National Renewable Energy Laboratory
Innovation for Our Energy Future

Optimize Deployment of Renewable Energy Technologies for Government Agencies, Industrial Facilities, and Military Installations

NREL Offers Proven Tools and Resources to Reduce Energy Use and Improve Efficiency

- *Site Assessments*
- *Analysis*
- *Training*
- *Project Financing Support*

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.

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With energy demands and costs increasing as budgets shrink in response to the economic downturn, large enterprises are recognizing that initiatives aimed at improving energy efficiency are as critical to the bottom line as they are to the environment. And with the passage of the 2009 American Recovery and Reinvestment Act, new funding is available for energy, transmission, and renewable integration projects. The National Renewable Energy Laboratory (NREL) can assist your organization in comprehensively evaluating and prioritizing these projects to ensure that investments are made where they can have the greatest impact on energy efficiency, renewable energy integration, and reduction of greenhouse gas emissions.

As the nation's primary laboratory for renewable energy and energy efficiency research and development, NREL uses its expertise and facilities to provide technical assistance for applying renewable energy and energy efficiency technologies.

Assessments and Technical Analysis

The assessments NREL offers can be applied in two ways:

- To develop campus-wide strategies for improving energy efficiency, optimizing renewable energy use, and reducing greenhouse gas emissions
- To develop strategies for improving the energy efficiency of new construction and building modifications.

FACILITIES: CAMPUS-WIDE

NREL is pioneering a process for assessing campuses, industrial facilities, and military installations from a "net-zero" perspective, and the assessment we recently conducted for the U.S. Navy provides a case study that illustrates the value of this process. The Navy defines a net-zero military installation as one that produces as much energy on or near the site as its buildings and facilities consume. Achieving net-zero status involves minimizing energy demand through conservation and efficiency as well as producing energy from renewable resources. To benchmark an installation's status from a net-zero perspective, energy use and production are net-averaged over a year. All energy required for the functioning of the installation, regardless of what organization controls it, is included. Transport fuel (for fleets, commuting, business travel, and flying missions) is also included in the analysis.

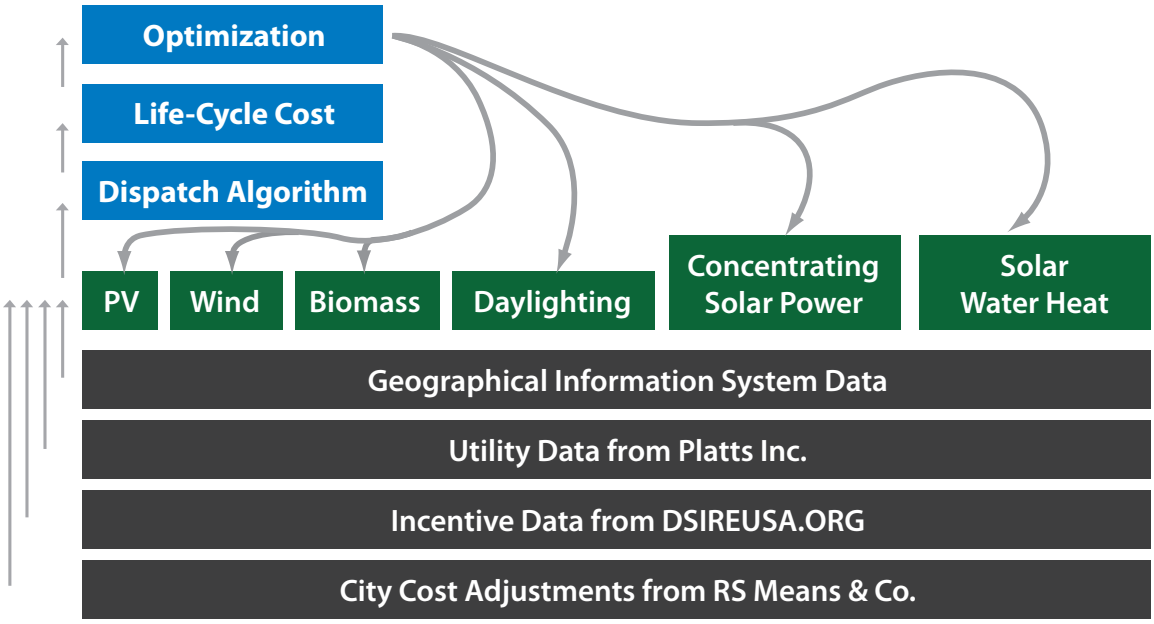
For the Navy's San Nicolas Island facility, NREL established the energy, water, and waste baseline and provided a roadmap for transitioning San Nicolas Island into a renewable community. (A detailed account of the assessment and the resulting recommendations is available in a draft report titled *San Nicolas Island, CA Renewable Community Plan Outline, Baseline Development, and Initial Renewable Assessment*. To obtain a copy, contact: Alicen.Kandt@nrel.gov.

The San Nicolas Island assessment is one example of how NREL harnesses many areas of expertise, tools, and resources to help develop site-wide energy efficiency strategies.

NREL is also conducting a net-zero assessment for the Miramar Naval Air Station. This assessment process leverages a variety of tools and protocols, including the Renewable Energy Optimization (REO) tool, the Climate Leaders Greenhouse Gas (GHG) Inventory Guidance, and the Petroleum Reduction Planning Tool.

In addition to using these resources to identify the right technologies to meet the needs of a site, NREL's assessments also incorporate several other engineering tools to help optimize the design of these energy systems. Learn more about these in Optimization and Analysis on page 9.

Renewable Energy Optimization Tool



The REO tool analyzes a variety of data used to identify the optimal combination of renewable energy technologies needed to minimize the life-cycle cost of achieving the net-zero goal.

Renewable Energy Optimization Tool

The REO tool is used to identify the optimal combination of renewable energy technologies that minimize life-cycle cost. The method relies on a variety of information, including:

- Data from the NREL Geographic Information System
- Information regarding the loads to be served, such as energy use and cost; purchased data, such as the amount utilities will pay for power; construction costs; and incentives available at a location
- Specific characteristics of the technologies, such as cost and performance.

The technologies considered include:

- Photovoltaic (PV)
- Wind
- Solar hot water
- Solar ventilation air preheating
- Parabolic troughs for heat and electricity
- Biomass for heat and electricity
- Daylighting.

All of these interact to yield a dispatch algorithm that we use to estimate how the energy delivery of the different technologies coincides.

A Newtonian search algorithm is used to determine the optimal combination of renewable energy technologies to minimize life-cycle cost. A constraint may be added, such as a percentage from renewables or even net-zero utility use. Results include the optimal size for each technology and report of capital investment required, operating costs, 25-year life-cycle cost, and rate of return. This method has been used for seven Frito-Lay plants; 62 Anheuser-Busch facilities; the town of Greensburg, Kansas; the National Zoo in Washington, D.C.; agricultural research stations in Texas; military installations, including San Nicolas Island; and U.S. Coast Guard facilities, including the Sand Island Integrated Support Command facility in Honolulu, Hawaii.

Strategic Planning for Renewable Energy Deployment at Barber's Point Air Station

Analysis shows $1 million investment in wind, solar, and daylighting could save the U.S. Coast Guard $100,000 per year and pay for itself within a decade

Need
To support the U.S. Department of Defense's commitment to reducing the environmental footprint of U.S. military forces in Hawaii, the U.S. Coast Guard sought to implement renewable energy technologies at the Barbers Point Air Station near Honolulu, Hawaii. Because of budgetary considerations, a critical first step was identifying the optimal combination of renewable technologies to minimize the life-cycle cost of the installation.

Solution
The Coast Guard contracted NREL to analyze the potential savings from photovoltaics, wind power, solar ventilation air preheating, solar water heating, solar thermal steam and solar thermal electric, and daylighting technologies. Using the REO tool, NREL performed a 25-year life-cycle cost analysis, discounting future costs to their present value.

The analysis factored in site data, information from NREL's renewable energy resource databases, utility data (avoided cost or wholesale power cost), and applicable financial incentives.

Results
The results of the analysis showed that a combination of wind energy, photovoltaics, and daylighting at its Barber Point facilities could help the Coast Guard cut its annual electricity and fuel costs by $100,000 per year, with a payback of less than 10 years for its initial $1 million investment.

Climate Leaders Greenhouse Gas Inventory Guidance

The Climate Leaders GHG Inventory Guidance is based on an existing protocol developed by the World Resources Institute (WRI) and the World Business Council for Sustainable Development (WBCSD). The WRI/WBCSD GHG Protocol was developed through a collaborative process involving representatives from industry, government, and nongovernmental organizations. The Climate Leaders GHG Inventory Guidance is a modification of the WRI/WBCSD GHG Protocol that fits the needs of Climate Leaders more precisely. Conducting the GHG inventory requires identifying energy use for all buildings and vehicles as well as other uses of energy (for example, air travel and commuting), as defined by the type of facility doing the inventory. As a member of the U.S. Environmental Protection Agency Climate Leaders program, NREL has used this protocol to create our own GHG inventory. In addition, we are supporting the U.S. Department of Energy (DOE) Federal Energy Management Program (FEMP) in assisting other federal agencies with their GHG accounting.

Petroleum Reduction Planning Tool

The Petroleum Reduction Planning Tool (https://www.afdc.energy.gov/afdc/prep/index.php) allows users to calculate the petroleum reduction potential of various strategies and combined strategies, including using alternative fuels and hybrid electric vehicles, increasing fuel economy, and reducing vehicle miles traveled.

Solar Advisor Model

For organizations looking to finance energy efficiency and renewable energy projects that incorporate Solar Energy Technology Program (SETP) technologies, NREL provides assistance through the use of our Solar Advisor Model (SAM). Using SAM, we can help clients evaluate several types of financing (from residential to utility-scale) and a variety of technology-specific cost models. The SETP technologies currently represented in SAM include concentrating solar power parabolic trough and dish-Stirling systems and PV flat plate and concentrating technologies. Other technologies will be added in future versions, including concentrating solar power central receivers and residential solar water heating.

NEW CONSTRUCTION AND BUILDING MODIFICATIONS

Energy Efficiency and Renewable Energy Assessment Tools

The suite of tools NREL uses to develop energy-efficient design strategies for buildings and electric infrastructure are automated, Excel-based calculation tools that use Visual Basic programming. Each individual calculation module is designed to operate transparently, so the user is not required to be proficient in the engineering analyses that are automatically generated by the tool.

The user is responsible for entering data that are easily collected during an energy assessment. The tool is set up such that each individual energy conservation measure (ECM) or renewable energy opportunity has its own worksheet. Each worksheet has a set of automated user forms that guide the user through the technological specifications that should be met for each ECM and provides cost guidelines that should be used when scoping a project. Once the user enters data into a worksheet and clicks on a control button, all of the ECM data automatically populate an output file. The tools also incorporate the building life-cycle costing equations and will calculate simple payback, discounted payback, net present value, and savings-to-investment ratio for each ECM.

The tools are currently set up to analyze ECMs for low- and high-bay lighting; and water conservation, plug load, and renewable opportunities. In addition, NREL is building ECMs for motors; insulation; steam and compressed air leaks; heating, ventilation, and air-conditioning (HVAC) systems; and electric power systems.

Among the energy efficiency and renewable energy assessment tools and protocols NREL uses to develop energy efficiency strategies for buildings and infrastructure are eQUEST software, the Building Energy Optimization Tool (BEopt), LEED certification consulting and guidance, and design charrettes.

eQUEST

eQUEST is a commercially available software package used with the DOE-2.2 building energy simulation and cost calculation engine to simulate the hourly performance of buildings. We also use this software to analyze options for the design or retrofit of buildings. eQUEST facilitates defining building geometry, space characteristics, schedules, and HVAC systems, as well as running parametric analyses to study design options. Another major benefit of eQUEST is the relatively short run times. eQUEST was used to model NREL's Science and Technology Facility (S&TF), which is the first federal LEED Platinum laboratory building. We used eQUEST to analyze various envelope, lighting, and HVAC ECMs throughout the design process to achieve a sustainable building design. eQUEST was instrumental in helping the S&TF achieve a 40% reduction in energy use over a standard laboratory building. We have also used eQUEST to model buildings for federal agencies.

Building Energy Optimization Tool

The Building Energy Optimization Tool (BEopt) is a software program developed by NREL that is designed to find optimal building designs along the path to net-zero energy. Used for residential construction, BEopt software finds optimal and near-optimal designs based on discrete building options reflecting realistic construction options.

In addition to an optimization search, BEopt includes:

- A main input screen that allows the user to select from many predefined options those to be used in the optimization
- An output screen that allows the user to display detailed results for many optimal and near-optimal building designs
- An options library spreadsheet that allows the user to review and modify detailed information on all available options.

NREL used BEopt software to compare the costs of a typical 1990s home to those of a low-energy home based on an analysis of the GEOS neighborhood in Boulder, Colorado. Factoring in the local climate, the BEopt analysis demonstrated that the homeowner costs for an average home that meets the minimum standard for energy efficiency were equivalent to those of a home designed to use 65% less energy. For more information, see *BEopt: Software for Identifying Optimal Building Designs on the Path to Zero Net Energy* (www.nrel.gov/buildings/energy_analysis.html#beopt).

Design Charrettes for LEED Certification

In-house NREL staff resources completed all of the documentation to achieve the LEED Platinum rating for NREL's S&TF, the first Platinum certification achieved for a federal building. Leveraging our considerable experience and success in this area, NREL assists federal managers with their LEED certifications. We offer in-depth knowledge of federal regulations governing the design of new buildings, including the guiding principles found in the Federal Leadership in High Performance and Sustainable Buildings Memorandum of Understanding (www.epa.gov/oaintrnt/projects/buildings_mou.htm). Executive Order 13423, "Strengthening Federal Environmental, Energy, and Transportation Management," signed on January 24, 2007, makes mandatory the five guiding principles of the Memorandum of Understanding for all new construction and major renovations and sets an aggressive goal for applying these practices to 15% of the existing federal building portfolio by 2015. Drawing on our depth of experience in this area, NREL also co-authored a leading guide to design charrettes, *A Handbook for Planning and Conducting Charrettes for High-Performance Projects* (www.nrel.gov/docs/fy03osti/33425.pdf).

Optimization and Analysis Tools

NREL has developed a number of engineering tools designed to optimize the design of energy systems, including:

- Renewable Energy Sensitivity Analysis Tool
- Hybrid Optimization Model (HOMER®)
- Distributed Engineering Workstation (DEW)
- In My Back Yard (IMBY).

Renewable Energy Sensitivity Analysis Tool

NREL developed the Renewable Energy Sensitivity Analysis Tool for the U.S. Navy to provide world-wide prescreening of solar (PV, solar wall, solar hot water) and wind, integrated with a modeling tool for U.S. Navy and Marine Corps energy managers, to assess potential payback of renewable energy technologies. The model includes tax and financial incentives and allows users to conduct "what if" scenarios by plugging in energy rates, technology costs, size, and other variables to identify conditions that will improve economic viability. This tool can be readily adapted to help other clients with geographically distributed facilities optimize deployment of renewable energy technologies and maximize their impact.

NREL Assesses Cost-Effectiveness of Photovoltaics at John F. Kennedy Center for the Performing Arts

Analysis Shows Potential for 15-year Return on Investment

Need

To comply with new energy efficiency standards for federal agencies, The John F. Kennedy Center for Performing Arts in Washington, D.C., was considering installing a rooftop photovoltaic (PV) system. The National Energy Policy Act of 2005 sets a goal for federal agencies to reduce their energy use by 2% annually and source energy by at least 7% of their electricity from renewable energy by 2015. The first priority of the Kennedy Center was to determine whether such an installation could be cost-effective.

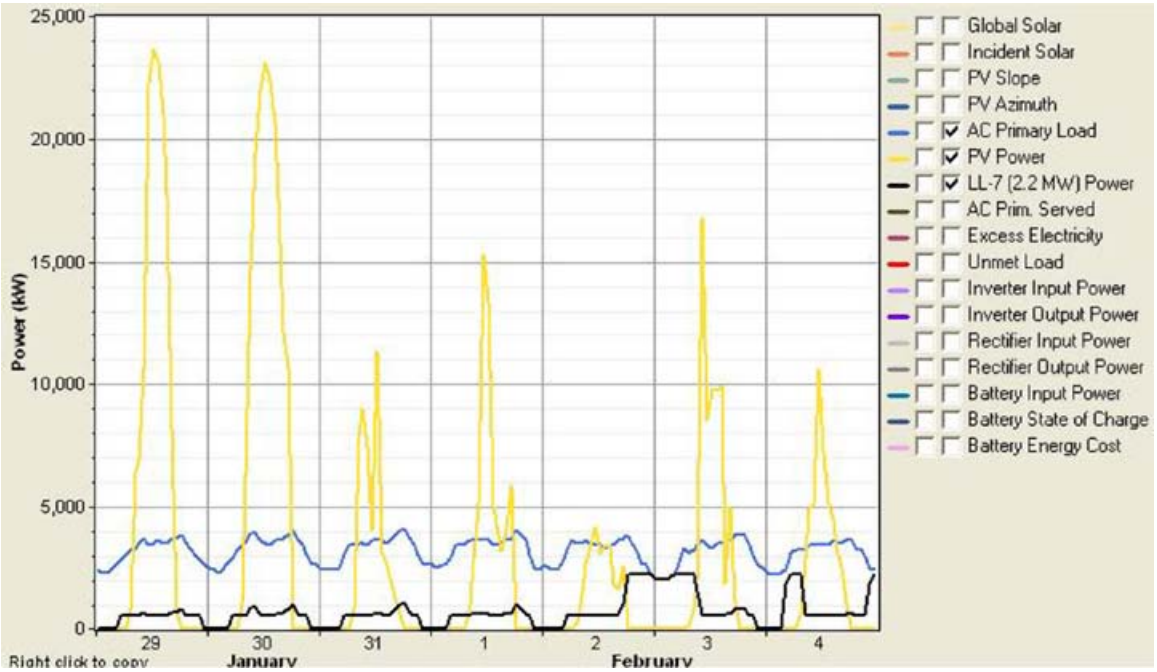
Solution

To evaluate the economic viability of the proposed PV installation, the Kennedy Center engaged a team of experts from NREL, DOE, and Sandia National Laboratories to perform a site assessment using the Renewable Energy Sensitivity Analysis Tool. During site visits to identify potential opportunities and obstacles, the team documented site conditions, collected data on electrical usage, tariffs, incentives, grants, and rebates. The team ran detailed simulations to analyze performance, then estimated energy delivery and energy demand savings. Finally, the team performed a 25-year life-cycle cost analysis, adjusted for inflation.

Results

The analysis showed the potential for installing numerous arrays on the building to deliver more than 1,178 kilowatts (kW) of photovoltaics at a cost of $9.5 million. Under scenarios that included financial incentives and renewable energy credits, the installation could bring a return on investment within 15 years, with a 5% rate of return. This would also save about 1.5 million kW of electricity annually and reduce greenhouse gas emissions by an estimated 1.2 million of CO_2 annually.

Hybrid Optimization Model



HOMER software simulates hour-by-hour operation of the system and the load profile to evaluate its performance and lowest cost of energy. It uses hourly resource data for wind and solar.

Hybrid Optimization Model

Developed by NREL, the HOMER computer modeling tool simplifies the task of evaluating options for off-grid and grid-connected power systems. The HOMER tool simulates various renewable energy configurations to optimize system design. The HOMER software evaluates the economic and technical feasibility of a large number of conventional and renewable energy technologies, ranking the feasibility of various system configurations according to total net present cost.

Distributed Engineering Workstation

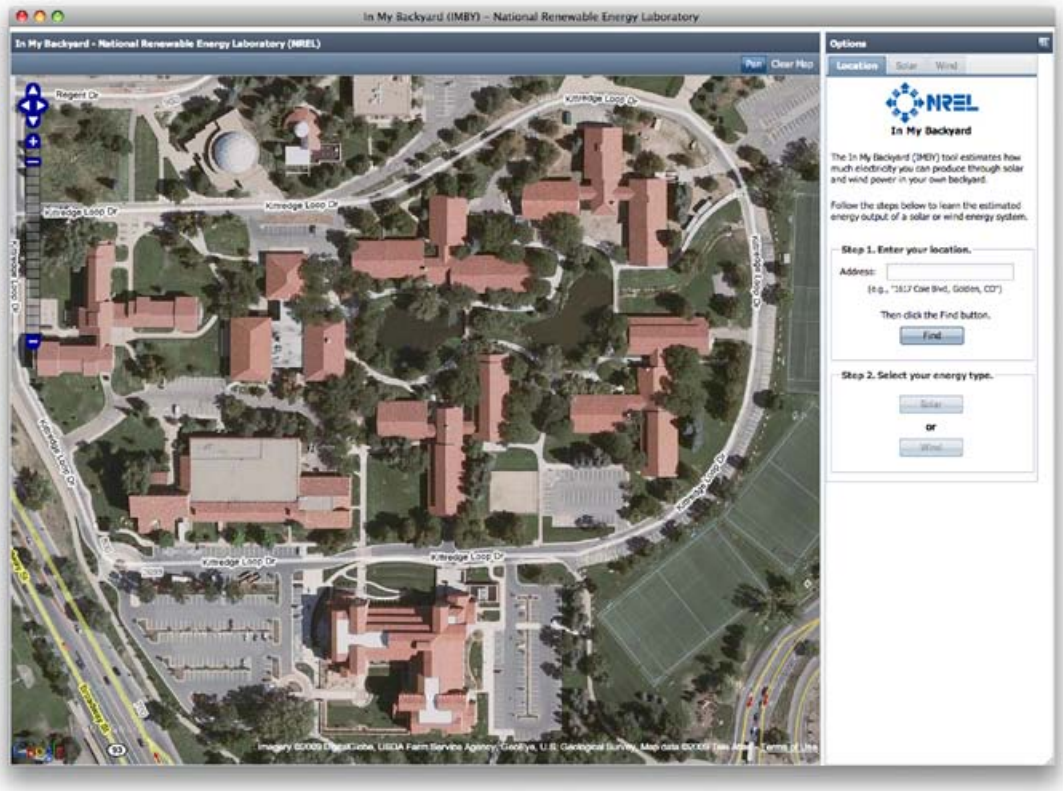
DEW is a steady-state electrical simulation environment capable of developing very large and complex electrical distribution system models. DEW algorithms include:

- Time-varying load flow
- PV impact analysis
- Protection/coordination analysis
- Contingency analysis
- Reconfiguration for restoration or minimum loss.

DEW can be used to:

- Evaluate resource placement and electrical interconnection
- Analyze the impacts of distributed resources on the existing base infrastructure
- Identify and evaluate opportunities to improve load and renewable resource coincidence.

In My Back Yard Mapping Tool



The IMBY tool can be used to estimate electricity production for a specific location using a Google Maps interface.

In My Back Yard

The IMBY tool estimates solar PV array and wind turbine electricity production based on specifications of system size, location, and other variables. IMBY uses a Google Maps interface to allow users to choose a system location with pinpoint accuracy. It then draws data for that location from one of NREL's renewable resource databases to estimate potential electricity production. The IMBY solar estimator is based on NREL's PVWatts™ calculator. However, unlike the PVWatts calculator, IMBY provides estimates only for fixed-tilt PV arrays. In addition, IMBY uses Perez data rather than typical meteorological-year data. Perez data are satellite-derived, high-resolution data from visible channel images from geostationary satellites.

Training

NREL provides training for government agencies and organizations worldwide to assist with energy efficiency and renewable energy project planning and development. These sessions introduce technologies and techniques for energy conservation and help participants better understand economic drivers and challenges that influence the adoption of energy efficiency and renewable energy technologies. Using this integrated approach, the training expands skill and knowledge and encourages energy management as a sustained organizational goal.

Trainings can be adapted for an organization's particular interest and geographic location or country, and may be targeted to specific audiences such as policy makers, energy planners, and engineers. These sessions can range from two to five days as onsite workshops, or presented as teleconferences or self-guided modules. In addition, NREL has also developed a series of 1-hour Webinars on specific topics.

Assessment Training

NREL's energy efficiency and renewable energy training expertise includes:

- Models and software tools
- Rural energy development
- Technology overviews
- Project financing options
- Policy development.

Energy assessment training helps engineers and other facility personnel increase their technical knowledge of energy efficiency and renewable energy technologies. This training introduces the tools and techniques needed to identify opportunities. The goal is to create energy management expertise among an organization's own workforce. Technical topics prepare participants to assess opportunities such as:

- Applying renewable energy technologies for buildings and fleets
- Improving building envelope efficiency
- Identifying approaches to lighting, HVAC, and plug load efficiency
- Reducing water use.

NREL Training Supports Defense Department Goals in Hawaii

NREL offers one-week, modular training sessions that provide instruction on the use of energy efficiency and renewable energy assessment tools. One such course, the Hawaii Energy Assessment Training held in December 2008, addressed the challenges involved in improving the energy performance of DOD facilities on Oahu. To reduce Hawaii's heavy dependence on fossil fuels for transportation and electricity generation, the state of Hawaii recently launched an initiative to achieve 70% clean energy by 2030 through increased energy efficiency and development of renewable technologies. The NREL training helped support this aggressive goal by providing hands-on tools and assessment techniques, improving understanding of the regulatory environment and renewable energy policy, and building awareness of the long-term benefits of energy management and conservation.

Several training modules are scheduled for 2009, including one in Guam and another in Hawaii.

Alternative Financing Training

While assessment training provides the tools and knowledge to help facilities identify *which* energy technologies and projects to consider, training on alternative financing options enables decisions on *how* they can be implemented. No single option is right for all facilities; NREL's experts customize this training to meet the needs of the project at hand, providing specifics on the appropriate mechanism for the situation. Typically, however, the training covers the process from kickoff to closeout, and may include topics such as project planning, proposal reviews and contract selection, roles of utilities or other third parties, measurement and verification, schedules, and cost estimates.

In particular, NREL works with facilities to understand these financing options:

- Energy savings performance projects
- Utility energy service contracts
- Power purchase agreements.

See page 15 for more on NREL's expertise in these financing options.

Alternative Financing Support

ESPC Quick Facts:

- More than 460 ESPC projects have been awarded by 19 different federal agencies in 47 states.
- Approximately $2.3 billion has been invested in federal facilities through ESPCs, saving more than 18 trillion Btu annually—equivalent to the energy used by a city of more than 500,000 people.
- ESPC projects have saved the federal government $7.1 billion in energy costs ($5.7 billion goes to finance project investments, for a net savings of $1.4 billion).

NREL's Project Development and Finance team offers assistance for projects, beginning with identification of goals, assessment of energy efficiency and renewable energy technical potential, project structuring and financing options, proposal review, and assistance with performance period questions and issues. In the case of campuses, communities, and military installations, we add to the basic energy efficiency and renewable energy topics, focusing on the built environment with particular attention to transportation fuel; the greenhouse gas impacts of proposed energy solutions; and energy security, surety, and reliability concerns.

NREL plays a leading role in helping FEMP and federal agencies develop the FEMP alternative financing program, and we can assist federal agencies in financing energy efficiency and renewable energy projects using energy savings performance contracts (ESPCs), utility energy savings contracts (UESCs), and power purchase agreements (PPAs). For example, we:

- Developed the PPA template being used by the Defense Energy Supply Center renewable team
- Negotiated NREL's 750-kW photovoltaic PPA to provide power to our research facilities
- Assisted various agencies (including NASA, the Jet Propulsion Laboratory, the U.S. Coast Guard, and DOD) with PPAs
- Facilitated or advised on approximately 25 UESC and ESPC contracts and PPAs for federal agencies annually; in 2008, this included DOD, the Federal Aviation Administration, the Federal Bureau of Prisons, and the U.S. Department of Commerce
- Are facilitating an ESPC contract for a 100-MW concentrated solar project with an excess power sales agreement at DOE's Nevada Test Site.

Energy Savings Performance Contracts

ESPCs allow federal agencies to form partnerships with energy service companies (ESCOs) that enable them to avoid the up-front capital costs and special Congressional appropriations that would otherwise be needed to implement energy savings projects. After conducting a comprehensive energy audit for a federal facility, the ESCO identifies improvements that will increase energy efficiency, works with the agency to design a project customized to its needs, and arranges the necessary financing. The ESCO guarantees that the cost savings resulting from the improvements will pay for the project over the term of the contract (up to 25 years), after which all cost savings accrue to the agency. DOE ESPCs are indefinite-delivery, indefinite-quantity contracts designed to be as practical and cost effective as possible for federal agencies. DOE ESPCs help federal agencies meet energy efficiency, renewable energy, and emission-reduction goals by streamlining contract funding for energy management projects.

Utility Energy Savings Contracts

The Energy Policy Act of 1992 authorizes and encourages federal agencies to participate in energy efficiency programs offered by electric and gas utilities. These programs enable agencies to partner with their franchised or serving utilities to finance energy improvements through UESCs.

With a UESC, the utility arranges financing to cover the capital costs of the project and is repaid over the contract term from the cost savings generated by the energy efficiency measures.

These contracts provide an ideal option for federal agencies looking to implement energy improvements with no initial capital investment, minimize their net costs, and save significant time and resources by taking advantage of the one-stop-shop financing services their franchised or serving utilities provide.

Power Purchase Agreements

Federal agencies seeking ways to finance their renewable projects can also opt for a PPA, wherein a private entity installs, owns, operates, and maintains customer-sited renewable equipment, and the site purchases the electricity. Such agreements allow renewable energy developers to benefit from tax incentives and accelerated depreciation while allowing agencies to reduce their exposure to risk and secure long-term electricity pricing. PPA contracts typically range from 10 to 20 years, with longer terms being ideal.

As an example, under a 20-year PPA contract for a 720-kW (1,200-MWh) NREL PV project on approximately five acres, solar developer SunEdison sold renewable energy certificates to Xcel Energy for a Renewable Portfolio Standard solar set-aside. The PPA price was equal to or less than utility electricity prices (based on Energy Information Administration projections). The PV installation became operational in December 2008.

For agencies interested in exploring this option, NREL can provide support in the form of renewable screening and assessments to determine cost-effectiveness and project viability; project facilitation, including market research; development of requests for information, requests for proposal, and opportunity notices; assistance with land use agreements and similar requirements (e.g., leases, easements, licenses); and bid evaluations.

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NREL
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Innovation for Our Energy Future

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