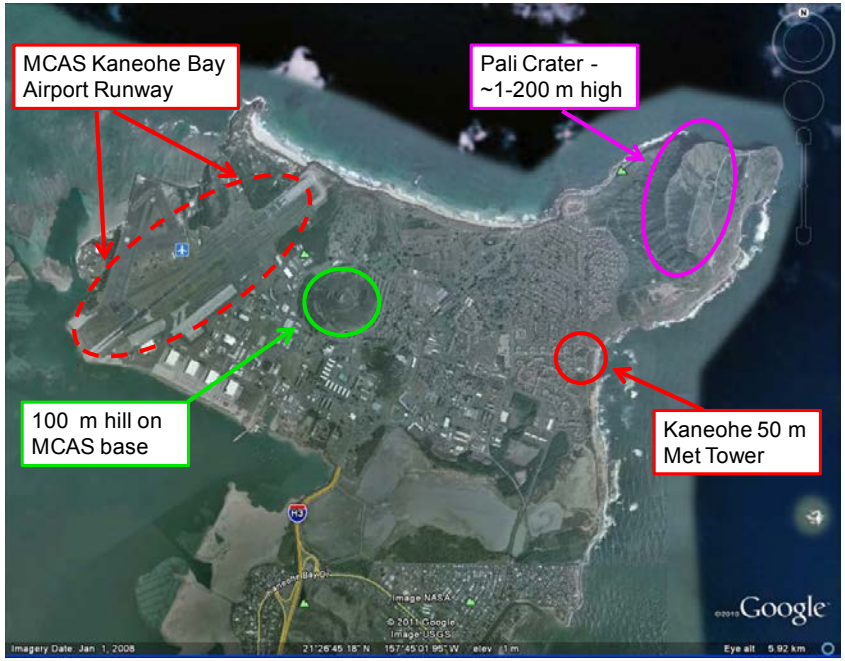
In the future it may be possible to replace the remaining propane thermal load with hydrogen produced on site from renewables

Economic Analysis

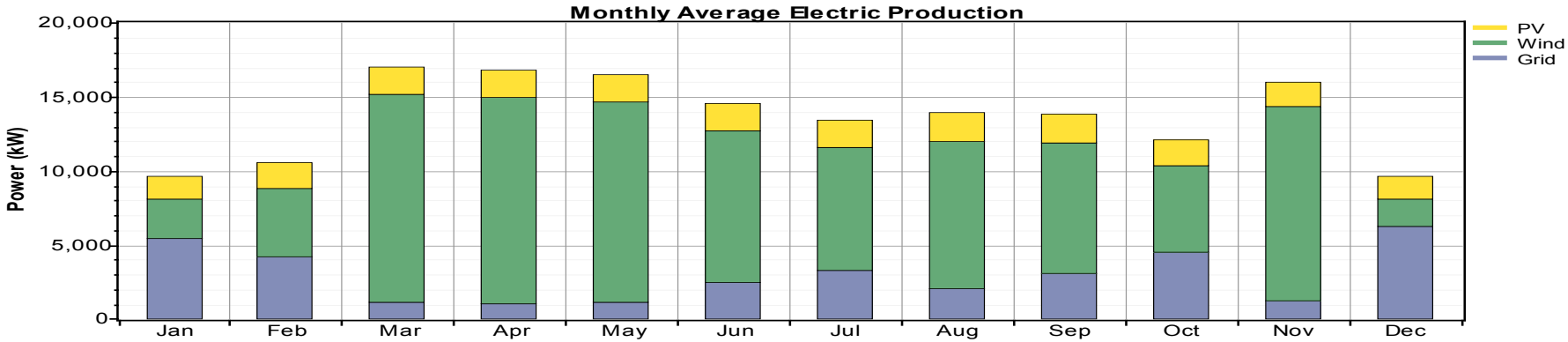
PV, Wind Hybrid System Optimal Solution

System Components size and Levelized Cost of Energy	
PV array	10.0 MW
Wind Turbines 16 (1.5 MW each)	24.0 MW
Utility Cost (Baseline)	$0.20/kWh
Levelized Cost of Energy of Wind/PV/Grid Hybrid System	**$0.09/kWh**

Production	*kWh/yr*	*%*
PV array	15,432,643	13
Wind turbines	78,213,952	65
Grid purchases	26,186,056	22
Total	119,832,648	100



Potential site for Wind turbines near Pali Crater/Met tower

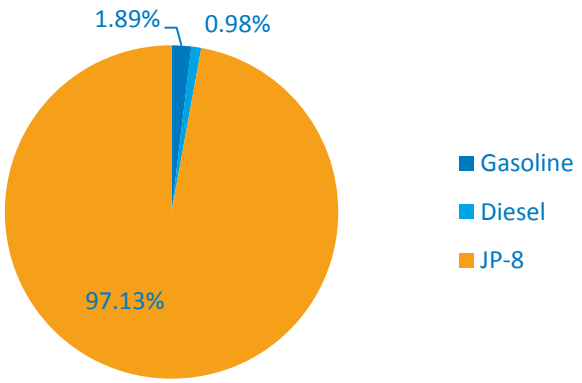


Transportation Analysis

- **Baseline Fleet**
  - Obtained MCBH Kaneohe Bay's fleet fuel consumption
  - Obtained a fleet list and estimated driving usage
  - Commuting patterns of staff were not available
  - Kaneohe Bay recently installed E85 & B20 refueling pumps
  - A portion of fleet is being converted to hydrogen vehicles by 2015.

- **Tactical**
  - No analysis conducted by NREL
  - Potential exists for future studies

Results From MCBH-Kaneohe Bay



Baseline Annual Fuel Usage Information 2009	
Total Gasoline (gallons)	181,802
Total Diesel (gallons)	93,967
Total JP-8 (gallons)	9,335,777

Transportation Analysis

- **Switch to alternative fuel vehicles**:
  - MCBH Kaneohe Bay recently installed E85 & B20 refueling pumps.
    - Switch 50% of gasoline vehicles to E85 → 67,000 gallon petroleum reduction
    - Expand biodiesel use → 2,000 gallon petroleum reduction

- **Hybrid electric vehicles (HEVs) and electric vehicles (EVs):**
  - HEVs are also being introduced into the MCBH Kaneohe Bay fleet to reduce their fuel use

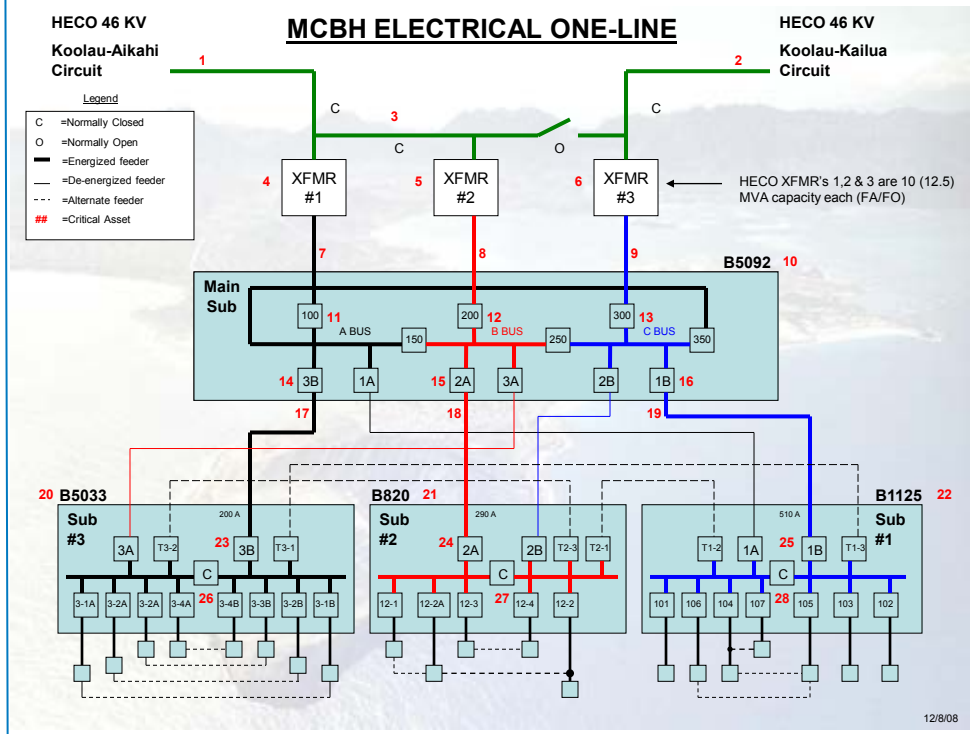
- **Hydrogen fuel cell vehicles:**
  - MCBH- Kaneohe Bay is converting some of fleet to new hydrogen fueled vehicles.
  - Installing electrolysis equipment to produce hydrogen on site
  - The hydrogen vehicle fleet is presently 3 sedans and electrolysis can handle additional 13 sedans

Hydrogen fuel station – Hickam Air Force base, HI (powered by 120 kW solar array)

Similar station to be installed at Kaneohe Bay

Electrical Systems Analysis

- **High Penetration of Renewables**
  - Interconnecting 20-30 MW of wind is challenging on island grid
  - Infrastructure would need to be upgraded to handle large variable power
- **Analysis Required**
  - Power flow analysis
  - Feasibility study
- **Additional Considerations**
  - **Utility interconnection may require storage to prevent from exporting power**
  - **The electrolyzer may act as energy storage**
  - **Using an electrolyzer to produce hydrogen on base could assist in smoothing the output power from the wind farm**
  - **Potential for hydrogen fuel cell to be installed for complete microgrid (loss of utility) scenario**



Implementation

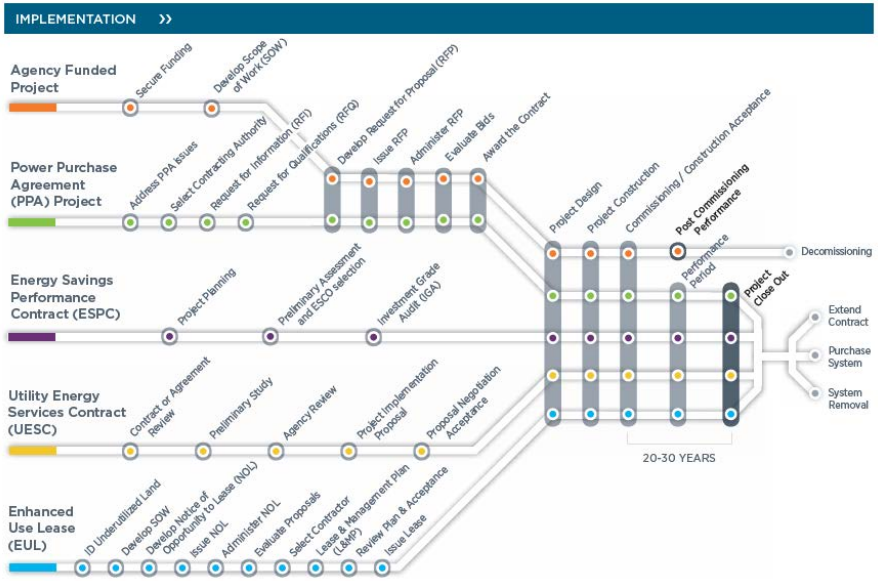
Power Purchase Agreements (PPA)	• With a PPA, a developer installs a renewable energy system on agency property under an agreement that the agency will purchase the power that the system generates.
Energy Savings Performance Contracts (ESPC)	• An ESPC is a partnership between a federal agency and an energy service company (ESCO). The ESCO conducts a comprehensive energy audit for the federal facility and identifies improvements to save energy.
Utility Energy Savings Contracts	• A UESC, the utility typically arranges financing to cover the capital costs of the project. Then the agencies repay the utility over the contract term, drawing on the cost savings that the energy generated
Enhanced Use Lease	• With a Enhanced Use Lease, a developer installs a renewable energy system on federal agency property and provides the agency with free electrical energy for use of land

Financial Assistance

NZEI assessments include potential financial routes for implementation (PPA, ESPC, UESC & EUL)

Resource Commitment

Provide implementation support after the assessment as part of the upfront project planning and budgeting



Targeting Net Zero Energy at Marine Corps Base Kaneohe Bay, Hawaii: Assessment and Recommendations http://www.nrel.gov/docs/fy12osti/52897.pdf

Mahalo- Thank you