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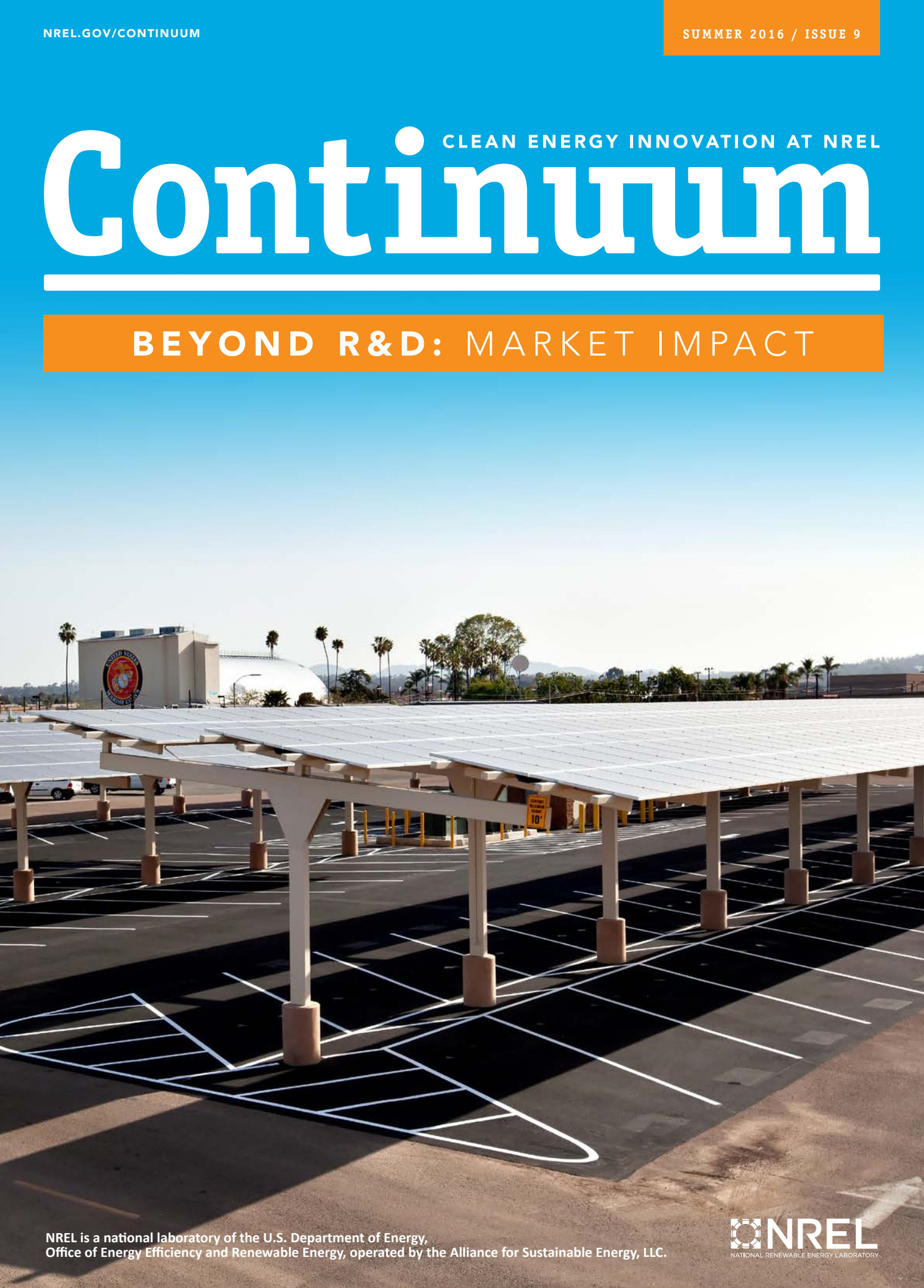
SUMMER 2016 / ISSUE 9

CLEAN ENERGY INNOVATION AT NREL

Continuum

BEYOND R&D: MARKET IMPACT



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NREL
NATIONAL RENEWABLE ENERGY LABORATORY

FROM THE DIRECTOR

Photo by Dennis Schroeder, NREL

A Q&A WITH NREL'S NEW DIRECTOR, MARTIN KELLER

Dr. Keller joined the U.S. Department of Energy's National Renewable Energy Laboratory (NREL) in November 2015 as its ninth director. Here he shares with Continuum his insights about clean energy innovations and market acceptance of cutting-edge technologies.

Q How does NREL view the evolution of technology innovation?

A Game-changing innovations respond to the marketplace. NREL's depth of foundational science, guided by our world-class analysis expertise and deployment knowledge, paves the way for launching clean energy breakthroughs.

Q Why is it important to demonstrate clean energy technologies in a real-world deployment environment?

A Demonstration projects and deployment work allow us to test new concepts and technologies. Pilot testing and performance validation are essential to overcoming barriers and reducing investment risk. NREL's unique simulation research labs demonstrate real-time conditions and resulting outcomes. Industry partners seek NREL's 40 years of scientific expertise to develop technologies in labs such as solar cell efficiency and performance, biomass enzyme conversion, and microgrid simulators capable of testing grid loads and reliance, renewable energy systems, and vehicle integration. Our research sweet-spot is the capability to couple these unique research labs with our ability to help industry make informed decisions while working side-by-side with world-renowned scientists and analysts.

Q How does NREL play a role in transforming clean energy innovation?

A In 2015, renewable sources were the largest contributors to growth in the energy sector. The cost of solar has dropped over 80% in the past five years and wind is often the lowest cost of power in many markets. Likewise, clean energy investment is at its highest level since 2011. For the first time we're looking at the market relative to renewable energy demand instead of working to meet the current energy supply. This fundamental shift opens marketplace opportunities in clean energy use, storage, and supply sources. NREL is equipped with the tools, expertise, and scientific knowledge to support the shifting energy sector.

Q How will NREL's work help meet the energy challenges of our time?

A Today's connected-world—smart and portable consumer products and technologies, power electronics, mobility and transportation options, and workplace and lifestyle shifts—are transforming the clean energy sector. NREL can uniquely influence and support the way we access, use, and store energy.

Our multidisciplinary knowledge, fundamental research, scientific expertise, analytical capabilities, and environmental drivers are impacting the cleantech sector. NREL leads customized partnering opportunities, fundamental renewable energy and energy efficiency research, and technology research and related analytical capabilities resulting in hundreds of patents and scientific and technology achievements. I'm excited to guide NREL's science and technology advancements and lead the lab's next-generation energy transformation.

Cover photo by MCAS Miramar

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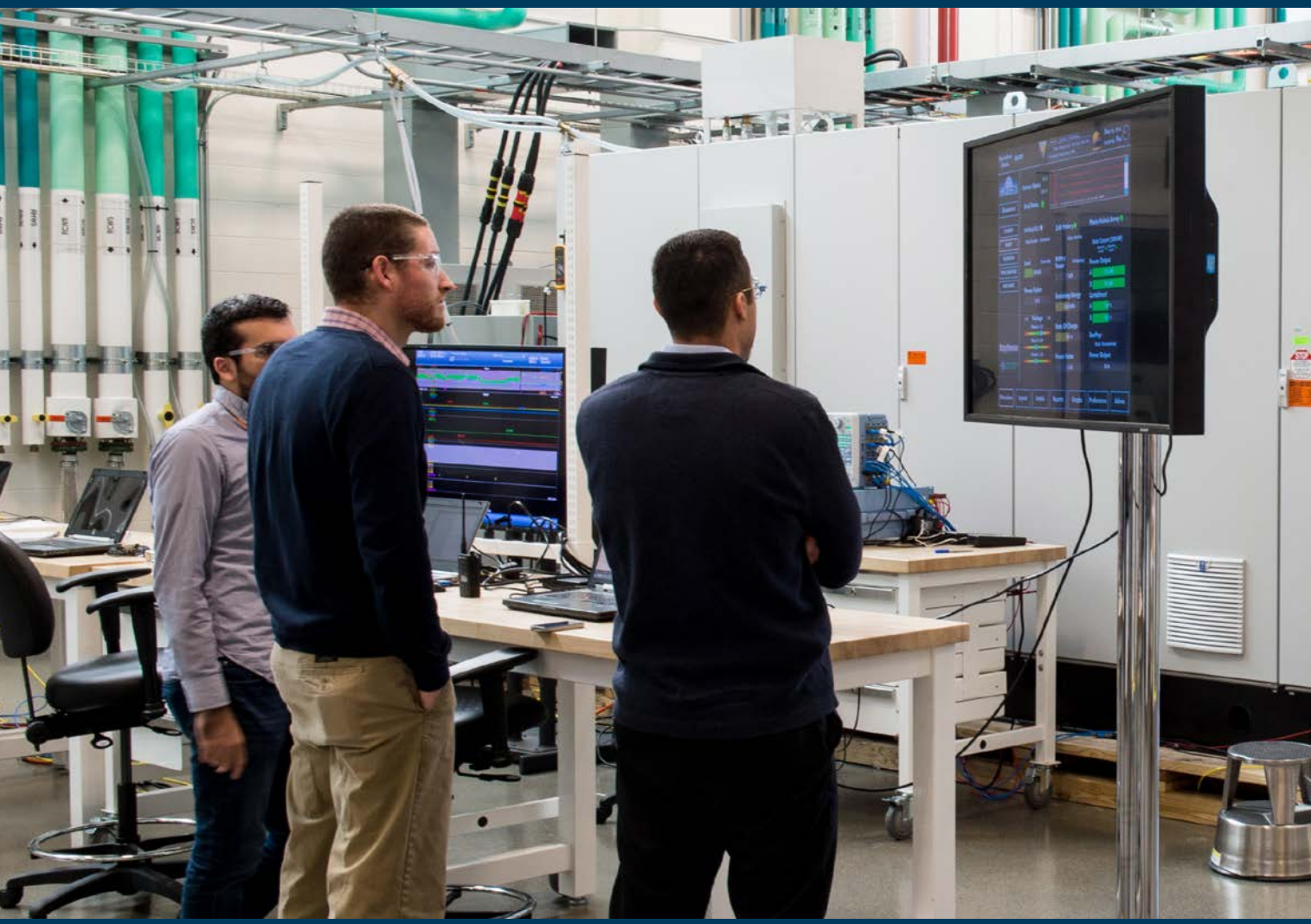
Photo by Dennis Schroeder, NREL



NREL and Raytheon researchers perform system-level testing on the Marine's Miramar simulated microgrid at NREL's Energy Systems Integration Facility.
Photo by Dennis Schroeder, NREL

"The project successfully demonstrated an islanded electrical system that was powered by batteries and solar photovoltaics (PV), without conventional generation."

— Robert Butt, NREL

MARKET DEMONSTRATION: NREL HELPS TRANSFORMATIVE TECHNOLOGIES GO MAINSTREAM

NREL BRIDGES SCIENTIFIC DISCOVERY AND MARKET ADOPTION BY HELPING TECHNOLOGIES MOVE FROM RESEARCH THROUGH DEVELOPMENT, DEMONSTRATION, AND DEPLOYMENT.

Marine Corps Air Station Miramar (MCAS Miramar) near San Diego, California, is a leader in supplying critical military missions with resilient and renewable power, thanks in part to a partnership with the National Renewable Energy Laboratory (NREL).

And when NREL engineers Robert Butt and Sam Booth went to Miramar in December 2015, they helped validate the functionality of a small microgrid—and further critical resiliency. "The project successfully demonstrated an islanded electrical system that was powered by batteries and solar photovoltaics (PV), without conventional generation," Butt said.

NREL's work is another step toward increased resiliency for the installation following an unexpected occurrence more than five years earlier: the Southwest Blackout of 2011. The event provided an unlikely opportunity for NREL to showcase its deployment expertise.

Around 3:30 p.m. on September 8, 2011, a blackout began to cascade across San Diego. For eight hours, one of the largest power failures in California history paralyzed a large swath of Southern California, including Miramar, about 10 miles north of San Diego.

Fighter jets at the typically busy flight center were grounded. While the power outage disrupted the base and halted the daily operations of the 3rd Marine Aircraft Wing, it proved beneficial in one respect: it provided an opportunity to evaluate the value of developing a microgrid to improve energy resiliency.

Coincidently, technical experts from NREL and the U.S. Navy's Naval Facilities Engineering Command (NAVFAC) were already evaluating options to improve energy resiliency through increased energy efficiency, renewable energy generation, and advanced microgrids.

This approximately 200-kilowatt solar PV carport provides renewable power to help meet the Navy's ambitious energy targets and reduce energy costs, as well as providing energy resiliency for Miramar when utilized along with energy storage in a microgrid.

Photo by MCAS Miramar

"We were able to go to Miramar after that outage and sit down with the flight operations and security personnel, and ask them, 'What happened?'" said Booth, a member of NREL's Integrated Applications Center.

The power failure revealed unexpected vulnerabilities: not only were planes grounded, some communication systems didn't function, flight line gates needed to be manned, generators failed, food spoiled, and employees were sent home. "They probably would never have predicted a lot of those things," Booth said.

A goal of this analysis, begun in August 2011, was to help meet the Navy's ambitious energy targets. In particular, NREL began developing a conceptual advanced microgrid design for the 23,000-acre site at Miramar. The microgrid assessment provided a systematic approach to meeting multiple energy goals through a single project that would increase resiliency, utilize renewable energy, and provide cost savings.

DID YOU KNOW?

"WE WERE ABLE TO GO TO MIRAMAR AFTER THAT OUTAGE AND SIT DOWN WITH THE FLIGHT OPERATIONS AND SECURITY PERSONNEL, AND ASK THEM, 'WHAT HAPPENED?'"

— Sam Booth, NREL

BUILDING ON A NET-ZERO STUDY

The base had already been a key subject of a 2008 joint initiative between the Department of the Defense (DOD) and the U.S. Department of Energy (DOE), which addressed military energy use. Working for DOE, an NREL team had examined the site for net-zero energy potential—that is, the ability to produce as much energy as the based consumed.

NREL, with the work of Booth and others, helped Miramar analyze its energy consumption along with on-site renewable energy. As a result, Miramar has been successfully implementing these measures, reducing building energy intensity by 44% and getting approximately 50% renewable electrical energy. "We learned a lot through our net-zero work," Booth said, including how to use renewable energy, such as photovoltaic energy, when the grid goes down.

After the 2011 blackout, NREL analysts moved ahead with the project, which was designed to provide electrical power to the designated critical loads on base. NREL assisted NAVFAC in planning the microgrid for Miramar—an independent electrical generation and distribution system, which delivers energy that is reliable, economical, and sustainable.

Booth, Butt, and others looked at what went wrong and, in partnership with NAVFAC, came up with a deployable solution. Under the unique plan, the base will construct an Energy Operations Center for the microgrid—along with three control points for the micro-electrical system, including one off base. The microgrid design includes PV, landfill gas, natural gas, and diesel fuel to provide continuous electricity. Further, during times when the external grid is functioning (typically more than 99% of the time), Miramar's energy team can monitor energy usage on the base, helping increase efficiency and savings.

The NREL team provided technical assistance getting the design ready for bid. The $18 million project, funded by the DOD, is expected to be built in the next few years and will increase the resiliency of the installation by providing approximately 100 buildings with more reliable power from the microgrid. "There are a lot of lessons the Air Force, Army, Navy, and others looking to do this can learn as they expand more broadly to a whole portfolio of microgrids," Booth said.

The NREL team was able to leverage innovative ideas for the larger microgrid from the smaller microgrid project that was commissioned in December 2015. To reduce risks and cost, in December 2014, the team utilized NREL's Energy System Integration Facility (ESIF) to conduct hardware-in-the loop testing of Raytheon's microgrid power and control system that closely mirrored the planned building-scale installation at MCAS Miramar's Public Works building. "Seeing a complete renewable energy system perform as envisioned felt like history in the making," said Mick Wasco, Miramar's installation energy manager.

NREL's work bridges scientific discovery and market adoption by helping complete the energy innovation cycle—as technology moves from research through development, demonstration, and deployment. The laboratory has provided such assistance for a range of entities in both the private and public sectors. Learn about how Joe Simon's work supports startups.

NREL engineers assisted Raytheon during this effort by reviewing test plans and procedures, acquiring data during demonstration and follow-on analyses, and contributing to the final report.

As energy storage technologies are improved and costs decrease, Butt noted, hybrid systems that can provide grid-connected benefits as well as standby functionality are expected to be more common for building-scale microgrids.

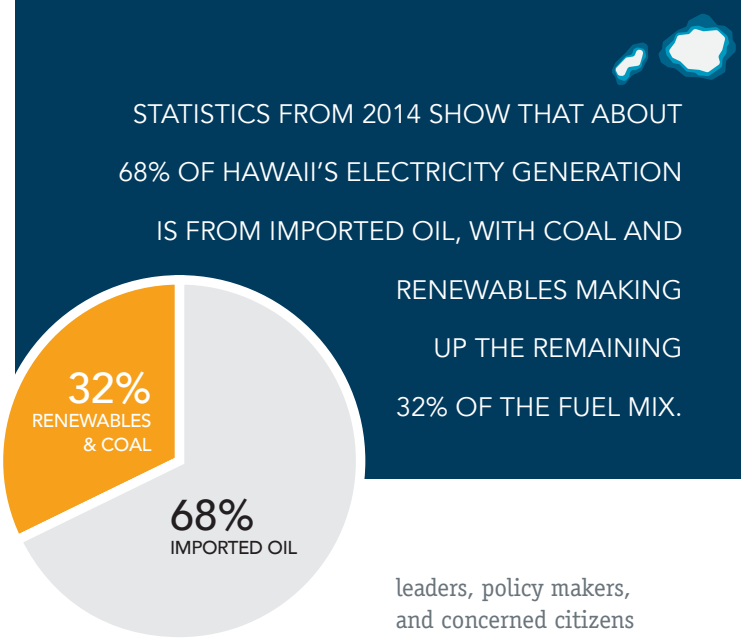
The engagements at Miramar are one example of how NREL bridges scientific discovery and market adoption by helping complete the energy innovation cycle—as technology moves from research through development, demonstration, and deployment. And Miramar isn't alone. The laboratory has provided such assistance for a range of entities in both the private and public sectors.

NREL TEAMS UP TO SPUR HAWAII'S ENERGY PROGRESS

Statistics from 2014 show that about 68% of Hawaii's electricity generation is from imported oil, with coal and renewables making up the remaining 32% of the fuel mix. NREL provided technical assistance to deploy renewable energy to military bases across the Atlantic and Pacific regions. For example, the Navy and a local utility announced in October 2015 that they would develop solar generating facilities for 117 megawatts at airfields used by two bases on Florida's Panhandle. By December 2015, the Navy completed their 1-gigawatt goal.

Yet, as vital as such installations in California and Florida are to national security, bases on islands have greater vulnerability because of the need to import fuel, as well as their reliance on smaller electrical grids. And the vulnerability extends beyond the military to commercial and residential applications.

About 90% of Hawaii's electricity is generated from imported petroleum. To relieve oil dependence, in 2008 the State of Hawaii and DOE launched the Hawaii Clean Energy Initiative (HCEI), made up of business leaders, policy makers, and concerned citizens committed to lead Hawaii to energy independence. HCEI set a goal of 70% clean energy by 2030, which the State of Hawaii recently updated to 100% by 2045.



NREL's foundational efforts in Hawaii have provided a textbook example of applying a fully integrated approach to renewable energy and energy efficiency deployment. This approach included aspects of target setting, stakeholder outreach, policy and legislation, and technology and economic analysis. In one instance, NREL helped the Department of Hawaiian Home Lands create a new net-zero community for low-income families.

Senior Engineer Ken Kelly, who succeeded two NREL team members stationed on the island, worked as a project manager on behalf of DOE with the State of Hawaii. The partners sought to determine how Hawaii could reach a statewide 40% renewable energy portfolio standard, along with a 30% energy efficiency standard, as well as transportation modifications and renewable fuels usage.

"One of our roles was convening the local stakeholders to define pathways and address barriers," Kelly said, including the Hawaiian Electric Companies (HECO), the Hawaii State Energy Office, The University of Hawaii System, and members of the private sector.

"We contributed to some of the backbone analysis, such as high-penetration island grid studies," he said, adding that the engagement "was absolutely a partnership, and showed the importance of that partnership" in furthering clean energy technologies. One tangible result in the quest for what Kelly termed "a very daunting transportation energy goal" was to accelerate the adoption of electric vehicles on the Hawaiian Islands.

Senior Project Leader Mike Callahan, who currently is based in Hawaii and concentrates on Navy efforts, has continued the tradition of building on NREL's clean energy efforts on the island—which now boasts the highest per-capita solar energy penetration of any state.

Callahan, who also supports the Navy's renewable energy project development in Guam and other parts of the Pacific, is helping implement NREL successes. In one case, NREL and NAVFAC implemented advanced control systems on existing rooftop air-conditioning units on Joint Base Pearl Harbor-Hickham. During the demonstration, the retrofits reduced overall energy by roughly 15%.

Even as DOD projects like that were showing gains, NREL was instrumental in pursuing even bigger improvements. NREL collaborated with SolarCity and HECO, using ESIF testing to assess challenges of interconnecting high penetrations of distributed photovoltaics with the electric power system. They analyzed high-penetration solar scenarios using advanced modeling and testing, power electronic devices (inverters) capable of converting the direct current produced by photovoltaic panels into alternating current, the type of electricity used by household appliances.

NREL provided the test results to the utility, and the utility then increased their PV penetration levels from 120% to 250%, enabling all island community members to reduce the amount of imported oil. Further, the test results helped the utility clear out a backlog of requests for distributed solar.

"NREL was able to test advanced inverters at the ESIF and demonstrate how they would perform, thus reducing risk to the utility and community," Callahan said.

The benefits don't end there. Callahan said that such a deployment—where lab research into clean technologies, policy analysis, and testing all get deployed in the field—help inform new research as he reaches back to NREL. "It's a virtuous cycle of what we see in the marketplace influencing the solutions we develop in the lab," he said.

NREL HELPS ICONIC PARK BRIGHTEN UP

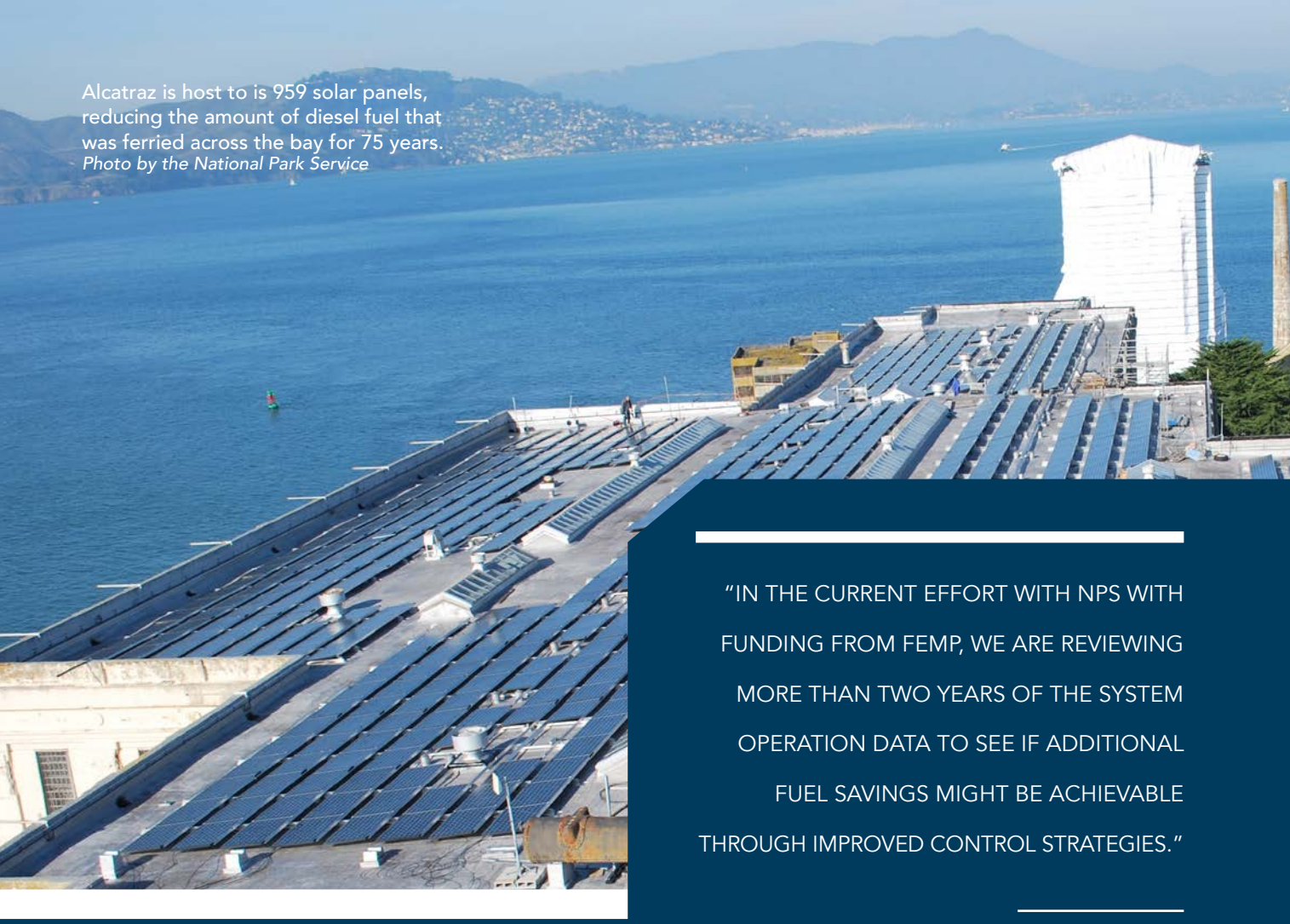
While there are many examples of NREL's work helping spread clean energy technology, the laboratory's role in transforming the iconic island of Alcatraz in San Francisco Bay is a highlight. The former prison is host to 959 solar panels, reducing the amount of diesel fuel that was ferried across the bay for 75 years. The island's solar panels produced more than 325,000 kilowatt-hours of electricity in 2013.

The panels are part of an effort by the National Park Service (NPS), in partnership with DOE and NREL, to bring clean energy to national parks and landmarks—but it rests on a foundation of research and development as solid as "The Rock," as the former prison is known.

NREL and DOE's Federal Energy Management Program (FEMP) work began when Andy Walker, Ph.D., installed instruments to measure loads and solar resources on the island and conducted a feasibility study. "I worked until the end of the day installing data loggers, and from the roof of the cellblock I could see the last ferry back to San Francisco about to pull out," he recalled.

After 14 months of data collection and modeling the energy and financial performance of a system, results indicated that a PV system with batteries would be cost-effective. NREL continued to support the project and NREL's Mary Werner facilitated a performance contract to finance and install the system. That installation, however, was suspended due to financier concerns about historic preservation contingencies, and the project stalled until the park received appropriations through the American Recovery and Reinvestment Act (ARRA) in 2009.

NREL was also supported by ARRA in providing a design charrette, system design input and analysis, updated load measurement, and assistance in the preparation of the schematic design report included in the request for proposal. NREL provided photo-realistic renderings of what the system would look like from the mainland to assuage concerns related to historic preservation.



Alcatraz is host to is 959 solar panels, reducing the amount of diesel fuel that was ferried across the bay for 75 years.
Photo by the National Park Service

> "IN THE CURRENT EFFORT WITH NPS WITH FUNDING FROM FEMP, WE ARE REVIEWING MORE THAN TWO YEARS OF THE SYSTEM OPERATION DATA TO SEE IF ADDITIONAL FUEL SAVINGS MIGHT BE ACHIEVABLE THROUGH IMPROVED CONTROL STRATEGIES."
>
> — Dan Olis, NREL

"There are two approaches to doing solar projects on historic buildings," Walker explained. "One is to hide it so that it can't be seen, and the other is to make it appear different so that there is no confusion about what is historic fabric and what is not. This project takes the first approach by keeping the PV array low on the cellblock roof behind a parapet wall."

A 307-kilowatt PV array now sits on the roof of the main cell house building, attached to two battery strings of 240 cells each, which add up to 1,920 kilowatt-hours. A modular inverter plant converts the DC power from the PV array, and to and from the batteries to AC power compatible with the island grid.

The array eliminates about 337,000 kilograms of carbon dioxide emissions per year while reducing the time the diesel generator runs from 100% to 40%, and saving about 40% of the fuel consumption. As a result of NREL analysis, the NPS also made some energy efficiency changes, such as better light bulbs and changes in operation to reduce energy consumption. But subsequent NREL analysis of the actual performance indicates there are more improvements that can be made.

"In the current effort with NPS with funding from FEMP, we are reviewing more than two years of the system operation data to see if additional fuel savings might be achievable through improved control

strategies," said Senior Engineer Dan Olis. Principal Engineer Otto Van Geet conducted a site visit to the installed system and met with park staff. Preliminary data shows the potential to reduce total fuel consumption by about 25% more per year, or by about 14,000 gallons per year. The most recent NREL report by Olis makes "low-cost, no-cost" control setting recommendations to improve the battery charging scheme and reduce the amount of PV generation that is curtailed, to bring the energy savings up to the 60% efficiency potential.

Clearly, NREL is making an impact—in areas as varied as military bases, residential communities, and public spaces, to name a few—but the influence don't end there. "Our job is to remove roadblocks to get renewables and energy efficient technologies more quickly and efficiently into the marketplace," said Kelly.

And being on the ground in unique island locations such as Alcatraz, Hawaii, and Guam, among others, is one way to leverage the laboratory's reach.

—Written by Ernie Tucker

New rules for interconnecting solar power systems to the grid in the U.S. Virgin Islands have led to a significant growth in installed solar power in the territory.
Photo by Don Buchanan, VIEO

In many U.S. cities, solar-powered traffic signs are commonplace, as are homes sporting solar panels.

STARTING SMALL, THINKING BIG

NREL helps communities of all sizes and types—from islands and tribes to rural villages and cities—transition to clean energy.

NREL is fostering a clean energy transition across the United States by providing objective information about policies and best practices to a diverse array of government entities, from islands, tribes, and remote communities to cities and entire states.

Across the United States, there is ample evidence that renewable energy has reached a tipping point and a clean energy transformation is underway. In many U.S. cities, solar-powered traffic signs are commonplace, as are homes sporting solar panels. Cross-country travelers are likely to encounter multiple wind farms along any given highway route.

But in many parts of the world—and even some areas in the United States—significant penetrations of renewable energy remain a rarity. Likewise, it's evident that energy efficiency is beneficial, and a growing number of public and private energy efficiency programs have yielded significant savings, but many homeowners and businesses never bother to obtain an energy audit or invest in energy retrofits.

The difference between the "haves" and "have nots" often lies in the policies and best practices instituted by territorial, state, local, and tribal governments—and, of course, the federal government. NREL analysts have long examined the various approaches taken by these governments, discerning what works and what doesn't when it comes to encouraging people to be energy efficient and adopt renewable energy technologies.

In the interest of streamlining our nation's transition to a clean energy economy, NREL is leveraging its insights and experience to help guide and inform the strategic energy roadmaps of islands and other remote or "islanded" communities, tribes, and cities as a partner or participant in various localized efforts.

Helping Islands Reduce Their Dependency on Expensive, Dirty Fuels

Islands generally present both a need and an opportunity for clean energy transformation. Because of their geographic isolation, relatively small size, and heavy dependence on fossil fuels to meet their energy needs, islands face a number of common challenges. Imported fuel is typically expensive, leading to very high retail electricity rates and transportation costs. As a result, these islanded energy systems are heavily impacted by fluctuations in global oil prices. In addition, the inherent infrastructure challenges of such remote areas mean electricity and fuel are not always reliable or accessible. The combination of sky-high energy costs, price volatility, and energy insecurity has significant economic fallout that affects productivity and quality of life.

Ted Wright of the Stillaguamish Tribe and Shannon Loeve of Turtle Mountain Band of Chippewa review resource maps during a tribal energy workshop in Denver, Colorado. *Photo Amy Glickson, NREL*

DID YOU KNOW?

THE U.S. VIRGIN ISLANDS (USVI) HAS SET A GOAL TO REDUCE ITS FOSSIL FUEL USE 60% BY 2025.

On the other hand, islands tend to have abundant renewable resources, small populations, and the political will to alter their course, making them ideal places to showcase the technical and economic viability of a large-scale transition to renewable energy.

NREL's initial work with islands involved on-the-ground engagements in places like Hawaii, where the majority of electricity is generated from oil and the cost for power is nearly 27 cents per kilowatt-hour (kWh)—more than double the average U.S. mainland cost of nearly 11 cents per kWh.

Hawaii has set increasingly ambitious goals for the amount of renewable energy that will supply the state. NREL started working with Hawaii after the state signed a Memorandum of Understanding with the U.S. Department of Energy (DOE) in 2008 to create the Hawaii Clean Energy Initiative (HCEI), which set a state goal of transitioning from more than 90% reliance on imported oil to 70% clean energy by 2030.

Already on track to achieve its initial goal, the state is raising the bar. In May 2015, the legislature adopted a renewable portfolio standard of 100% by 2045, positioning Hawaii to become the first U.S. state to reach 100% renewable energy and setting a bold example for other states and islands to follow. Since 2008, when Hawaii launched the HCEI, NREL has provided critical expertise that has made the state a pioneer in adopting clean energy technologies.

Another example is the U.S. Virgin Islands (USVI), which has set a goal to reduce its fossil fuel use 60% by 2025. According to NREL's Adam Warren, Ph.D., the lab started working with the USVI nearly six years ago, just after the territory had instituted a net-metering policy, which allows owners of solar power systems to earn credit or payment for excess energy generation that is fed back into the power grid.

Despite this progressive program, the territory had no clear policy for interconnecting distributed generation sources, so it was difficult to actually connect solar power to the grid. NREL, working with Keyes, Fox & Wiedman, examined the best practices for interconnection, and the resulting report informed the USVI's work to codify critical interconnection procedures.

The effort paid off, as the territory went from almost no distributed solar generation to about 15 MW—a significant renewable penetration given a total grid capacity of 110 MW. The territory is also buying power from utility-scale solar facilities totaling about 9 MW. Altogether, the USVI is now

NREL helps communities of all sizes and types—from islands and tribes to rural villages and cities—transition to clean energy. Learn about how Andrea Watson's work helps developing nations meet their COP21 goals.

using 20% less diesel fuel to meet its energy and water needs, putting it at about one-third of its 2025 goal while lowering energy costs for consumers and significantly reducing pollution.

"Islands are leading the way on the use of efficiency but also renewables," said Warren. "In doing so, they're natural laboratories for the policies that promote that adoption and transformation of the energy sector."

The successful island energy transitions NREL has shepherded are providing models for increasing energy efficiency, developing indigenous renewable resources, and achieving high penetrations of renewable energy on islands. To assist other remote and noncontiguous communities throughout the world in leveraging the lessons learned from these pilots, NREL worked with DOE to produce the "Energy Transition Initiative: Islands Playbook", a 120-page guide to achieving clean energy transformation in an island environment.

> "Islands are leading the way on the use of efficiency but also renewables."
>
> — Adam Warren, NREL

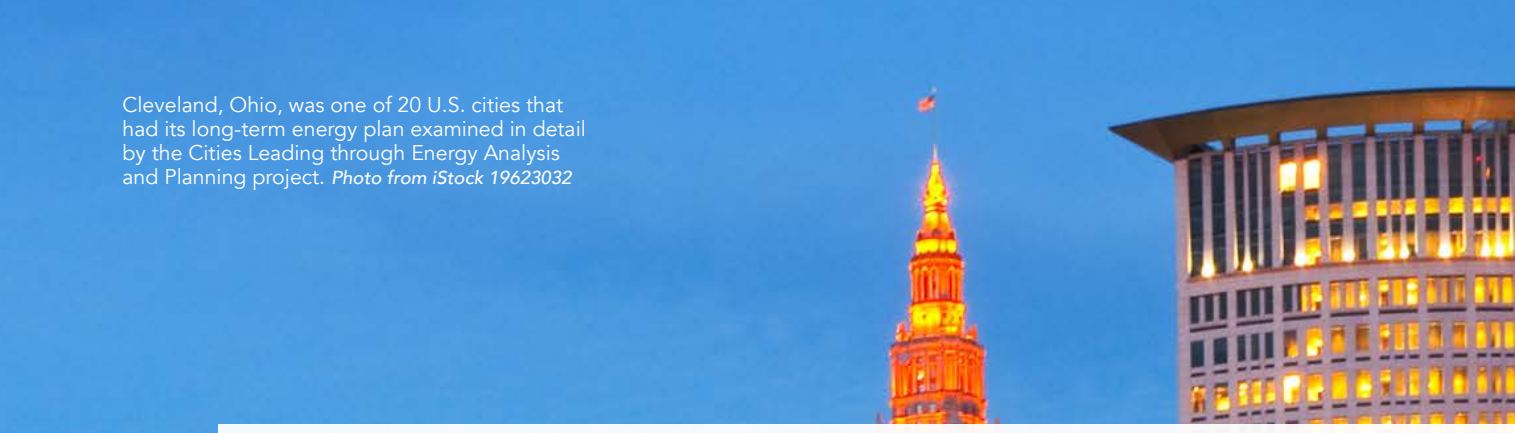
Tribes and Other Remote Communities Look to Their Renewable Resources

Tribes and other remote, noncontiguous communities face challenges similar to islands. In fact, some tribal communities in Alaska are located on islands. But even tribes in the contiguous United States often deal with insufficient and unreliable energy services. On the upside, most tribal lands have ample renewable resources.

The potential for tribal leadership in clean energy is significant: NREL geospatial research shows that while American Indian land comprises only about 2% of the total U.S. land base, it represents an estimated 5% of the total U.S. renewable energy generation potential.

NREL is a key strategic partner for the DOE Office of Indian Energy Policy and Programs' Strategic Technical Assistance Response Team (START) Program, which is designed to build tribal capacity for clean energy projects on tribal land and create replicable models for state, local, and tribal governments. Through START and START Alaska, tribes can apply for and are competitively selected to receive technical assistance from DOE and national laboratory experts to advance renewable energy and energy efficiency projects.

NREL also supports the Office of Indian Energy in providing tribal communities with short-term, on-request technical assistance in clean energy planning and development. For example, NREL facilitated an on-site strategic energy planning workshop for the Saint Regis Mohawk Tribe in New York State. The resulting plan takes advantage of the state's aggressive clean energy goals. NREL provided similar technical assistance to support the California-based Bishop Paiute Tribe in developing a strategic energy plan that takes advantage of the state's incentives for solar power.



Cleveland, Ohio, was one of 20 U.S. cities that had its long-term energy plan examined in detail by the Cities Leading through Energy Analysis and Planning project. *Photo from iStock 19623032*

Helping Cities Leap Into Clean Energy Plans with Cities-LEAP

Cities are another example of jurisdictions in the midst of the clean energy transition.

"Cities are on the front lines of the clean energy transition," said NREL's Elizabeth Doris. "City electricity costs can be a large percentage of city costs, and cities are going to have to start making decisions about how much clean energy they want as they negotiate with their power providers. Digging into NREL technologies, research, and analysis, we get actionable information to city governments to support them in achieving their energy and economic development goals."

One way NREL is starting to prepare for those challenges is the Cities Leading through Energy Analysis and Planning (Cities-LEAP) project, which aims to arm city-level decision makers with data to drive informed energy decisions using a multi-pronged approach. First, analysts looked at what cities are doing now, and the extent to which data can be, and is being, used to inform energy decisions. NREL selected a diverse group of 20 U.S. cities for in-depth analysis and found limited evidence of data-driven decision making or impact evaluations, indicating either that the energy data isn't available or that it doesn't offer a clear value proposition for decision makers. NREL found that most city leaders don't have access to detailed energy data.

Second, to address this need, NREL developed and will soon roll out standardized, localized energy calculations and analyses that will provide cities with estimates of their energy use and costs by sector. This project uses innovative data science methodologies to derive city-specific data for 23,400 cities across the United States.

"The idea is to enable city leaders to make more data-driven energy decisions," said Doris.

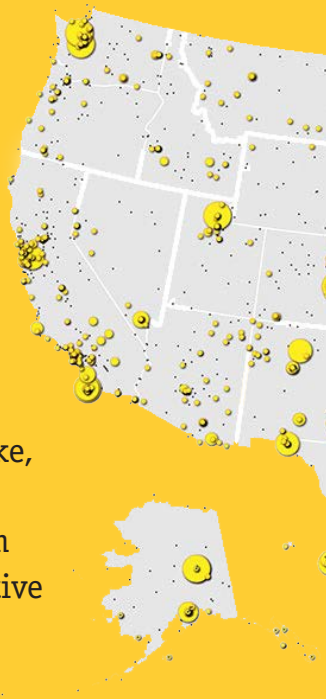
The project builds on the State and Local Energy Data (SLED) tool, a tool developed by NREL for DOE that pulls available energy data sets together to help a wide range of communities make energy-related decisions. By entering any U.S. ZIP code or city name, users can quickly discover average retail electricity rates and trends, fuel sources, and electricity demand by sector—all good starting places in creating a strategic energy plan. But Cities-LEAP goes much farther.

"The idea is to get everyone access to that data, and then the next stage is to say, 'these are the actions that cities are taking; this is how to connect your city-specific calculated data to NREL's in-depth analysis of the energy actions taken by cities,'" said Doris. "With the revisions to SLED that include both the calculated city-level data and the actions collected from the 20 city-level case studies, it's possible to say, 'Oh, you use a lot of electricity in your industrial sector? Other places that use a lot of electricity in their industrial sector have used these actions to optimize that energy use.'"

NREL's cross-organizational work supports cities by providing technology-neutral, actionable energy data and strategies for achieving their energy and economic development goals. These innovative methodologies contribute to a rapidly developing field of urban science by preparing cities with world-class decision support.

—Written by Kevin Eber

NREL HELPS AGENCIES TARGET NEW FEDERAL SUSTAINABILITY GOALS



AGENCIES ARE SEEKING SUPPORT FROM NREL FOR ITS ANALYSIS CAPABILITIES, TECHNICAL AND FINANCIAL MODELING TOOLS, AND EXPERTISE HELPING BRING ENERGY PROJECTS TO FRUITION.

"We help answer questions like, 'Should this agency purchase a renewable electricity system outright or look into alternative financing agreements?'"

— Andy Walker, NREL

With last year's Executive Order (EO) 13693, "Planning for Federal Sustainability in the Next Decade," President Obama issued firm goals for federal agencies to get at least 30% of their electricity from renewable sources, and 25% of federal facility energy from "clean" sources by 2025. Though the current overall percent of electricity from renewable sources used by the federal government is 8.8%, the number on a per-agency basis fluctuates greatly. Much work needs to be done as some agencies did not reach the 7.5% by 2013 statutory renewable energy goal. To define the pathways to meet the EO goals, agencies are seeking support from NREL with its analysis capabilities, technical and financial modeling tools, and expertise helping develop energy projects.

The U.S. Department of Energy's Federal Energy Management Program (FEMP) and the Navy are two good examples.

PLANNING FOR THE THOUSANDS

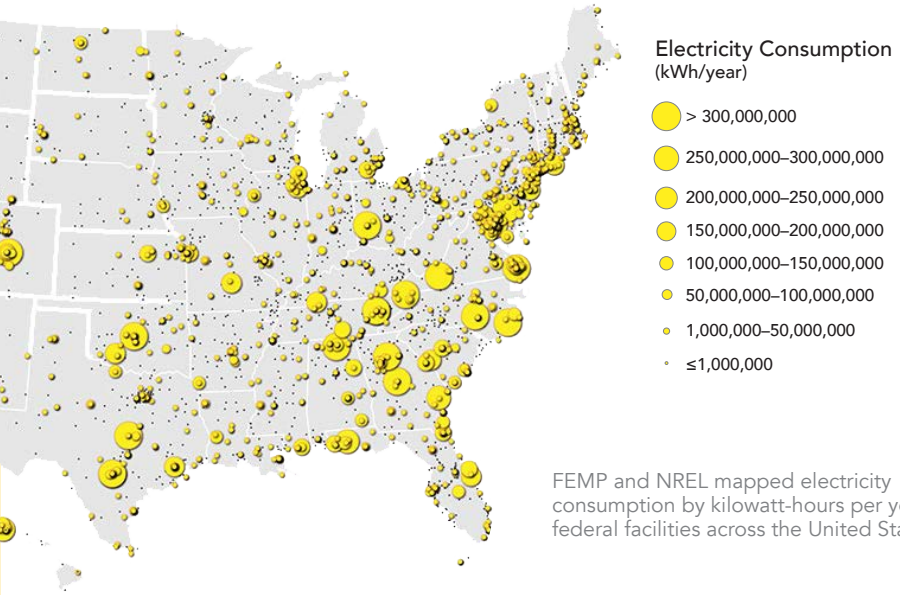
NREL is assisting FEMP with planning that involves more than 7,000 federal facilities across the country. "To meet the 30% electric goal for these buildings, on PV alone—9,500 megawatts—it would take almost all the PV that was sold in the United States in 2015," says Andy Walker, principal engineer. "We're thinking, 'What are the projects that are going to get us to that [EO] goal?'"

Walker and his team have leveraged geospatial data on more than 7,000 federal facilities across the country. After determining which renewable energy project opportunities are cost-effective in each market and identifying drivers (i.e., high utility rates, local incentives, a robust solar industry, etc.), "we help answer questions like, 'Should this agency purchase a renewable electricity system outright or look into alternative financing agreements?'" he explains.

There are many considerations for this kind of analysis, including renewable resources, available space, utility energy costs, incentives, and financing mechanisms, to name a few. With a huge number of prospective projects, the opportunities need to be prioritized. That's where REopt comes in. NREL's REopt energy systems integration and optimization tool can be used to evaluate the combination of technology types and sizes that minimize energy cost and achieve various energy goals. "By taking a methodical planning approach, we can explore options that reduce overall costs of meeting this goal," said Walker. Once the top opportunities are identified, more detailed REopt analysis is conducted to refine technology types, sizes, and operating strategies to maximize economic return and achieve client energy goals, such as renewable energy targets or energy resiliency.

From there, NREL helps agencies take advantage of private-sector financing options like power purchase agreements. One way to make progress on so many potential projects is to consider aggregating procurements. An example is the NREL-assisted Capital Solar Challenge, launched in 2014, which combined 18 buildings in Washington, D.C., into one General Services Administration contract.

The lab's technical assistance service reviews thousands of possible projects, but for select, strategic opportunities, NREL makes site visits, assesses specific site conditions,



FEMP and NREL mapped electricity consumption by kilowatt-hours per year at federal facilities across the United States.

"THIS IS WHAT MAKES US PROUD TO WORK AT NREL—THE QUALITY OF THE ANALYSIS AND THE CLEAR WAY IT WAS COMMUNICATED."

— Jeff Dominick, NREL

evaluates the electric system, prepares a feasibility study, and does design review, among other things. "We get a lot of requests through the technical assistance portal," Walker noted. They're usually from smaller civilian agencies, which may also need more help in planning, but NREL contributes even to the larger defense agencies that have their own planning programs. "They rely on NREL geospatial data and REopt results," he confirmed.

NREL even has advisors embedded in federal agencies. Mike Hillesheim, senior engineer, for instance, is in Norfolk, Virginia, with the Department of Navy's (DON) Renewable Energy Program Office (REPO). Recently, Mike and his team made recommendations for four specific projects at six naval air stations and one auxiliary landing field totaling approximately 450 megawatts. "This is another great testimonial to the REPO team. There is nothing as convincing as objective data and analysis to educate and convince key players about the benefits of renewable energy," said Dennis McGinn, assistant secretary of the Navy – Energy, Installations, & Environment.

The NREL support team addressed a variety of barriers to PV siting near naval airfields. "This was an effort where NREL took the initiative and completed sound analyses that ultimately removed development hurdles for the Navy," said Hillesheim.

And the Navy is serious about meeting renewable energy project development goals. The technical analyses conducted by NREL in support of developing large-scale renewable energy projects on Navy lands helped them to achieve, and even exceed, their 1-gigawatt goal in an unprecedented timeframe (from a Navy directive to finish in less than two years). The Navy started with a long list of hundreds of megawatts of renewable energy projects that were initially screened and then developed with NREL support.

"This is what makes us proud to work at NREL—the quality of the analysis and the clear way it was communicated," said Jeff Dominick, lab program manager for Strategic Partnerships.

The sense of pride comes from the fact that NREL is being sought out for reliable, unbiased technical analysis and project guidance in support of federal agencies as they seek to meet EO targets and energy goals. "The breadth and depth of NREL is unmatched," said Mike Callahan, senior advisor, who is embedded at Pearl Harbor with the DON's REPO. "We have dedicated subject matter experts in such a wide array of energy topic areas that we can help agencies develop and implement comprehensive solutions to their energy challenges, whatever they might be. NREL continues to build on its deep experience, helping all federal agencies more effectively reach our nation's energy goals."

—Written by Kendra Palmer

DID YOU KNOW?

NREL is serious about helping federal agencies meet their renewable energy project development goals. Learn about Dylan Cutler's work to support the Navy become more energy efficient.

Two students assemble their project during the Race to Zero Student Competition at NREL. *Photo by John De La Rosa, NREL*

STUDENT ENGAGEMENTS HELP EDUCATE AND BOOST WORKFORCE DEVELOPMENT

NREL is helping develop the workforce of the future by having students learn about building renewable energy technologies, as well as offering onsite internships.

When Hurricane Sandy crashed into the East Coast in October 2012, it caused an estimated $65 billion in damages. The disaster also inspired students from New Jersey's Stevens Institute of Technology (Stevens) to tackle the problem of climate change directly through their project for the U.S. Department of Energy (DOE) Solar Decathlon 2015.

Over two years, the 40-member team designed a structure that can withstand the effects of global warming along the Jersey Shore such as savage coastal storms. The team's vision paid off when Stevens took first place among 14 collegiate teams in the competition held in Irvine, California. During that period, more than 50 NREL staff members supported the event.

That's part of the laboratory's legacy. NREL has organized all seven Decathlons since the inaugural event in 2002. But it isn't just project management—NREL lets participants develop valuable skills, crafting the 10 events so teams stretch their talents.

"We make the energy efficiency and renewable energy design challenge into a game," said NREL's Sara Farrar, the event production manager, adding that NREL created "an interesting problem that college students are inspired to solve." As decathletes work together to solve real problems, they gain real-world experience.

Yet the story doesn't end there. The benefits of workforce development expand outward over time, something an estimated 20,000 decathletes can attest to. The skills—ranging from fund-raising and communication through construction experience—become building blocks for the next generation of clean energy innovators.

> "WE MAKE THE ENERGY EFFICIENCY AND RENEWABLE ENERGY DESIGN CHALLENGE INTO A GAME."
>
> — Sara Farrar, NREL

NREL Mentors and Competitions Boost Skills

NREL has an array of such educational and developmental engagements. Through DOE's Office of Science's Science Undergraduate Laboratory Internship (SULI) program for undergraduates, NREL encourages rising scientists and engineers each year to excel in science, technology, engineering, and mathematics.

For example, NREL's James Young is part of "four generations" of mentorship at NREL. His own mentor, former SULI intern Todd Deutsch, is now an NREL senior scientist. It was during Young's second SULI stint in 2010 that he bonded with Deutsch. "It was a lot of fun, and really expanded my thinking," Young said. Deutsch remained Young's advisor as he worked to complete his Ph.D. in the Materials Science and Engineering Program at the University of Colorado-Boulder.

"Through the years, hundreds of SULIs have gained valuable research experience at the laboratory, and used that experience to enrich their careers. These investments clearly have had significant workforce development impacts" said Linda Lung, NREL's Workforce Development and Education Programs manager.

In honoring Lung in 2014 with the STEM (science, technology, engineering, and mathematics) Mentorship Award from the Federal Labs Consortium Mid-Continent Region, the awards committee noted that her program "touched an amazing number of individuals." At times, students engage in multiple programs. For example, two past SULI interns, Ben Brannon of Missouri University of Science and Technology and Ben Kurtz of California Institute of Technology, were also decathletes.

The teams, jurors, and speakers from the 2016 Race to Zero Student Competition. *Photo by John De La Rosa, NREL*

Keeping Pace with New Opportunities

As new educational opportunities have developed, the laboratory has expanded its role. In 2013, NREL issued a request for proposals seeking participants in DOE's inaugural National Collegiate Wind Competition—challenging teams to design and construct a wind-driven power system, develop a business plan to market their product, and demonstrate their knowledge of current and emerging issues facing the wind industry. The following year, NREL set the stage—literally—for the competition in Las Vegas, Nevada. Ten teams' small wind turbines went blade-to-blade in an NREL-constructed wind tunnel.

"The Collegiate Wind Competition inspires our nation's students to design, build, and test a real-world wind turbine prototype," said NREL's Suzanne Tegen, manager of NREL's Wind and Water Deployment Group. The competition is not a beauty pageant; education is the focus.

The second wind competition, held in May 2016, included a key component to ensure team diversity of backgrounds and educational training for team members. "This event brings students and professors from business, engineering, marketing, and the sciences together with the U.S. wind industry and DOE," Tegen said. In addition to a chance to compete with other universities, students have the opportunity to meet with leaders in the wind industry. NREL also developed the wind energy career map that is now available on DOE's website, and the laboratory continues to partner with DOE to bring K-12, community college, and university students together around the topic of wind energy in the national program Wind for Schools.

With all of NREL's experience in workforce development, it is only natural that in April 2015, lab staff welcomed students and faculty from 33 college team in the United States, Canada, and China for DOE's Race to Zero Student Design Competition—repeating the event this year. The weekend gatherings give teams a chance to present their research and designs for the future of energy efficiency building. One competitor, Humboldt University's Julian Quick, used his Race to Zero experience to successfully apply as a 2015 summer SULI intern; he returns again in 2016. Planning is underway for next year's competition.

"What most impressed me about the Race to Zero is the students," said NREL's Stacey Rothgeb, event project manager and residential buildings manager. She praised "the general level of enthusiasm and engagement" in the students.

And as students move on from such experiences as Solar Decathlons, wind competitions, SULI internships, and other offerings, their paths have been illuminated by opportunities NREL supports. The laboratory has helped them strive to reach their goals in the clean energy workforce—and in turn, prepare them to help others on their journeys.

—Written by Ernie Tucker

CLEAN ENERGY SOLUTIONS CENTER:

ASSISTING COUNTRIES WITH CLEAN ENERGY POLICY

NREL HELPS DEVELOPING COUNTRIES COMBAT BARRIERS TO PAVE THE WAY FOR POLICIES AND PROGRAMS THAT ADVANCE CLEAN ENERGY TECHNOLOGY DEPLOYMENT.

Many countries are looking to grow their renewable energy and energy efficiency portfolios to meet environmental, economic, business, and energy security goals. In addition to reducing greenhouse gas emissions and adapting to climate change impacts, developing countries are looking for clean energy solutions that will also help with the societal development of remote and underserved populations. While priorities differ from one country to another, energy policy can have a significant impact on a variety of national objectives.

Most often, the biggest barriers to achieving a clear, renewable energy policy that supports clean energy scale-up in the developing world are knowledge, capacity, and cost. The Clean Energy Solutions Center (Solutions Center), an initiative of the Clean Energy Ministerial and operated by NREL, helps countries around the world create policies and programs that advance the deployment of clean energy technologies.

POLICY RESOURCES AND ANALYSIS SERVICES

As part of its commitment to providing clean energy policy resources to policymakers in developing countries, the Solutions Center offers a no-cost "Ask an Expert" service. A team of more than 50 international experts has supported more than 250 requests for policy advice from more than 90 countries, island nations, and regional organizations worldwide. From Nepal to the Governments of Chad and Grenada, the team is helping scale-up renewable energy and energy efficiency, analyzing standards and regulations, reviewing legislation, and providing advice on financing instruments.

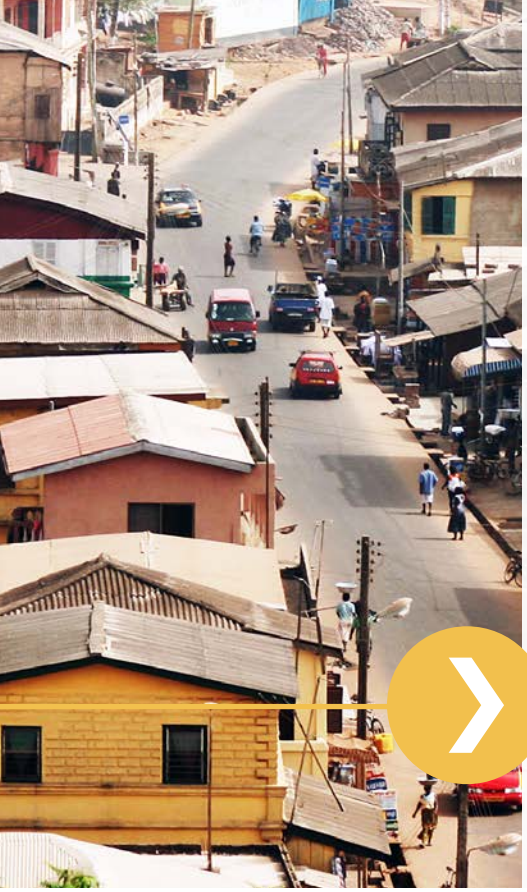
In a recent keynote to the Climate and Clean Energy Investment Forum, U.S. Secretary of Energy Ernest Moniz touted the benefits of the Solutions Center's no-cost technical assistance and remote training to developing countries on instruments for mobilizing investment. He also mentioned the new Clean Energy Finance Solutions Center, which will serve as a central resource for information on clean energy finance instruments, highlighting partner organizations and initiatives that are focused on catalyzing larger and lower-cost capital flows to accelerate clean energy deployment.

At the seventh Clean Energy Ministerial (CEM7) on June 1 in San Francisco, Moniz debuted the Solutions Center/NREL Clean Energy Design Studio video that highlighted assistance provided to partner countries, and also offered a glimpse into the future of clean energy decision science: the NREL Clean Energy Design Studio.

In addition, the Solutions Center recently published "Policies to Spur Energy Access", a report produced jointly with NREL and the International Institute for Environment and Development that reveals policy options for developing countries to engage the private sector in creating market solutions to energy access.

ESTABLISHING FEED-IN TARIFFS IN GHANA

In the early stages of designing and developing their feed-in tariff (FIT) policy, the Ghana Energy Commission turned to the Solutions Center. FITs are designed to increase deployment of renewable energy technologies by offering long-term purchase agreements for electricity generation at a specified price per kilowatt-hour, thereby providing market certainty for developers. When Ghana requested assistance from the Solutions Center, experts helped them identify best practices for FIT policy design and resources. The Solutions Center also engaged in consultations with the Ghana Energy Commission to provide additional guidance and support for the FIT



THANKS TO NREL'S LEADERSHIP AND SUPPORT FROM THE U.S., AUSTRALIAN, AND SWEDISH GOVERNMENTS, THE SOLUTIONS CENTER IS:

- Advancing renewable energy and energy efficiency programs in Namibia
- Supporting clean energy policy in the Caribbean community
- Informing energy access and clean energy project finance programs in Chile
- Structuring energy efficiency and biofuel policies in Guyana
- Advising efficiency programs in Mexico
- Strengthening Nicaragua's renewable energy framework
- Creating waste-to-energy programs in St. Kitts
- Establishing geothermal development and policy in the Caribbean
- Establishing feed-in-tariffs in Ghana
- Informing Kisumu Country, Kenya, on energy access and health correlations
- Supporting solar hot water schemes in Mauritius
- Creating commercial building efficiency regulation in South Africa
- Developing renewable energy and energy efficiency action plans for West African countries
- And much, much more.

Solutions Center assistance will help develop policies to support renewable energy deployment in Ghana. Photo from iStock 7000749

policy. This early support facilitated both effectiveness and speed of policy development. Once complete, implementation of the FIT policy will encourage scaled-up deployment of renewable energy into the Ghana energy mix.

INFORMING ENERGY ACCESS AND CLEAN ENERGY PROJECT FINANCE PROGRAMS IN CHILE

When the Chilean Renewable Energy Centre (CER) wanted to develop energy access programs focused on renewable energy projects, they turned to the Solutions Center. Solutions Center policy experts provided vital information on policies that increase the success of renewable energy projects while promoting full competition, viability of publically backed guarantees to manage commercial risk for renewable energy projects in an unregulated environment, and best practices on engaging venture capitalists to finance renewable energy research and development projects.

The Solutions Center provided CER with guidance and information needed to develop clean energy access programs and projects in remote and isolated communities within Chile. Additionally, support from the Solutions Center helped CER develop fundamental understanding and knowledge of how to design policies that enable financing and encourage investment in clean energy projects. These programs and policies have the potential to significantly increase deployment of renewable energy technologies in Chile.

ALL PLACES, ALL PEOPLE

Beyond assisting countries and their governments, the Solutions Center has turned its attention toward groups of people. NREL staff and Solutions Center policy experts conducted an analysis, "The Situation Analysis of Energy and Gender Issues in ECOWAS (Economic Community of West African States) Member States", which provides a comprehensive look into traits of the ECOWAS, such as energy poverty, development implications, and gender programs. The analysis was designed to inform the development of a new ECOWAS policy and design an implementation plan, and it worked. The ECOWAS recently adopted the Policy for Gender Mainstreaming in Energy Access, which is based on the analysis. This innovative policy supports women in energy and also helps bring clean energy access to remote populations across West Africa. This is a prime example of how energy policy can have a significant impact on a variety of national objectives. "It is important that women throughout the world can realize their potential and have confidence in their abilities to eliminate energy poverty and drive sustainable development in their communities," said Bobi Garrett, NREL's Deputy Laboratory Director.

—Written by Connie Komomua

RESILIENCY: PLANNING AHEAD FOR DISASTERS

NREL IS TAKING A PROACTIVE APPROACH TO LESSEN THE IMPACTS OF CLIMATE CHANGE AS DISASTERS OCCUR MORE FREQUENTLY AND WITH GREATER INTENSITY.

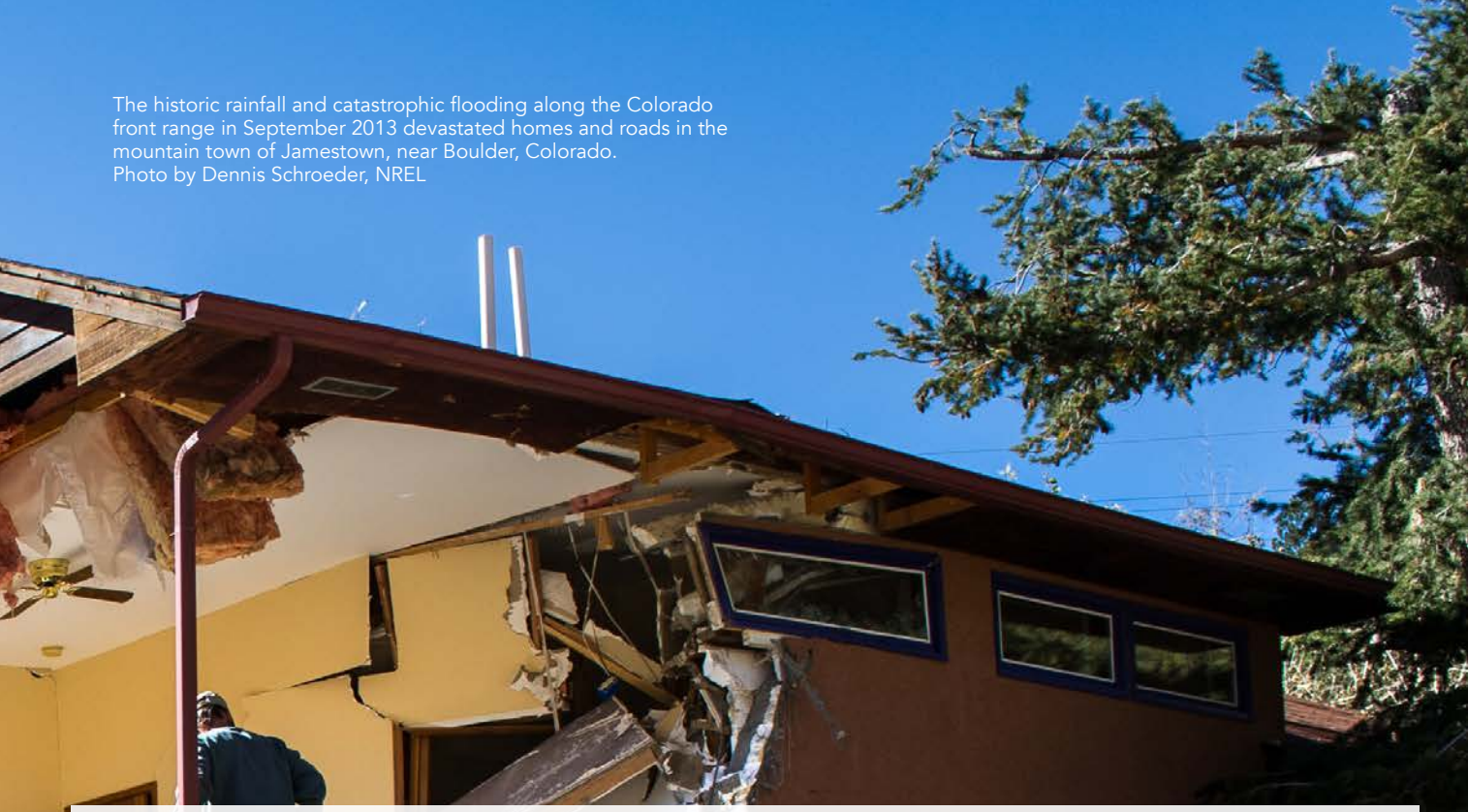
For the last 15 years, NREL has provided expertise, tools, and innovations to private industry; federal, state, and local governments; nonprofit organizations; and communities during the planning, recovery, and rebuilding stages after disaster strikes. Now, NREL is taking a proactive approach to lessen the impacts of climate change as disasters occur more frequently and with greater intensity.

When Superstorm Sandy struck New Jersey in October 2012, the state was one of the top five in the United States in terms of number of solar photovoltaic (PV) installations. However, most of New Jersey's solar PV systems were not operational during and after the storm as operating standards require grid-connected solar PV systems automatically disconnect from the grid during a power outage to protect utility workers and grid integrity on restart.

Similar to other recent natural disasters, the aftermath of Sandy illustrated that renewable energy alone does not equal resiliency. Renewable energy systems provide clean, sustainable energy; however, to increase the resiliency of the electricity system, they must be designed with other technologies such as energy storage, controls, and auxiliary generation. "We suggest taking sustainability measures one step further to ensure systems are resilient," said Eliza Hotchkiss, disaster recovery and resilience lead at NREL. "And by resilient, we mean, not only able to rapidly recover from a disaster, but also to adapt to and prepare for changing climate conditions and strengthen resistance to disruptive events. NREL's resilience activities incorporate clean energy solutions, which is a piece that is missing from a lot of other planning efforts."

As part of fieldwork conducted during the Sandy rebuilding effort, NREL provided the U.S. Department of Energy (DOE) and Federal Emergency Management Agency (FEMA) with opportunities for more resilient distributed generation systems. The opportunities NREL identified included systems that can contribute renewable energy to the grid supply during normal operation, as well as operate independently during a grid disruption or outage. Some of NREL's recommendations were included in President Obama's Climate Action Plan.

In addition to creating new rules to reduce greenhouse gas emissions, the President's Climate Action Plan established the State, Local, and Tribal Leaders Task Force on Climate Preparedness and Resilience (Task Force), charged with providing recommendations on how the federal government can respond to the needs of communities dealing with the impacts of climate change.



The historic rainfall and catastrophic flooding along the Colorado front range in September 2013 devastated homes and roads in the mountain town of Jamestown, near Boulder, Colorado.
Photo by Dennis Schroeder, NREL

WHITE HOUSE CLIMATE CHANGE PREPAREDNESS PILOTS FOCUS ON RESILIENCY

One of the actions identified by the Task Force was to build more resilient communities. In July 2014, the White House Council on Environmental Quality (CEQ) announced two preparedness pilot projects designed to showcase community resiliency efforts in the City of Houston and the State of Colorado.

The City of Houston's Climate Change Preparedness pilot, led by the National Aeronautics and Space Administration (NASA), focuses on how to mitigate the effects of severe weather and rising sea levels on NASA's mission and coastal properties, and on the community of Houston.

The State of Colorado's Climate Change Preparedness pilot, led by NREL on behalf of DOE, focuses on the effects of severe inland weather on a state-wide scale. Through Colorado's CEQ pilot, NREL works closely with the Colorado Governor's Resiliency and Recovery Office to bring together stakeholders from federal and local governments to identify shared vulnerabilities and interdependencies related to climate change. The efforts are being documented in a roadmap to identify areas of replicability that other states, communities, tribes, and agencies can utilize.

A ROADMAP FOR RESILIENCE

Solutions that address multiple hazards are more resilient and more replicable for other communities. For example, when installing a PV system, Hotchkiss suggests installing dynamic inverters and islanding controls to ensure continuity of power during a grid outage. If designed properly, a renewable energy microgrid may be equally effective during a flood that washes out part of the grid or during a wildfire that cuts off a transmission line. If passive survivability measures are applied in conjunction with a microgrid to allow residents to stay safely at home or shelter in place without grid power, the stress to emergency systems and responders is reduced.

In 2016, NREL will consolidate lessons learned from the Colorado pilot project and deliver a replicable resiliency roadmap to DOE and CEQ. The goal is to outline the process for identifying stakeholders, analyzing climate change vulnerabilities and system interdependencies, establishing long-term goals for resiliency, and providing location-specific and actionable strategies that support continuity of energy and water service. NREL plans to test its resiliency roadmap development with the U.S. General Services Administration (GSA) and U.S. Environmental Protection Agency to help federal agencies in the Rocky Mountain region (GSA Region 8) meet Executive Order 13693 climate-resilient building design requirements. Visit NREL's Disaster Resiliency and Recovery Web page for additional information.

—Written by Heidi Blakley

BECOMING RESILIENT

NREL's resiliency program offers a broad range of services, including whole-community energy planning, on-site technical assistance, energy-efficient design and rebuilding strategies, and clear information for decision makers. NREL's comprehensive energy solutions address the full spectrum of disaster planning and recovery.

BOULDER, COLORADO

In September 2013, parts of Colorado recorded historic rainfall, exceeding 1,000% of normal precipitation for that time of year. Flood conditions stretched 150 miles along the Front Range as water and debris flooded basements, disrupted power, and collapsed roads, isolating some mountain towns. To aid in the region's future resiliency efforts, NREL will provide technical assistance to the City of Boulder through a DOE grant as the city creates safe havens that focus on critical infrastructure. The city aims to ensure that vulnerable populations can shelter in place, the water treatment plant can maintain operations, and the hospital can continue to serve with clean water and power in the event of another natural disaster.

NREL technical experts provided on-the-ground assistance in New York and New Jersey during recovery efforts to educate communities

GALENA, ALASKA

In May 2013, the Yukon River overflowed its banks with water and ice, severely impacting the remote Alaskan community of Galena. To help the community recover more effectively and prepare for future floods, FEMA funded NREL to identify energy-efficient rebuilding solutions, including measures to increase the efficiency and resiliency of the power plant. NREL also worked with tribal, community, state, and federal stakeholders to explore options to increase building energy capacity and resiliency.

NEW YORK AND NEW JERSEY

In October 2012, Hurricane Sandy left nearly 5 million people without electricity, and caused fires and extensive property damage. With funding from FEMA, teams of NREL technical experts provided on-the-ground assistance in New York and New Jersey during recovery efforts to educate communities about rebuilding more energy efficiently, incorporating appropriate renewable energy technologies, diversifying transportation solutions, and implementing sustainability measures.

GREENSBURG, KANSAS

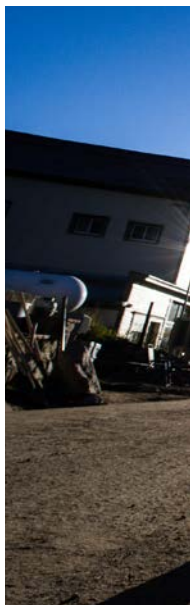
After a devastating EF-5 tornado destroyed or damaged 95% of the town of Greensburg in 2007, local and state leaders decided to rebuild as a model green community. Funded by DOE, NREL provided technical expertise to city and community leaders, local businesses, homeowners, and builders, and conducted analyses and energy modeling to demonstrate and implement successful, cost-saving energy solutions.

NEW ORLEANS, LOUISIANA

Hurricane Katrina and Hurricane Rita struck the Gulf Coast in 2005. In 2007, DOE funded NREL to help New Orleans incorporate energy efficiency into its rebuilding efforts for K-12 schools and homes, and provided technical support and analyses to improve energy policy efforts.

INTERNATIONAL SUPPORT

NREL also provides technical assistance to support international communities, such as such as American Samoa and Haiti, with incorporating clean energy into disaster preparedness and recovery efforts.



DISASTER PLANNING AND RECOVERY TECHNICAL ASSISTANCE

Reliable Third-Party Expertise in Energy Efficiency and Renewable Energy

PREPAREDNESS AND PLANNING

NREL advises on how to:

- Improve resistance and resiliency (microgrids, building efficiency, island capabilities, etc.).
- Plan for secure, sustainable, and safe communities.
- Establish policies and codes that support sustainability, security, and safety.

RECOVERY AND REBUILDING

NREL identifies opportunities to:

- Deploy on-site technology demonstrations (e.g., emergency backup power).
- Incorporate energy efficiency, sustainability, and renewable energy measures into disaster recovery efforts.
- Design sustainable, resilient buildings.

NREL is taking a proactive approach to help lessen the impacts of climate change on communities like Jamestown, Colorado. As part of the State of Colorado's Climate Change Preparedness pilot, NREL will deliver a resiliency roadmap that outlines the process for analyzing climate change vulnerabilities, among many other things. Photo by Dennis Schroeder, NREL

Continuum

CLEAN ENERGY INNOVATION AT NREL

Continuum is NREL's publication that showcases the laboratory's latest and most impactful clean energy innovations and the researchers and unique facilities that make it all happen.

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NATIONAL RENEWABLE ENERGY LABORATORY

As the only U.S. national laboratory singularly focused on advancing renewable energy and energy efficiency, NREL's mission spans the spectrum of clean energy solutions—including pioneering research in solar, wind, biomass, hydrogen, and geothermal energy. With 37 years of successful innovation from fundamental research and analysis through commercializing and deploying energy efficiency and renewable energy solutions, NREL continues to pave the way toward clean energy transformation.

National Renewable Energy Laboratory

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A CLOSER LOOK

Increasing impact through the next generation of clean energy decision science. Visit www.nrel.gov/continuum/market-impact/multimedia.html