NREL
NATIONAL RENEWABLE ENERGY LABORATORY

Sustainable NREL

BIENNIAL REPORT | FY 2012–2013

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.

ACKNOWLEDGMENTS

Going beyond performance goals, objectives, and strategies, the Sustainable NREL Annual Report, Fiscal Year 2012–2013 reflects the human side of sustainability. Without human vision, ingenuity, and simply caring—the facilities that make up NREL's campus would be merely utilitarian, a place to report to work. Instead, NREL's "living laboratory" culture embodies the value of employee participation to create the most sustainable environment possible.

I'd like to acknowledge NREL staff for engaging in initiatives that minimize our carbon footprint and reduce waste and pollution. And I would especially like to acknowledge those who collaborated on producing this document—telling the Sustainable NREL story.

Thanks to the many managers and staff members who provided technical content, data collection, and communication support, including: the Sustainable NREL staff; Communications; Environmental, Health, Safety, and Quality; Site Operations; Human Resources; Finance Public Affairs; General Counsel; and Internal Audit.

Special thanks to Michelle Slovensky, who vigilantly led the project and who is the primary author; Communications staff: Grace Griego, who provided editorial leadership, and designer Joelynn Schroeder.

Their efforts have heightened NREL's level of socially and environmentally responsible reporting.

Frank Rukavina, Sustainability Director,
Chief Sustainability Officer

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Kevin Donovan, Data Center Manager (on the cover), is one of the many sustainability champions at NREL. In addition to integrating sustainable choices in his work he drives an electric vehicle and collaborates with NREL researchers to conduct energy efficient experiments on the equipment in his net-zero energy home.

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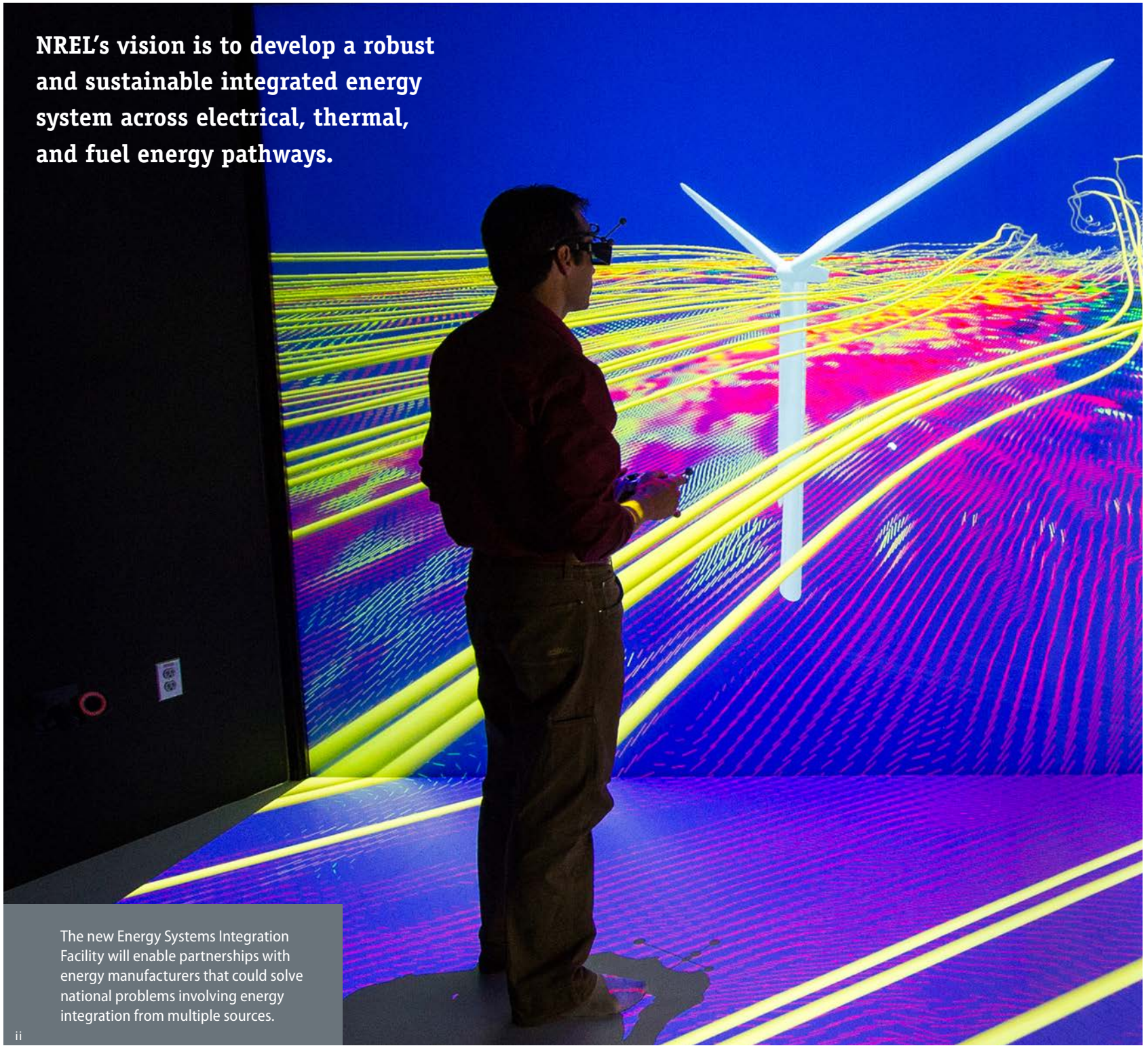
NREL's vision is to develop a robust and sustainable integrated energy system across electrical, thermal, and fuel energy pathways.



The new Energy Systems Integration Facility will enable partnerships with energy manufacturers that could solve national problems involving energy integration from multiple sources.

"Sustainability at NREL is driven in large part by our desire to reduce our environmental footprint—particularly carbon emissions, or greenhouse gases responsible for global climate change."

Message from the NREL Director

Sustainability at NREL is driven in large part by our desire to reduce our environmental footprint—particularly carbon emissions, or greenhouse gases responsible for global climate change. While global climate change is a widely recognized issue, scientists internationally are still grappling with meaningful solutions.

At the utility-scale level, much can be done—update the country's aging infrastructure, reduce the need for fossil fuels such as coal, integrate clean energy technologies into the grid, improve efficiencies. These are incremental steps within a conventional natural gas and electrical delivery system.

But the most powerful solution may reside in more unconventional delivery systems such as distributed (local) generation. This could unleash a lot of innovation that looks much like the IT industry today—giving consumers more control over their energy consumption—using less of it and more wisely. For example, what if all home appliances had an IP address? This would allow consumers to control home energy remotely via their smart phones. In addition, attention to consumer behavior could also influence how energy systems are designed and built—improving efficiencies at the local level.

Changing the thinking from incremental changes in a conventional environment (such as setting rates for the next year) to rethinking the whole process and end point (such as less energy and more output) calls for a paradigm shift.

That's where NREL researchers come in—promoting understanding with credible information—sharing the way with highly sophisticated scientific tools and discoveries to unlock a wave of innovation.

—Dan E. Arvizu, NREL Director

NREL marked its 35th anniversary with a celebration—providing tours of the RSF—a showcase for clean-energy technology and sustainability.

SUSTAINABLE NREL BRIDGES RESEARCH AND OPERATIONS

NREL's Sustainability Program plays a vital role in bridging research and operations—integrating energy efficiency, water and material resource conservation, and cultural change—adding depth in the fulfillment of NREL's mission.

Implementation

NREL implements and optimizes sustainability through:

- **Energy Master Plan.** NREL goes beyond mission requirements by deploying on-site renewable systems, constructing high performance buildings, conducting energy and water audits, and working toward Scope 2 carbon neutrality and near-zero waste. Sustainable NREL works within the context of both mandated and self-imposed goals and continuously explores and implements opportunities to achieve them.
- **Campus Energy Dashboard.** NREL's energy tracker helps manage and minimize energy consumption—facilitating building performance assessment across the campus.
- **Water Conservation.** Sustainable NREL collaborates with Environment, Health, and Safety (EHS) to reduce potable water consumption using an integrated water resource management plan. This protects and enhances on-site water resource and improves water quality through the use of surface stormwater flows to irrigate vegetation, pervious pavers for infiltration, construction of wet meadows for pollutant biodigestion, and monitoring the efficient operation of irrigation use with the Weather Trak system.

Culture and Behavioral Change

Operating as a "living laboratory," NREL promotes cultural and behavioral change among building occupants in order to maximize energy efficiency, reduce the carbon footprint, and minimize waste. In addition to fostering awareness, engagement and understanding of sustainable accountability, the laboratory also assesses occupant participation in the real life context of new and existing facilities. Using cultural information as data, NREL is able to modify facilities and infrastructure for continuous improvement.

- **Building Agent.** The feedback from deploying the Building Agent (software that continuously surveys building occupants' comfort) informs operations personnel of the successes and challenges in the interface between building occupants and equipment and their environs to enhance employee wellbeing and productivity.
- **Share the Road.** Campus infrastructure including bike lanes, bike lockers, preferred parking, and shuttles promotes walking, biking and alternative commuting. An education and outreach campaign followed by an informal survey reinforce the importance of sharing the road safely.
- **Waste Audits and Green Cleaning.** Through building waste audits, Sustainable NREL monitors the understanding of campus recycling and composting programs and identifies opportunities to improve education and awareness in our pursuit of a near-zero waste campus. Sustainable NREL also developed and monitors NREL's green (janitorial) cleaning program to uphold the highest environmental standards.

Leadership

NREL is recognized for its successful demonstration of federally mandated and site performance goals.

- **Net Zero Energy and Low Carbon Campus.** Net-zero energy and Scope 2 carbon neutrality are NREL's long term goal for its living laboratory campus. Sustainable NREL is a change agent that assists in materializing this vision. Achieving these significant milestones demonstrates to our clients and community a greater emphasis on operational, financial and environmental accountability.
- **Work for Others.** DOE and other federal agencies have recognized Sustainable NREL's significant achievements in its sustainability performance and implementation processes. This success has led to the group's capacity to receive revenue sources to further develop program initiatives for deployment for multiple agencies in the federal portfolio.
- **Awards and Recognition.** From science and technology to sustainability and leadership, NREL has garnered more than 100 awards, honors, and appointments in recent years—demonstrating the laboratory's wide range of pioneering capabilities.
- **Climate Change.** Clean, renewable energy remains a critical part of an energy strategy that reduces harmful greenhouse gas emissions, diversifies our energy economy, and brings innovative technologies on line. NREL is working to help the nation double the renewable electricity generation from energy resources like wind power by 2020.

Outreach and Education

NREL's efforts help internal and external stakeholders understand the benefits of sustainability and what needs to be done to achieve results. Each year, NREL is recognized for its tactical strengths and successes—including:

- **Training on Sustainable Modules.** NREL has delivered tools via training webinars in support of FEMP's Sustainability education—enhancing knowledge and empowerment in the work environment.
- **No Idling Program.** This program helped reduce vehicle idling by approximately 1,700 gallons/year and $6,400/year in diesel fuels use for NREL shuttles.
- **Sustainable Acquisition.** NREL makes it convenient for employees to buy green products that are energy efficient, contain recycled and/or biobased content, nonozone depleting and nontoxic.

PROMOTING SUSTAINABILITY BEYOND THE CAMPUS: LEADING BY EXAMPLE

NREL's state-of-the-art "laboratory of the future" is a model for sustainability—incorporating clean-energy technologies that are a direct result of the lab's innovative research, development, and commercialization efforts.

Far from keeping this model secret, NREL shares information with others through NREL-hosted training sessions, building tours, and interagency partnerships. "We apply what we learn to our facilities, and then we monitor, analyze, and validate the information—not only from a building level, but a campus level as well," said Sustainable NREL Director Frank Rukavina.

NREL's Sustainability Program plays a major role in bridging NREL research and operations—integrating energy, water, and material resource conservation and efficiency in short- and long-term planning.

Over the last few years, Sustainable NREL has been ramping up its efforts to promote sustainability beyond the campus—to DOE labs, federal agencies, local agencies, and the community. Those efforts have been rewarded with a number of prestigious awards from the White House and the U.S. Department of Energy (DOE).

"NREL is taking lessons learned and sharing them through publications like the Biennial Sustainability Report and community projects like the Graham House and the NREL Parking Garage Workshop."

Graham House Energy Efficiency Makeover Begins with Energy Audit

In 1997, Jean Graham donated her home to the City of Lakewood, to be used as community meeting center. Although the 1948-era house is an ideal gathering place with expansive views of the Rocky Mountains, it's in desperate need of an energy-efficiency makeover.

To identify the most pressing energy problems, Sustainable NREL staff partnered with Lakewood's Red Rocks Community College on energy audits earlier this spring. Although the city is still looking for funding for recommended improvements, the students at Red Rocks Community College have already benefited from the joint project.

"We hope the Graham House will be a model project with energy-efficient systems that will help educate visitors on ways to save energy," said Lakewood Director of Community Resources Kit Botkins.

From left: NREL's Jesse Dean, Wally Piccone from the City of Lakewood, and NREL's Frank Rukavina assess the utility room at the City of Lakewood's Graham House. NREL is coordinating a joint effort to audit the Graham House and make suggestions for sustainable and energy-efficient modifications.

More than Just a Parking Garage

NREL's parking structure may look like your average parking garage, but "everything that we do at NREL has multiple purposes," Rukavina said. "For instance, the parking garage is also used as another laboratory for grid integration, electric vehicles, and sustainable building design."

While it may not be glamorous, a parking garage typically uses 15% of the energy used by the building that it is designed to support. Making NREL's garage an attractive structure that's both affordable and high performing presented a unique combination of challenges. In the end, the design team came up with a structure that is expected to perform 90% better than a standard garage built just to code.

In March, NREL and DOE hosted the NREL Parking Garage Workshop to communicate NREL's building process and help others understand opportunities for replication while raising the energy performance of parking structures. Attendees included representatives from the Regional Transportation District and Colorado Department of Transportation, local businesses, government agencies, and universities. Some of these organizations are planning to build parking structures in the near future.

Linda Kogan, sustainability director for the University of Colorado, Colorado Springs, said, "the workshop was incredibly valuable with very specific strategies that we are already pursuing to reduce energy consumption, including planning for electric vehicle charging stations. We will follow up on recommendations specific to energy-efficient parking garages such as occupancy and daylighting sensors, daylighting design, LED lights, and photovoltaic panels."

NREL Deputy Directors Kenneth Powers, Laboratory Operations; Bobi Garrett, Strategic Programs and Partnerships; and Dana Christensen, Science and Technology, are executive sustainability champions fostering staff participation to attain measureable gains in sustainable initiatives.

Standard Disclosures

NREL ORGANIZATIONAL PROFILE

Alliance for Sustainable Energy, LLC (Alliance), equally owned by Battelle and MRIGlobal, is the management and operating contractor for NREL. The Alliance is fully accountable to DOE for NREL's performance over a five-year contract period that began in October 1, 2008 and may be extended for up to five additional years.

The Alliance's role is to build on the strong foundation that NREL has built over the last 35 years and ensure the laboratory's strategy to advance innovation across the clean energy portfolio and push the frontiers on related science. This is accomplished through:

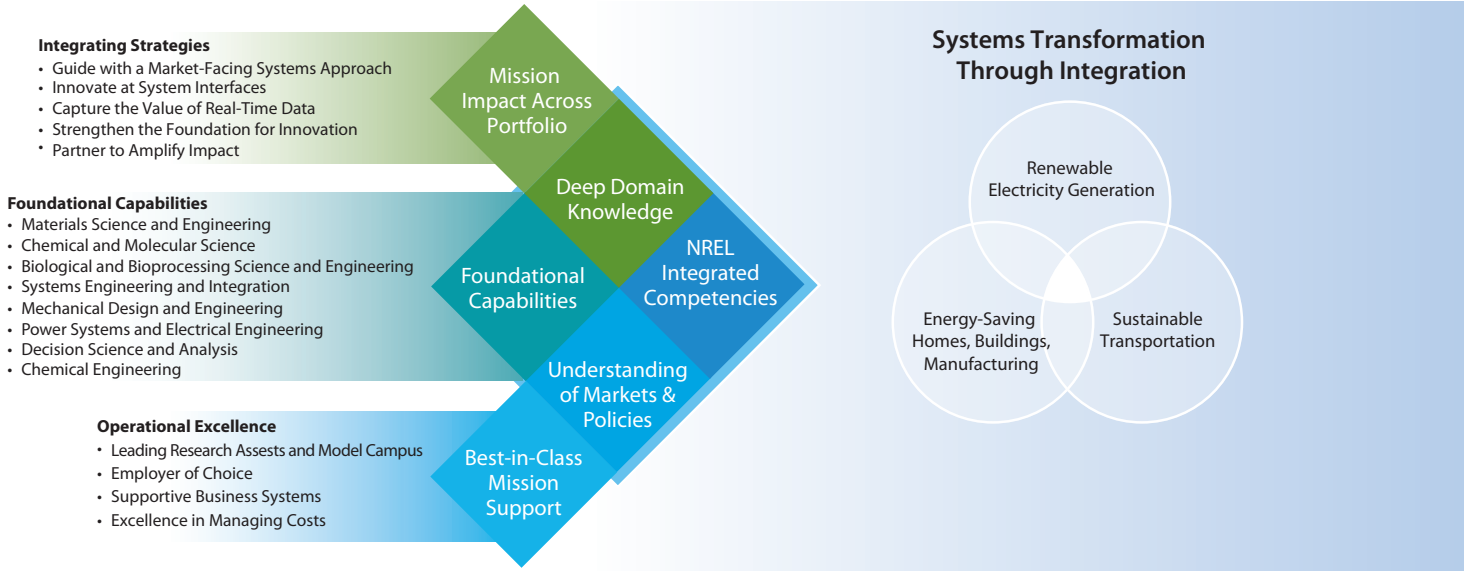
- R&D initiatives that extend the impact of the laboratory beyond its baseline program roles for DOE's Office of Energy Efficiency and Renewable Energy (EERE)
- Foundational capabilities that underpin NREL's research, deployment, and analysis.

R&D Initiatives

The laboratory's leading R&D initiatives focus on breakthrough advances in key technology areas—solar, wind, biofuels, and vehicles—and integrated energy systems research and development, which includes:

- SunShot and Beyond—achieving cost and performance targets and accelerate basic science discoveries.
- Wind at Half the Cost—cutting the cost of land-based and offshore wind power in half.
- Electrification of Transportation—speeding the development of advanced batteries into electric-drive vehicles.
- Infrastructure-Compatible Biofuels—developing hydrocarbon replacements for petroleum-derived gasoline, diesel, jet, and maritime fuels from indigenous, biomass resources.
- Energy Systems Integration at all Scales—doubling overall energy system efficiency and enabling high levels of renewable energy to operate synergistically with other clean energy resources in systems of all scales.

Together, these initiatives will drive improvements in the performance and cost of key technologies to be market-competitive without subsidies.



NREL's strategy is to deliver knowledge and innovations to U.S. industry that support a profound transformation of today's energy systems. We envision a future energy system that is carbon neutral, highly efficient, affordable, reliable, and supportive of high-value domestic jobs.

They'll also enable their effective integration and operation within the nation's energy infrastructure.

Foundational Capabilities

Underlying NREL's ability to produce mission outcomes are eight foundational capabilities which support the programs within the EERE portfolio:

- Materials Science and Engineering
- Chemical and Molecular Science
- Biological and Bioprocessing Science and Engineering
- Chemical Engineering
- Mechanical Design and Engineering
- Power Systems and Electrical Engineering
- Systems Engineering and Integration
- Decision Science and Analysis.

NREL's distinctive competencies combine foundational capabilities and scientific expertise; deep domain knowledge of the behavior of clean energy resources, technologies, and systems; and an understanding of energy markets and policies. It is the combination of these capabilities with the knowledge resulting from more than three decades of experience that sets the laboratory apart and makes it a valued partner for industry and government. These integrated competencies enable advancement of knowledge and delivery of information and innovations to meet market-relevant performance and cost targets.

Directorates Demonstrate Lab's Leadership in Sustainability

In FY 2012 and 2013, NREL had three directorates that included Strategic Programs and Partnerships, Science and Technology and Laboratory Operations. Together with associated offices and programs, these directorates help accelerate the advancement of renewable energy and energy efficiency technologies.

Strategic Programs and Partnerships

NREL's commercialization and deployment activities aim to accelerate new technology commercialization and remove barriers to market adoption of existing clean energy solutions. To this end, NREL has streamlined the way we do business and enhanced the entrepreneurial environment, providing greater access to capital and engaging strategically with industry and stakeholders.

Partnerships are at the core of NREL's strategy. We collaborate with industry; academia; non-profit organizations; federal agencies; state, local, and tribal governments; and international institutions to commercialize and deploy renewable energy and energy efficiency technologies. The laboratory engages with the private sector through a variety of research contracting mechanisms, as well as through licensing new technologies. Overall, federal investment in these partnerships has leveraged private funds by a factor of eight. NREL links entrepreneurs with investors, helps small businesses and supports the emerging clean energy business sector through its enterprise development program and annual Industry Growth Forum.

NREL advances integrated, sustainable energy solutions to meet local and regional energy needs by looking at the entire renewable and energy efficiency portfolio, tailoring cost-

NREL's STM site consists of approximately 999,796 gross square feet (GSF) of existing facilities on 327 acres of land. Of these acres, DOE has granted a 175-acre conservation easement on its STM site to Jefferson County, which provides hiking trails and permanent conservation status for the land. The remaining 152 acres are utilized for development of campus infrastructure and high performance building facilities for laboratories, offices, and supporting mission functions.

effective solutions based on locally available resources. NREL's deployment program supports DOE's strategy to accelerate market adoption of alternative energy solutions. Our comprehensive approach helps transform the way we use energy in local communities by identifying opportunities, building partnerships, and creating a foundation for technology implementation. We offer technical assistance, with staff helping communities assess renewable options and providing training to help build a skilled workforce.

Science and Technology

The laboratory's science and technology teams work in the full range of research and development (R&D), from basic science to applied research, engineering to testing and scale-up to demonstration. NREL is developing nanoscale materials to convert the sun's energy into electricity, improving understanding of wind aerodynamics, and diving into the cellular structure of plants to make cost-competitive renewable biofuels. NREL also boasts strong R&D efforts in materials for renewable buildings, transportation, electric infrastructure systems, and hydrogen, ocean, and geothermal energy.

Laboratory Operations

Intrinsic to all levels of laboratory operations is a culture of safety, security, and quality. This translates to action via sustainable environmental management, integrating clean-energy technologies in new buildings, and supporting workforce growth and development.

As a world class research institution NREL commits to:

- Optimizing and managing natural resources to help sustain the environment
- Reducing our environmental footprint by constructing and monitoring the performance of our green buildings and providing alternative working and commuting programs for staff
- Supporting the community by stimulating the local economy, managing NREL's environmental impacts, and creating educational programs.

Summary

NREL focuses its integrated strengths on creative answers to today's energy challenges. From concept to the commercial marketplace, our discoveries are transforming the way the world uses energy.

REPORT PARAMETERS

Determining Materiality

NREL's sustainability effort has evolved from basic paper recycling in the early 1980s to a comprehensive sustainability program that was formalized a decade ago.

The level of annual sustainability reporting has also progressed. From FY 2010 to FY 2013, NREL has utilized the GRI Sustainability Guidelines to highlight activities, progress, and accomplishments.

Critical to evaluating annual progress is the establishment and benchmarking of goals and objectives. Our mission remains the same as our internal activities respond to emerging circumstances:

- Implementing DOE EERE directives
- Continuing as a leading innovator in the clean-energy research technology market while anticipating the dynamic changes occurring in the external geography of regional, national, and global politics, and environmental, social, and economic conditions.

Our chosen materiality assessment sections, per the GRI reporting format, represent key performance areas critical to achieving NREL's mission. A continuous stakeholder process is conducted to examine and identify achievements, challenges, and methods to enhance data collection vital to these sections. Stakeholders include our DOE client and various NREL staff members representing science and technology research, commercialization and deployment, and laboratory operations.

NREL prioritized and selected six materiality assessment sections.

1. GHG Emission reduction
2. Clean-energy technologies
3. Energy management
4. Water management
5. Environment and pollution prevention
6. Stakeholder Initiatives.

Six specialized subgroups were formed to identify performance indicators and determine action steps to collect data unique to each section. Planning actions were also derived from these beneficial group discussions for future performance indicators that would require more intensive tracking and monitoring activities.

The NWTC site is located approximately 20 miles north of the STM site, and has approximately 72,919 GSF of existing facilities on 280 acres of land.

Additionally, several NREL communication specialists were asked to create feature articles to highlight significant achievements.

Report Scope and Boundaries

NREL's facilities are primarily located on two sites: South Table Mountain (STM) in Golden, CO, and the National Wind Technology Center (NWTC) in Louisville, CO. Facilities on these two sites are owned by DOE. NREL also leases office space in the Denver West Office Park, a Refuel Facility in Denver, as well as an office in Washington, D.C.

NREL's STM site consists of approximately 999,796 gross square feet (GSF) of existing facilities on 327 acres of land. Of these acres, DOE has granted a 175-acre conservation easement on its STM site to Jefferson County, which provides hiking trails and permanent conservation status for the land. The remaining 152 acres are utilized for development of campus infrastructure and high performance building facilities for laboratories, offices, and supporting mission functions.

As a DOE national laboratory, NREL works to meet environmental and energy-related regulatory requirements as defined by the EPACT of 2005; EO 13423 and EO 13514; and the EISA of 2007. These laws and regulations establish federal requirements spanning energy efficiency, greenhouse gas, high performance buildings, renewable energy, water conservation, pollution prevention, sustainable acquisition, electronic stewardship and vehicle fleet.

Data Collection and Metrics

NREL's sustainability metrics are built upon a wealth of data that fully encompasses our campus operations. A large component of our reporting is focused on energy, specifically building-level energy consumption and on-site renewable energy production. NREL tracks energy information starting with building-level electricity and natural gas meters, which tie into a DOE energy dashboard system allowing access to up-to-date energy information.

On-site renewable energy production from the Renewable Fuel Heating Plant, photovoltaic arrays, and wind turbines is also tracked in this dashboard system. Other on-site renewables are captured in tracking matrices that Sustainable NREL uses to manage capacity, production, LEED allocation, and Renewable Energy Certificate (REC) retention. NREL regularly reports these energy data to DOE headquarters in federal reporting tools and annually benchmarks our energy performance to look for improvement opportunities

In addition to energy data and water usage, Sustainable NREL tracks the performance of Scopes 1, 2, and 3 GHG emissions sources. Scope 1 sources include NREL's: vehicle fleet, refrigerants, fugitive gases, process, and on-site combustion. NREL's Scope 2 sources are entirely comprised of electricity purchases and on-site renewables. Information is tracked for Scope 3 emissions sources, which include commuting, business ground and air travel, waste disposal, wastewater treatment, and transmission and distribution losses. These data originate from a variety of sources, including utility meters, databases, travel, and expense reporting records. GHG data are compiled for each fiscal year and entered into the Consolidated Energy Data Report (CEDR) to calculate emissions—allowing for annual tracking of progress towards our reduction goals.

PERFORMANCE SNAPSHOT | Summary of Goals for Material Assessments Key Performance Status: ✚ Exceeds Target ✱ On Target ▲ Behind Target

GREENHOUSE GAS MANAGEMENT	Objective and Target	Baseline	FY 2012	Status	FY 2013	Status
GHG EMISSIONS	Reduce GHG Scope 1 and Scope 2 emissions by 28% by FY20 from a FY08 baseline.	FY08: 26,201 $MTCO_2e$	23,754 $MTCO_2e$, a 9% decrease from 2008 baseline, RECs are purchased for Scope 2 neutrality achieving an 84% reduction.	✱	23,621 $MTCO_2e$, a 10% decrease from 2008 baseline, RECs are purchased for Scope 2 neutrality achieving an 31% reduction.	✱
GHG EMISSIONS	Reduce GHG Scope 3 emissions by 13% by FY20 from a FY08 baseline.	FY08: 6,375 $MTCO_2e$	7,259 $MTCO_2e$, a 14% increase from 2008 baseline.	▲	7,047 $MTCO_2e$, an 11% increase from 2008 baseline.	▲
CLEAN TECHNOLOGY	Objective and Target	Baseline	FY 2012	Status	FY 2013	Status
SCIENTIFIC AND TECHNICAL INNOVATION	Conduct outstanding basic and applied research and accelerate discoveries toward market-variable applications.		Created a petascale high performance computing capability; enhanced the early-stage research; demonstrated a stable quantum dot solar cell; constructed a recombinant organism that can sense hydrogen produced by green algae; collaborative work in developing a catalyst for ethanol production.	✱	Developed and characterized a heat exchanger based on passive boiling of refrigerants; released first version of battery design software to the battery R&D community; single-molecule imaging techniques combined with electrochemical measurements show how fast hyrogenases convert electrochemical energy into hydrogen.	✱
COMMERCIALIZATION AND DEPLOYMENT	Accelerate the commercialization of clean energy technologies; remove barriers to enable their deployment at scale.		SunShot and Beyond; Energy Systems Integration at All Scales; Electrification of Transportation, and Infrastructure Compatible Biofuels. Alliance has brought a privately funded technology transfer (PFTT) program to NREL. The PFTT portfolio includes 28 inventions at various stages of commercialization.	✱	Department of Defense remains a strategic partner, with new opportunities emerging, Agreement to Commercialize Technology (ACT) program has been launched. Online tool deployed for high-quality residential energy upgrade (FEMP). Released high-impact reports: techno-economic critical barrier analysis for fuel pathways; wind production tax credit (PTC) assessment; natural gas/ renewables study by Joint Institute for Strategic Energy Analysis; transportation energy futures report.	✱
ENERGY MANAGEMENT	Objective and Target	Baseline	FY 2012	Status	FY 2013	Status
ENERGY	Reduce energy intensity by 30% by FY15 from a FY03 baseline.	FY03: 257,887 Btu/GSF	Energy intensity decreased 29% since 2003, 182,726 Btu/GSF.	✱	Energy intensity decreased 50% since 2003, 127,444 Btu/GSF.	✱
ENERGY	Reduce campus annual electricity consumption by 7.5% by FY10 utilizing renewable sources.		18.8% of NREL's power came from on-site generation.	✚	30% of NREL's power came from on-site generation.	✚
ENERGY	Install advanced metering for electricity (by October 2012), steam and natural gas (by October 2016), and standard meters for water.	FY09: 74 meters	92 electric meters; 6 thermal meters; 9 natural gas meters.	✚	Replaced 13 NWTC electric submeters to increase data quality and added 27 new meters at ESIF	✚
ENERGY	EISA section 432 energy and water evaluations.		NREL conducted EISA evaluations for 50% of total site energy use.	✱	NREL conducted EISA evaluations for 7% of total site energy use.	✱

PERFORMANCE SNAPSHOT | Summary of Goals for Material Assessments Key Performance Status: ✚ Exceeds Target ✱ On Target ▲ Behind Target

WATER MANAGEMENT	Objective and Target	Baseline	FY 2012	Status	FY 2013	Status
WATER	Reduce water intensity by 26% by FY20 from a FY07 baseline.	FY07: 28.61 gallons/ft^2	Reduced water intensity by 30% from a 2007 baseline, 21.1 gallons/ft^2	✱	Reduced water intensity by 16% from a 2007 baseline, 22.9 gallons/ft^2 but measured 12.5% above the reduction target	▲
WATER	EISA section 432 energy and water evaluations.		Performed energy and water audits on three buildings; SERF, S&TF, and FTLB.	✱	Performed energy and water audits on four buildings: OTF, TTF, IBRF (east), S&R.	✱
ENVIRONMENT AND POLLUTION PREVENTION	**Objective and Target**	**Baseline**	**FY 2012**	**Status**	**FY 2013**	**Status**
ENVIRONMENT, HEALTH, AND SAFETY	Demonstrate excellence in quality, environmental protection, and safety, by attaining ISO 9001, 14001, OHSAS 18001 registration for the integrated management system.		NREL EHS Management Systems attained ISO 9001 (Quality), ISO 14001 (Environment), and OHSAS 18001 (Safety) certification. Sustainable NREL attained ISO 9001 (Quality) certification. Continued conformance with these international standards is verified annually through third party audits.	✱	NREL EHS Management Systems attained ISO 9001 (Quality), ISO 14001 (Environment), and OHSAS 18001 (Safety) certification. Sustainable NREL attained ISO 9001 (Quality) certification. Continued conformance with these international standards is verified annually through third party audits. Performed a gap analysis for ISO 50,001 certification.	✱
ENVIRONMENTAL MANAGEMENT	Participate in the Sustainable "SITES" Initiative program.		NREL prepared and submitted all required documentation for certification review.	✱	Received three star certification.	✚
ENVIRONMENTAL MANAGEMENT	Develop a site-wide landscape maintenance program.		NREL developed a joint site-wide landscape maintenance program among Sustainable NREL, EHS and SITE Operations Group.	✱	NREL put into practice the site-wide landscape maintenance program.	✱
ENVIRONMENTAL MANAGEMENT	Develop a site-wide monitoring program.		NREL developed a joint site-wide monitoring program among Sustainable NREL, EHS and SITE Operations Group.	✱	NREL is monitoring three projects: water quality, revegetation, and wildlife.	✱
ENVIRONMENTAL MANAGEMENT	Incorporate bird-friendly glass into building designs		Incorporated into the parking garage, Café, RSF and ESIF are many architectural features and materials that have the benefit of reducing risk collisions. CollidEscape was installed on campus bus shelters.	✱	CollidEscape was installed on the bus shelter in front of ESIF.	✱
POLLUTION PREVENTION	Divert from landfills at least 50% of non-hazardous solid waste, excluding construction and demolition debris, by the end of FY15.		NREL recycled 951,583 lbs; composted 700,878 lbs; disposed of 439,880 lbs of sanitary solid waste; and diverted 81% of campus waste from landfill.	✱	NREL recycled 1,109,026 lbs; composted 560,904 lbs; disposed of 509,360 lbs of sanitary solid waste; and diverted 77% of campus waste from landfill.	✱
POLLUTION PREVENTION	Divert from landfills at least 50% of construction and demolition materials and debris by the end of FY15.	FY08: Recycled 299,090 lbs	Diverted 88% of construction waste from landfill.	✱	Diverted 90% of construction waste from landfill.	✱
SUSTAINABLE ACQUISITIONS	Meet procurement requirements by including necessary provisions and clauses (sustainable procurements/ biobased procurements).		NREL met new P-Card sustainable purchasing requirements. NREL enhanced green office-supply subcontract requirements.	✱	100% of construction contracts met sustainable acquisition requirements; 100% of custodial contracts meet sustainable acquisition requirements.	✱

PERFORMANCE SNAPSHOT | Summary of Goals for Material Assessments Key Performance Status: ✚ Exceeds Target ✱ On Target ▲ Behind Target

STAKEHOLDER INITIATIVES	Objective and Target	Baseline	FY 2012	Status	FY 2013	Status
INTEGRATED PROJECT TEAMS	Use a collaborative, integrated planning and design process that initiates and maintains an integrated project team in all stages of a project's planning and delivery.		All construction projects and sustainable initiative projects have cross-functional Integrated Project Teams (IPT), based on specific project scope and size. These members represent the diverse user community, project stakeholders, and include subject matter expertise and knowledge in project management, budget, finance, sustainable buildings design, and procurement.	✱	All construction projects and sustainable initiative projects have cross-functional Integrated Project Teams (IPT), based on specific project scope and size. These members represent the diverse user community, project stakeholders, and include subject matter expertise and knowledge in project management, budget, finance, sustainable buildings design, and procurement.	✱
PARTNERING TO AMPLIFY IMPACT	Host and sponsor educational and partnering activities to share knowledge and promote the adoption of energy efficiency and renewable energy technologies.		NREL's Energy Systems Integration Facility (ESIF) is the nation's first facility to help both public and private sector researchers focus on utility-scale clean energy grid integration. NREL technical expert advisors participated in the development of net zero energy for nine Department of Defense navy and army bases, renewable energy integration in the country's energy plan for the U.S. Virgin Islands, and the use of renewable energy to stimulate the economy for the country of Indonesia and Millennium Challenge Corporation.	✱	NREL's ESIF is designated a user facility by DOE. As the first industry partner to use ESIF, Advanced Energy Industries is testing its new solar photovoltaic (PV) inverter technology with the facility's utility scale grid simulators and hardware-in-the-loop systems.	✱
BEHAVIOR CHANGE	Cultivate an employee culture focused on reduction of electricity use, process and fugitive emissions, waste, sustainable acquisition, commuting and business travel.		Sustainable NREL, RSF building Area Engineer, and the Commercial Buildings Group continued to develop the Building Agent platform, an interactive comfort survey, with building occupants of RSF to investigate and assess building environmental conditions and employee workstations.	✱	Surveys were conducted for RSF II and IBRF. Plug load management profiles are being generated by SERF users and assessed to create a new plug load management settings policy that will be deployed campus wide.	✱

Greenhouse Gas Emissions Reduction

Multi-Year Goals:

NREL's long-term vision is to achieve carbon neutrality—i.e., balancing greenhouse gas (GHG) emissions with carbon reductions. Recognizing that carbon neutrality will require ongoing planning and implementation of reduction measures and/or the purchase of renewable energy credits (RECs), the laboratory's interim goal is to meet or exceed these DOE agency-wide GHG reduction targets:

- Reduce Scope 1 and 2 GHG emissions by 28% by FY 2020 from a FY 2008 baseline.
- Reduce Scope 3 GHG emissions by 13% by FY 2020 from a FY 2008 baseline.

NREL staff help reduce greenhouse gas emissions by bicycling to work, taking public transportation and participating in carpools and vanpools. NREL incentives include free Eco Passes for rapid transit, vouchers for official vanpools, incentive parking for high occupancy and low-emission vehicles and amenities such as conveniently located bicycle racks, lockers, and bicycle repair stations.

Greenhouse Gas Emissions Reduction

Strategic Intent

NREL is working to establish a carbon-neutral campus that makes efficient use of limited resources, reduces waste, and demonstrates fiscal responsibility. NREL's strategy for accomplishing carbon neutrality and reducing impacts on local and global environments includes establishing interim GHG goals based on a GHG baseline, DOE's sustainability commitments, and NREL's mission. Through the laboratory's GHG leadership, NREL hopes to catalyze the development of new technologies, maximize the use of renewable energy sources, and educate others on the feasibility of operating in a carbon-neutral paradigm.

STRATEGY AND PERFORMANCE SUMMARY

NREL has been tracking and reporting GHG emissions for more than 10 years. NREL demonstrates leadership in GHG management by maximizing the use of energy efficiency practices and on-site renewable power, reducing the use of petroleum fuels, and minimizing impacts associated with all aspects of the laboratory's operations. NREL continuously pursues new technologies and strategies to reduce operations-related GHGs.

PERFORMANCE STATUS

Scope 1 GHG Emissions

Scope 1 GHG emissions include stationary, mobile, fugitive, and process. The overall Scope 1 emissions from FY 2012 were 4,279 $MTCO_2e$, a 27% decrease from the FY 2008 baseline. In FY 2013, Scope 1 emissions were 4,059 $MTCO_2e$, a 31% decrease from the FY 2008 baseline.

NREL will continue to optimize performance of the Renewable Fuel Heat Plant (RFHP) to reduce natural gas requirements for the campus. NREL will also work to reduce emissions from the vehicle fleet through implementation of a no-idling policy, working to acquire more Alternative Fuel Vehicles (AFVs) as mission appropriate, and annually evaluating fleet reduction opportunities in light of changing mission requirements.

Stationary Emissions

More than 90% of NREL's Scope 1 emissions are from stationary combustion. These emissions are primarily due to the use of natural gas for the generation of heat and hot water for NREL's DOE-owned and leased buildings. NREL's on-site RFHP decreased the need for natural gas purchases in FY 2012 and FY 2013. In FY 2012, overall emissions increased 20% from FY 2011, but are almost 2% below the 2008 baseline. The increase is due to three main factors:

1. Higher ventilation rates in the laboratory spaces, requires more heating in those spaces.
2. The new wing of the Research Support Facility (RSF II) became occupied, increasing the overall heating demand (these two factors increase the heating demand by 29,000 therms).
3. Temporary heating in the new Energy Systems Integration Facility (ESIF) increased heating demand by 150,000 therms.

In FY 2013, the operation of NREL's on-site RFHP improved greatly, decreasing the need for natural gas. Stationary emissions have decreased 6% from FY 2012 and are 7% below the 2008 baseline. The RFHP received recognition by the Biomass Thermal Energy Council in July 2013

Mobile Emissions

NREL's mobile emissions represent just over 3% of NREL's Scope 1 sources. In FY 2012, emissions from the vehicle fleet decreased 37% from the previous year; however, mobile emissions have increased 65% relative to the 2008 baseline. In FY 2013, emissions from the vehicle fleet increased 9% from the previous year and mobile emissions have increased 89% relative to the 2008 baseline due to increased vehicle utilization. While NREL is working to acquire more AFVs, the lab has increased the number of petroleum hybrid vehicles in the past year, increasing emissions from this source. Also, due to substantial campus growth, utilization of fleet vehicles by staff has increased. An increase in equipment and non-highway vehicle usage also took place in FY 2013 due to improved reporting procedures as well as greater demands for a growing campus.

Fugitive Emissions

NREL's fugitive emissions make up less than 1% of NREL's Scope 1 source and include fluorinated gases, refrigerants, and emissions associated with NREL's on-site septic systems at the National Wind Technology Center and the Solar Radiation Research Laboratory.

NREL tracks its refrigerant and fluorinated gas emissions, the purchases of which are monitored in NREL's chemical inventory, using a three-year rolling average. In FY 2012, fluorinated gas and refrigerant emissions decreased 95% from the baseline year and decreased 2% more in FY 2013.

Success Story

NREL REDUCED GHG EMISSIONS

Switching Tracer Gas to Nitrous Oxide for Fume Hood Commissioning

After an FY 2011 assessment and further investigation in FY 2012, it was determined that nitrous oxide (N_2O), which produces far fewer GHG emissions than SF_6, could be used to perform fume hood commissioning. NREL modified its contract with its fume hood testing contractor to require that N_2O be used as the tracer gas for all ASHRAE 110 tests. Fume hood commissioning is conducted to verify that new or relocated fume hoods meet state requirements. A test meeting the requirements of the ASHRAE 110 standard must be conducted before fume hoods are commissioned. NREL typically conducts five to ten ASHRAE 110 fume hood tests annually.

SF_6 is the most potent of the six commonly accepted GHGs, with a global warming potential 23,900 times that of carbon dioxide (CO_2) when compared over a 100-year period. SF_6 is also extremely long-lived, is inert in the troposphere and stratosphere, and has an estimated atmospheric lifetime of 800 to 3,200 years. N_2O has been proven as a successful alternative tracer gas for testing fume hoods to the ASHRAE 110 standard. With a global warming potential of 310, N_2O produces far fewer GHG emissions than SF_6. NREL achieved a reduction of roughly 337,580 pounds of equivalent CO_2 emissions annually by switching to N_2O, a tracer gas used for fume hood commissioning, from SF_6, which is now specifically banned from NREL campuses for this purpose.

Commuting is partly responsible for Scope 3 emissions. The Denver Regional Transportation District's light rail will make alternative commuting more convenient to staff.

There were no purchases of sulfur hexafluoride (SF_6) in FY 2012 or 2013, but NREL did, in FY 2012, purchase 120 pounds of R-22 refrigerant. On-site wastewater emissions decreased 31% from FY 2011, which is 27% above the baseline year. On-site wastewater emissions decreased 18% from FY 2012 which is 2% of the baseline year.

Process Emissions

A small quantity of dry ice was reported for both fiscal years to comply with recent Safety and Investment Protection reporting guidance. These emissions represent less than 1% of NREL's Scope 1 emissions.

Scope 2 GHG Emissions

NREL's Scope 2 emissions are associated with purchased electricity for DOE-owned and leased buildings. In FY 2012, 19,475 $MTCO_2e$ and FY 2013, 19,562 $MTCO_2e$ were generated from NREL's electricity purchases. This is a 4% decrease from the FY 2008 baseline. This trend is attributed to the revised Emissions and Generation Resource Integrated Database (eGRID) emissions factors used in the 2012 calculation. It should be noted, however, that due to the construction and operation of high-efficiency buildings, NREL's electricity consumption has not increased during this timeframe, even though the campus footprint has increased over 145% since 2008. Additionally, NREL purchased Green-e certified RECs to offset all Scope 2 emissions, making NREL Scope 2 carbon neutral again in FY 2012 and FY 2013.

While NREL maximizes the amount of electricity generated on-site, many of these systems were financed through power purchase agreements that required the RECs to be sold. When financially practical, NREL retains the RECs for on-site renewable systems. NREL purchases replacement RECs for these systems and has committed to purchase additional RECs to ensure the campus achieves Scope 2 carbon neutrality. In FY 2012, NREL finalized the contract and procured RECs from the new Gamesa on-site wind system.

In FY 2012, growth continued at NREL with the construction of RSF II, the Cafeteria, parking garage, the South Entrance Building, and a 5 MW dynamometer facility. In FY 2013, the ESIF

construction was completed. With each campus addition, NREL upholds the highest standards for energy efficiency and deployment of on-site renewable energy. Due to the construction of these on-site facilities, NREL will vacate three leased spaces and move staff to DOE-owned facilities; however, this growth will increase campus electricity use. To combat this increase, NREL will look for opportunities to improve energy efficiency of existing buildings through Energy Independent Security Act (EISA) audits, deploy additional on-site renewable energy, and also purchase RECs to ensure all Scope 2 emissions are offset. As a long term goal NREL will work to decrease REC purchases as additional on-site renewable energy installations are constructed on campus.

Scope 1 and 2 Summary

The adjacent graphs track NREL's overall performance toward meeting Scope 1 and 2 GHG reduction targets. NREL is significantly exceeding DOE's 28% target for Scope 1 and 2 GHG emissions. In FY 2013, NREL decreased total Scope 1 and 2 emissions over 10% from the 2008 baseline.

Simultaneously, NREL makes additional efforts to reduce GHG emissions through the purchase of RECs, further reducing Scope 1 and 2 emissions to a combined 31% from the 2008 baseline.

Scope 3 GHG Emissions

Scope 3 emissions are attributable to: commuting, air travel, transmission and distribution losses, solid waste, ground travel, and wastewater treatment. In FY 2012, NREL's Scope 3 emissions were 7,259 $MTCO_2e$—representing a 2% increase from FY 2011. In FY 2013, NREL's Scope 3 emissions were 7,047 $MTCO_2e$—representing a 3% decrease from FY 2012.

Transmission and Distribution Losses

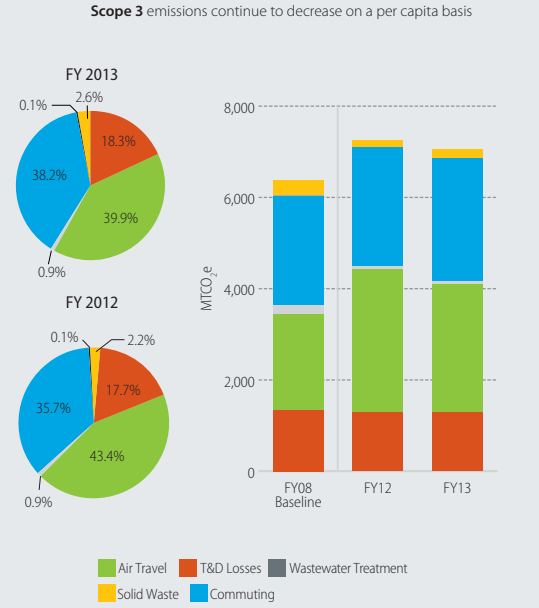
NREL's transmission and distribution (T&D) losses decreased 5% in FY 2012 and 4% in FY 2013 from the baseline due to purchasing less electricity and revised eGRID emissions factors. NREL uses the standard T&D factor for 6.8% to estimate these system losses. These emissions represent 18% of NREL's Scope 3 sources in FY 2013. NREL's deployment of on-site renewable energy and highly energy-efficient buildings helps to mitigate emissions from this source.

T&D losses, however, represent a challenging category for NREL. While RECs can be used to offset Scope 2 emissions, they cannot offset T&D losses. With the ESIF High Performance Computer coming online in FY 2013, NREL anticipates emissions from this source to increase.

Business Air Travel

NREL's business air travel emissions were 51% higher in FY 2012, and 34% higher in FY 2013 than 2008 baseline levels. These trends are reflective of a slight recovery from travel restrictions in FY 2011 and FY 2012 and an 87% population growth since 2008. The data also reflect a more accurate accounting of air miles. In previous years, air miles have been calculated based on the distances between origin and destination cities. The new mileage is calculated based on the distance of each leg of a flight. This has the effect of changing the distribution of total miles into short, medium, and long haul flights.

Air travel is NREL's largest Scope 3 source, representing over 40% of this category. NREL has extensive teleconferencing and video conferencing systems in place, and is installing video conferencing systems in new office buildings to continue to address this emissions source. NREL has also implemented travel restrictions to operate the lab as efficiently as possible in this economic time, which will also help to curb these emissions.



Success Story

BEST WORKPLACE FOR COMMUTERS

This year, the National Center for Transportation designated NREL as the "Best Work Place for Commuters." This is an elite designation from the Center for Urban Transportation Research at the University of South Florida and is provided to qualified employers for meeting a national standard of excellence in offering outstanding commuter benefits, such as free or low-cost bus passes, vanpool vouchers, and strong telework programs.

Air travel poses a challenge for NREL given the dramatic population growth experienced since 2008. A certain degree of travel is necessary to support NREL's mission. To mitigate these impacts, NREL will continue enhanced campus-wide video conferencing programs to reduce travel by providing additional outreach and education to staff and increasing video conferencing capabilities. Additionally, NREL will continue to look for other opportunities to reduce air travel beyond what is required for mission-critical activities.

Business Ground Travel

In FY 2012 and FY 2013, business ground travel increased slightly—but emissions remain 69% lower than the FY 2008 baseline. This drastic reduction is due to improved data availability for cars rented on business travel. This improved level of detail provides better accuracy for NREL's reporting on business ground travel emissions. This category represents less than 1% of NREL's Scope 3 emissions. To manage emissions from this source, NREL works to educate staff on available alternatives to ground travel including teleconferencing and video conferencing. NREL's rental car policy also allows the use of mid-size AFVs or hybrids when available. For FY 2013, 90% of the cars rented on business trips were in the compact category, 5% were full size, and 4% were midsize. The remaining 1% includes full-size vehicles, minivans, and sport utility vehicles. NREL will also investigate opportunities for improved ground travel data collection methods that could potentially identify areas for further ground travel reductions.

Employee Commuting

Employee commuting represents 36% in FY 2012 and 38% in FY 2013 of NREL's Scope 3 emissions. This year, commuting emissions corresponds to a 12% increase over FY 2008's baseline. FY 2013 showed a 3.5% increase in round-trip commuter miles for NREL staff. This information was applied to NREL's FY 2011 commuter survey distribution that provided improved data on staff commuting modes as well as adoption of telecommuting and alternative work schedules (AWS).

NREL offers multiple commuting programs to its employees in order to reduce the lab's Scope 3 commuting emissions. Those programs include:

- Free public transit passes
- A rideshare website to find carpools and vanpools
- Vanpool vouchers
- Bicycle-friendly infrastructure (bicycle parking, maintenance and repair stations, and showers)
- Free shuttles to move employees between NREL facilities and to connect to public transit route
- Flexible work practices such as: Telecommuting, compressed work weeks or AWS.

For many years, NREL has offered incentive parking to staff who participate in carpools or vanpools. With the completion of the new parking garage, NREL has added new incentive parking for low emitting vehicles. This "green vehicle" program, as defined by the U.S. Environmental Protection Agency's Smart Way certification program, applies to other buildings on campus as well.

NREL will continue to offer programs to encourage the use of alternative commuting modes including telecommuting, AWS, carpool and vanpool, bicycling and public transit. NREL will also continue to provide free public transit passes, vanpool vouchers, and shuttles. In FY 2013, RTD's new West Corridor Light Rail line began operating. NREL provides shuttle services to connect the light rail line to the STM campus to enable more staff to commute using mass transit. In FY 2013, NREL also developed an STM bicycle and pedestrian facility map on NREL's intranet site and completed a feasibility assessment for an on-site bicycle share program. A commuter survey is planned for FY 2014 in order to update information on the modes of transportation used by employees.

Contracted Wastewater Treatment

NREL's emissions from contracted wastewater treatment increased 27% in FY 2012 and 22% in 2013 from the baseline. These emissions are calculated on a population basis, so the substantial growth NREL has experienced is reflected in this increase. Wastewater emissions make up less than 1% of NREL's Scope 3 emissions, so the increase does not significantly contribute to overall emissions from this scope.

While GHG emissions from wastewater are a function of population, NREL makes every effort to reduce the amount of sewage through the use of high efficiency, low flush or low flow toilets, urinals, and faucets. These products are in NREL's design standards for all new construction and remodeling of existing buildings. Additionally, NREL's support for telecommuting and AWS will decrease the load on the municipal wastewater system.

Contracted Waste Disposal

NREL's contracted waste disposal comprises 2.5% of the overall Scope 3 emissions. Emissions increased 16% from FY 2012 resulting in a 45% overall decrease in FY 2013 from the 2008 baseline.

NREL's goal is to become a near-zero waste campus. To support this goal, NREL will continue to provide staff training through the Near-Zero Materials Waste program and roll out sustainable purchasing practices. In FY 2013, NREL continues to perform audits of campus waste to identify problem areas and target additional efforts.

NREL is working to mitigate the effects of travel and commuting through programs such as alternative work schedules, telecommuting, and alternative commuting incentives.

Total GHG Emissions

NREL's overall emissions have decreased in FY 2013—4% from FY 2012, but remain 66% below 2008 emissions with REC purchases included. In FY 2013, the majority of the laboratory's emissions (64%) came from the Scope 2 purchase of electricity. These emissions are offset in their entirety through the purchase of RECs. Scope 3 represents the next largest emissions source, comprising 23% of all NREL's emissions. Through campus policies and programs that address travel and commuting, NREL is working to mitigate this source. The final category, Scope 1, represents 13% of NREL's overall GHG emissions.

In spite of NREL's measures to promote campus efficiency of energy, waste, commuting, and travel, NREL expects Scope 3 emissions to continue to increase. This increase is a result of the substantial population and campus footprint growth since the baseline year of 2008. On a per capita basis, however, NREL will continue to work to decrease emissions from the Scope 3 category by implementing available measures to support DOE's reduction goal.

National Context

The magnitude of federal government operations is substantial, occupying "nearly 500,000 buildings, operat(ing) more than 600,000 vehicles, employ(ing) more than 1.8 million civilians, and purchas(ing) more than $500 billion per year in goods and services[1]." Executive Order 13514 required federal agencies to set aggressive GHG reduction goals to help improve the environmental, economic, and energy performance of the federal government. By setting these GHG reduction goals, the federal government is leading by example in the fight against climate change. Through achievement of the 2020 reduction goals, it is anticipated that the federal government will "save up to $11 billion dollars in energy costs over the next decade and eliminate the equivalent of cumulative 235 million barrels of oil[2]."

The first federal GHG inventory, developed for FY 2010 showed that the federal government reduced GHG emissions "by 2.5 million metric tons of carbon dioxide from its 2008 baseline[3]." DOE's emissions represented over 7% of the overall federal inventory for FY 2010[4]. NREL's contribution in GHG reduction supports DOE and the federal government's efforts to reduce global climate change impacts.

The federal government sets a precedent for the rest of the nation with its leadership in GHG reduction. In 2011 state and local governments employed over 16.3 million full and part-time workers[5]. Employing over nine-fold more civilians than the federal government, state and local governments' contribution to climate change mitigation has the potential to be even more substantial.

1 Accessed 2/4/13. http://www.whitehouse.gov/administration/eop/ceq/sustainability

2 Accessed 2/4/13. http://www.whitehouse.gov/blog/2011/04/28/knowing-where-we-stand-save-money-improve-efficiency-reduce-pollution-and-eliminate-

3 Accessed 2/4/13. http://www.whitehouse.gov/blog/2011/04/28/knowing-where-we-stand-save-money-improve-efficiency-reduce-pollution-and-eliminate-

4 Accessed 2/4/13. http://www1.eere.energy.gov/sustainability/pdfs/doe_sspp_2011.pdf

5 Accessed 2/27/13. http://www2.census.gov/govs/apes/11stlus.txt

Clean Energy Technologies

Multi-Year Goals:

- Conduct outstanding basic and applied research and accelerate discoveries toward market-variable applications.
- Accelerate the commercialization of clean energy technologies; remove barriers to enable their deployment at scale.

NREL's Summer Internship Program is the lab's premiere workforce development program to ensure that DOE, NREL and the nation have a sustained pipeline of highly skilled workers in science, technology, engineering and mathematics. Intern Jacob Weber and NREL Researcher Judith Gomez work on an experiment related to building thermal systems.

Clean Energy Technologies

Strategic Intent

To align with national priorities and meet the global demand to produce clean energy alternatives, NREL must plan for program growth expectations and strategize an effective investment plan. Critical to advancing our role from scientific innovation to commercial implementation is our future investment in our scientific staff, research equipment, facility operations, and a work environment that supports NREL's significant mission.

National Energy Context

Dependence on energy from foreign sources—as well as environmental threats associated with energy use and emissions—poses significant challenges to the nation's economic vitality, the global and local environment, and national security. The recent Gulf oil spill, the nuclear power plant issues following the earthquake and tsunami in Japan, and the significant electricity disruptions resulting from tornadoes and hurricanes in the Southeast United States are stark reminders of our current energy systems' vulnerabilities. Addressing these complex and interrelated issues requires a profound and rapid transformation in how energy is generated, delivered, and used.

In the midst of these challenges, other energy opportunities are developing:

- Domestic natural gas resource estimates and production have increased significantly during the past few years due to economic breakthroughs in recovering unconventional gas, particularly shale gas.
- Advances in energy efficiency and renewable energy offer the opportunity to create a sustainable energy system that optimizes the combined use of renewable, fossil, and nuclear energy resources. This system would provide critical energy services through a "system of systems" that works in unison, tailored to meet regional needs, but connected through a 21st century grid to provide high system efficiency and reliability.

The Department of Energy Strategic Plan sets goals to catalyze the timely, material, and efficient transformation of the nation's energy system and secure U.S. leadership in clean energy technologies, and to maintain a vibrant U.S. effort in science and engineering as a cornerstone of our economic prosperity.

NREL MISSION PRIORITIES

Strengthening Core Competencies and Enabling Capabilities

Short-term specific activities include a strong focus on developing the laboratory's electrical and thermal engineering and integration competency. These competencies combined with NREL's partnerships and business model will encourage broad access and use of the Energy Systems Integration Facility (ESIF) when completed. In addition:

- A plan to develop petascale high performance computing will be implemented.
- The laboratory will maintain the certifications that validate the quality of our research and testing methods.
- An additional commercial-scale wind turbine will be added to the National Wind Technology Center.

Partner to Amplify Impact and Leverage the DOE EERE Investment

NREL's core capabilities are supported by facilities that enable partnering with industry on energy systems integration, solar, biofuels, wind, alternative fuels, and vehicle research, development, and demonstration (RD&D). NREL is developing a Partnering/User Facility model that will use best practices from DOE user-facility models, but will be tailored to meet the unique needs for applied RD&D conducted in close partnerships with industry and universities. NREL will strengthen its long-term relationships with organizations that can complement work sponsored by DOE's office of Energy Efficiency and Renewable Energy (EERE). These relationships will be supported through innovative partnership models and new partnering mechanisms that provide broad access to unique capabilities.

Create the Laboratory of the Future

NREL will keep a sharp focus on maintaining a safe and healthful workplace, advancing integrated safety management through improvements to management systems, and demonstrating leadership in sustainable operations of the laboratory and its research activities. To the extent that resources allow, key activities in the NREL Site Sustainability Plan will be pursued to maintain NREL's leadership position in implementing Executive Order 13514 and to further NREL as DOE's "showcase" for the practice of energy efficiency and the application of renewable energy technologies.

	SUSTAINABLE TRANSPORTATION			RENEWABLE ELECTRICITY GENERATION			ENERGY-SAVINGS HOMES, BUILDINGS, AND MANUFACTURING				
	Biomass	Vehicles	Fuel Cells	Solar	Wind & Water Power	Geothermal	Advanced Manufacturing	Buildings	FEMP	WIP	Strategic Programs
Energy Systems Integration at All Scales		●	●	●	●	●	●	●	●	●	●
SunShot and Beyond	●	●	●	●	●		●	●	●	●	
Electrification of Transportation		●	●	●	●	●	●		●	●	●
Infrastructure-Compatible Biofuels	●	●							●		

Maintain a Best-in-Class Cost of Doing Business

NREL will continue to enhance its competitiveness by maintaining the laboratory's labor multiplier, implementing standard labor rates across all projects, and applying direct funding to safeguards and security. Effective program management practices and communications will support NREL's ability to manage assigned resources to deliver milestones and appropriately manage uncosted balances.

- Responsiveness to DOE's dynamic needs while avoiding adverse impacts to the program plans
- Efficient coordination of information and resources
- Prudent and measurable stewardship of those resources
- Consistent communication across all programs.

Operating Budget

Because NREL is a not-for-profit organization, the term net revenue does not apply. However, our total revenue, assets, and cost of operations and research are as follows:

- FY 2012
  - Revenue from the U.S. government and Work for Others Project: $513.4 million
  - Total capitalization as of September 30, 2012
    - Debt: $0
    - Equity: $1.1 million
  - Total assets: $94.9 million
  - Total revenue: $513.4 million
- FY 2013
  - Revenue from U.S. government and Work for Others Project: $383.3 million
  - Total capitalization as of September 30, 2013
    - Debt: $0
    - Equity: $1.3 million
  - Total assets: $82 million
  - Total revenue: $383.3 million

Clean Energy Technology Initiatives

NREL's deep domain knowledge resulting from its multi-decade mission-focus on clean energy resources, technologies, and systems makes it a valued partner for industry and government. This combined with understanding of energy markets and policies positions NREL to strategically deliver knowledge and innovations to U.S. industry that support a profound transformation of today's energy systems.

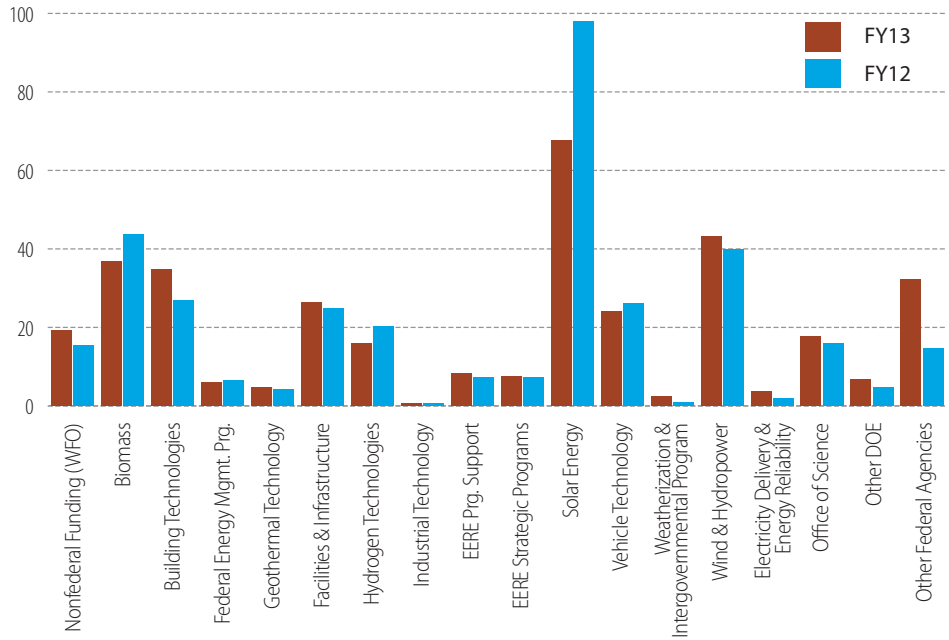
NREL envisions a future energy system that is carbon neutral, highly efficient, affordable, reliable, and supportive of high-value domestic jobs. Through carefully targeted research and development initiatives, NREL will deliver research outputs that support a future energy system that efficiently and cost-effectively provides critical energy services

For 10 weeks every summer, college students from across the county migrate to NREL to work side-by-side with top researchers on renewable energy and energy efficiency research and development.

Intern Thomas Bethel (opposite page photo) works on experiments related to photovoltaic research and intern Sarah Stahl works on research in the biofuels area.

tailored to local and regional needs through highly interconnected fuels and electricity networks. These intelligent energy networks will incorporate high levels of renewable resources and highly efficient, dynamic loads that operate reliably and synergistically with other clean energy resources in integrated systems. Their scale will range from vehicles and buildings, to communities, to regional and national levels.

FY12 and FY13 Funding by Source ($M)



"ESIF is an excellent example of the impact that federally-funded research can have on solving national problems beyond the scope of private investment. And, it demonstrates the importance of partnerships among the federal government, industry, and academia."

Dan Arvizu
NREL Director

The SunShot Grand Challenge: Summit and Technology Forum which drew 700 participants, focused on SunShot Initiative goals aimed at achieving grid-parity for solar energy within the decade.

ENERGY INITIATIVES EXPAND NREL'S CAPABILITIES, SUPPORT NATIONAL GOALS

SunShot and Beyond

DOE's SunShot Initiative, launched in February 2011, aims to reduce the cost of Photovoltaic (PV) solar energy at the utility- and residential-scales and re-establish the U.S. as a global leader in this growing industry. Specifically:

- Utility-scale—75% cost reduction (approximately $1/watt) so that PV is competitive with other forms of energy without subsidies before the end of the decade.
- Residential systems—reducing current soft costs from $1.80/watt to $0.65/watt.

According to the SunShot Vision Study,[1] accomplishing these goals could result in:

- Meeting 14% of U.S. electricity needs with solar energy by 2030 and 27% by 2050
- Reducing annual U.S. electricity sector greenhouse gas emissions by 8% (or 181 million metric tons) by 2030 and 28% (or 760 million metric tons) by 2050
- The creation of 290,000 new solar jobs by 2030 and 390,000 by 2050
- Saving $30 billion in annual costs across all market sectors, rising to $50 billion by 2050.

NREL's Solar Initiative leadership is helping make this happen by advancing basic science discoveries that enable revolutionary leaps in solar energy technology performance beyond SunShot. Solar Initiative projects include:

- Solar Photovoltaic Conversion and Manufacturing Technologies. By better understanding material defects and successfully achieving a 25% efficient cell, NREL researchers will demonstrate progress toward manufacturing processes and materials that are capable of attaining the SunShot goals.
- Innovations and Strategies to Reduce PV System Soft Costs and Increase High Penetration in the Grid. By working closely with industries and stakeholders to develop a comprehensive database of soft costs as a function of geographic market region and other variables, NREL will be able to inform and develop options to improve policies, procedures, and requirements that currently cause high levels of soft costs. Because large-scale deployment of solar technologies is potentially high if the SunShot goals are met, NREL is also leading efforts to:
  - Understand how solar systems affect utilities' reserve requirements, emissions from fossil plants, and production costs
  - Develop solar power production and integration models that provide solar power performance system data to the utility industry
- Solar Energy Conversion Science for Electricity and Energy Storage. NREL is conducting leading-edge experimental work to develop an understanding of the scientific foundations for converting energy absorbed photons into electricity, thermal

1 *SunShot Vision Study*. DOE/GO-102012-3037. Washington, D.C.: U.S. Department of Energy, 2012.

media, and chemicals using novel concepts for harvesting solar energy in molecular, nanoscale, and semiconductor systems.

Electrification of Transportation

EV Everywhere Grand Challenge, announced by President Obama in March 2012, focuses on the U.S. becoming the first nation in the world to produce plug-in electric vehicles (PEVs) that are as affordable for the average American family as today's gasoline-powered vehicles within the next 10 years. To meet this challenge, the industry will need to rapidly develop and commercialize next generation technologies to achieve the sufficient PEV cost, range, and charging infrastructure necessary for widespread deployment—including improving batteries.

Transitioning to a light-duty fleet of hybrid electric vehicles (HEVs) and PEVs could reduce U.S. foreign oil dependence by 30% to 60% and greenhouse gas emissions by 30% to 45%, depending on the exact mix of technologies.[2] NREL projects that support this effort include:

- **Computer-Aided Engineering for Batteries.** This multi-industry/national laboratory project will produce an open architecture toolkit based on decades of software and data from various hardware experiments. The toolkit will be used primarily for industry to speed the development of advanced batteries for EVs and will integrate multi-physics aspects for batteries (such as material science, electrochemistry, structural, thermal, fluid flow) at the cell, module, and pack levels.
- **Computer-Aided Engineering for Power Electronics and Electric Motors.** This follow-on initiative will strengthen the multi-physics identified in the Computer-Aided Engineering for Batteries project and provide seamless integration into power-train component tools, data, and analysis to help industry understand the relationship between magnetics, current, and voltage-level trade-offs as functions of speed, motor losses, and thermal management as well as structural packaging and weight optimizations simultaneously.

Infrastructure-Compatible Biofuels

Transportation accounts for nearly 71% of the nation's total petroleum use and 33% of total carbon emissions.[3] The DOE Transportation Energy Futures (TEF) indicates that these numbers could be reduced by 80% using a combination of strategies that include the use of more biofuels for the jet fuel, gasoline, and diesel fuel markets—but only if the goals of the nation's Renewable Fuel Standard (RFS) are met.

The RFS, introduced by the Energy Policy Act of 2005 and extended by the Energy Independence and Security Act (EISA) of 2007, requires transportation fuel sold in the United States to contain a minimum volume of renewable fuels (conventional biofuel, biomass-based diesel, cellulosic biofuel, and other advanced biofuels) in increasing amounts each year, reaching 36 billion gallons by 2022.

In order to meet the TEF and RSF targets, significant modifications will be needed to transport and deliver renewable fuels that are not compatible with the country's existing infrastructure.

Through its Infrastructure-Compatible Biofuels Initiative, NREL is working to develop native

Congressional staff members tour NREL's Integrated Biorefinery Research Facility where researchers are working to develop native biomass resources to replace gasoline, diesel, jet and marine fuels.

2 "Energy Storage." U.S. Department of Energy Office of Energy Efficiency and Renewable Energy Vehicle Technologies Program, 2013. Accessed July 11, 2013: https://www1.eere.energy.gov/vehiclesandfuels/technologies/energy_storage/m/index.html

3 *Transportation Energy Futures: Combining Strategies for Deep Reductions in Energy Consumption and GHG Emissions.* DOE/GO-102013-3845. Washington, D.C.: U.S. Department of Energy, 2013. http://www.nrel.gov/docs/fy13osti/56269.pdf.

"This new facility (ESIF) will allow for an even stronger partnership with manufacturers, utilities and researchers to help integrate more clean, renewable energy into a smarter, more reliable and more resilient power grid."

Ernest Moniz
Secretary of Energy

NREL plans to conduct extensive R&D systems integration models, simulations, operations, and controls that can be used to inform energy system architecture, policy and investment at its Energy System Integration Facility.

biomass resources to replace gasoline, diesel, jet, and marine fuels. In 2012, NREL achieved its goal of demonstrating two pilot-scale cellulosic ethanol conversion technologies based on a biochemical and a thermochemical pathway, pushing cellulosic ethanol into the advanced stages of development and commercialization.

In addition, NREL plans to use the two-pronged approach below to tap into the lab's chemical engineering, decision science and analysis, applied materials science and engineering, chemical and molecular science, biological systems science, and computational science capabilities to further develop large-volume, cost-effective production of infrastructure-compatible biofuels.

- **Sugar or Soluble Carbon Approach.** Through the National Advanced Biofuels Consortium and other projects, the lab is working with industry partners to develop bacterial and yeast strains capable of fermenting an intermediate that is readily converted to a high-quality diesel or jet fuel. NREL is also developing promising strains of other bacteria and fungus to produce isoprenoids, isobutanol, terpenes, and alkanes that can be readily converted to diesel fuel. Complementary to this, NREL is working on a number of projects with the biofuels start-up company Virent to conduct groundbreaking work on catalytic conversion of biomass sugars and other intermediates into high-quality diesel and jet fuels.
- **Bio-Oil/Lipid Intermediate Approach.** Converse to Sugar or Soluble Carbon Approach outlined above, this approach relies on fast pyrolysis, or a thermal liquefaction technique instead of bacteria or fungi, to produce an intermediate. NREL has been working on deoxygenation pyrolysis chemistry and mechanisms as well as the role of catalysts at length and has made significant strides to identify bench-scale reactors for performing deoxygenation pyrolysis that would be invaluable for performing additional work in this area.

Energy Systems Integration at all Scales

The nation's aging electricity, transmission, and distribution infrastructure has remained the same, while more renewable energy electricity options become available. This presents a significant challenge when integrating the electricity produced from renewable energy resources.

NREL's Energy Systems Integration at all Scales Initiative aims to increase overall energy system efficiency and enable high levels of renewable

energy and energy efficiency technologies to operate in sync with other energy resources.

Through five key areas, NREL plans to conduct extensive R&D of systems integration models, simulations, operations, and controls that can be used to inform future energy system architecture, policy, and investment and meet this initiative's objectives.

- **Operate the Energy Systems Integration Facility (ESIF) as a Unique Technology User Facility**
  The 185,000 square-foot ESIF enables simulation, engineering, and experimentation of advanced energy systems that effectively integrate clean-generation technologies, energy storage, and a variety of controllable energy-use applications. Integration research includes building and facility systems, community power generation and microgrids, utility generation, and grids that incorporate renewable energy, energy efficiency technologies, electricity system architectures, and grid interoperability.
- **National Energy Systems Integration Research, Development, and Deployment Agenda**
  In an effort to drive this agenda, NREL hosted a series of workshops in 2012 with potential ESIF users. Additionally, the Alliance for Sustainable Energy, which manages and operates NREL's contract for DOE, has established an Energy Systems Integration Technical Review Panel (TRP) comprised of utilities, equipment suppliers, academic representatives, and facility energy managers to provide strategic advice as the overall RD&D agenda and user facility model develops. NREL drafted a proposed RD&D plan based on TRP input for consideration by DOE's Office of Energy Efficiency and Renewable Energy. The proposal included four areas of research: science and technology development, system simulation and data integration, integrated system experimentation, and impact analysis.
- **Enhance Key NREL Capabilities.** To develop the next generation of power engineers who have a deep understanding of how to design and operate advanced, clean energy technologies, NREL recognizes the need to partner with universities and commercial companies. To date, NREL has established a joint appointment with the lead for Engines and Energy Conversion Laboratory at Colorado State University and strategic partnerships with the Electricity Research Center at the University of Dublin and the Georgia Institute of Technology. The lab is also involved in the Power Systems Engineering Research Center, a network of universities with leading power systems programs funded by the National Science Foundation. Key hires, joint appointments, and recruitment of postdoctoral candidates and student interns will enhance NREL's electrical and power systems competency.
- **Establish Integration Capabilities and Conduct Proof-of-Concept Experiments.** During the next several years, the lab expects to dedicate an increasing share of its resources to advance energy systems integration capabilities and proof of concept in the areas of system experimentation and performance verification, energy system modeling and simulation, energy systems informatics, and power systems components and controls.
- **Exploration of Synergies among Energy Pathways.** NREL has been exploring the potential synergies between renewables and other energy pathways, with a particular focus on nuclear and natural gas via the Joint Institute for Strategic Energy Analysis founded by the Alliance in September 2011, and the Nuclear and Renewable Energy Synergies Workshop convened at NREL.

What Successful Initiatives Mean to the Country

The success of NREL's four key initiatives will improve the performance and costs of solar, vehicle, fuel and energy systems technologies and enable effective renewable energy resource integration and operation within the nation's energy infrastructure (tailoring energy solutions to the local and regional levels). This translates to

- Boosting our economic competitiveness
- Rebuilding our manufacturing industry
- Helping to double our use of clean energy in the next 25 years
- Creating a "future energy system that is carbon neutral, highly efficient, affordable, reliable, and supportive of high-value domestic jobs.[1]"

Written by Devin Egan

1 *2013 Five-Year Plan*. Golden, CO: National Renewable Energy Laboratory, 2013.

Energy Management

Multi-Year Goals:

- Reduce energy intensity by 30% by FY 2015 from a FY 2003 baseline.
- Conduct EISA Section 432 energy and water evaluations.
- Reduce campus annual electricity consumption by 20% by FY 2020 utilizing renewable sources.
- Meter individual buildings or processes for 90% of electricity (by October 1, 2012); for 90% of steam, natural gas, and chilled water (by October 1, 2015).

NREL's Automated Home Energy Laboratory, housed at the Thermal Test Facility, enables researchers to study the complex interactions of multiple appliances and plug-load devices with the broader distribution grid. The laboratory features high-frequency monitoring of all end-use energy consumption devices found in a typical home, as well as smart grid emulation.

Energy Management

Strategic Intent

NREL's goal is to establish a campus of the future that showcases the benefits of energy efficiency and renewable energy technologies. To support this goal, NREL invests in site design and building development that maximizes energy efficiency and renewable energy opportunities. Where possible, NREL integrates renewable technologies on campus through a variety of financing mechanisms that help to minimize our energy footprint while accommodating campus growth.

FY 2012 PERFORMANCE STATUS

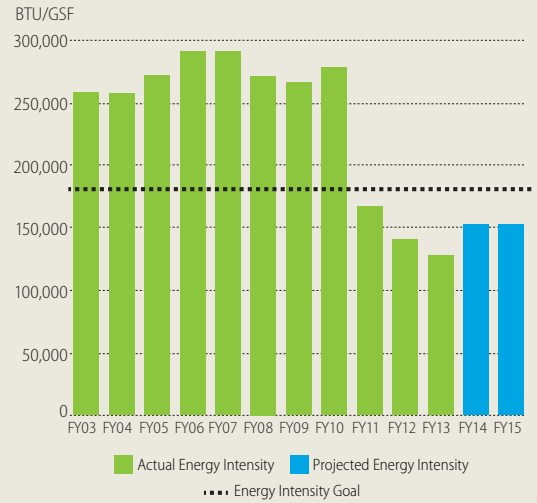
Energy Intensity

Electrical energy use in NREL's DOE-owned facilities increased slightly from FY 2012 (20,730 MWh) to FY 2013 (21,111 MWh). This increase can be attributed to the occupation of the Research Support Facility (RSF) II and the Integrated Biorefinery Research Facility (IBRF) becoming active in FY 2012. In the context of the ESIF opening, the addition of a new HPC, and construction of a new 5MW dynamometer, this small increase is a significant achievement. While these facilities stand to increase campus energy use significantly, as yet, the impacts have not been seen. In FY 2014, these facilities will be fully operational and NREL anticipates an increase in campus energy intensity.

Natural gas use in NREL's DOE-owned facilities decreased in FY 2012 (73.4 BBTU) and FY 2013 (71.7 BBTU). NREL's wood-chip fueled Renewable Fuel Heating Plant (RFHP) displaced 24.4 BBTU of natural gas during the recent reporting period. NREL has two natural gas-fired boiler plants, at the Solar Energy Research Facility (SERF) and the Field Test Laboratory Building (FTLB), and a wood fired hot water boiler at the RFHP. These are tied into the campus' central heating system. In FY 2012, work was completed to replace inefficient boilers in the FTLB with high-efficiency condensing boilers. The SERF implemented a new operating scheme to minimize the use of its existing boilers as much as possible to conserve energy. Building automation system programming was rewritten to run the FTLB boilers first and to export hot water to the SERF when there is sufficient capacity. Valves were also added so that hot water from the RFHP flows to the SERF to maximize use of the new FTLB boilers.

NREL is on track to meet the FY 2015 energy intensity goal (to reduce energy intensity 15% from 2003 values), with a value of 127.4 kBTU/ft^2—a 50% decrease from NREL's FY 2003 baseline. This intensity reduction can be attributed to the completion of RSF II and its addition to the Facilities Information Management System (FIMS) database in FY 2012, increasing NREL's DOE-owned space by almost 25%. The photovoltaic (PV) arrays associated with the RSF I, RSF II, and parking garage projects will ultimately provide enough on-site production to make these buildings net-zero energy. In FY 2012, NREL continued entering office building data into the EPA Portfolio Manager Tool to benchmark our metered building energy performance. At this time, the RSF is the only building on campus with a space type that allows for benchmarking in the EPA Portfolio Manager tool. Using Portfolio Manager, NREL achieved ENERGY STAR certification for the RSF I in 2012. Once a year's worth of operational data is available, RSF II will also be benchmarked in the Portfolio Manager tool. NREL began benchmarking laboratory buildings in the Labs21 tool in FY 2013.

The intensity reduction achievement in FY 2013 can also be attributed to NREL's large fraction of energy efficient office and lab space, increased by the completion of ESIF. Both RSF and ESIF facilities integrate waste heat recovery systems from internal data centers to heat other building spaces such as offices and laboratories.



NREL aims for 30% energy intensity reduction by 2015 from an FY 2003 baseline.

NREL's 2012 and 2013 EISA audits were performed using in-house expertise to evaluate mechanical, water, and plug load systems. Engineer Bethany Sparn measures energy consumption.

EISA Audits

In 2012, energy and water audits were performed on three of NREL's buildings: Field Test Laboratory Building (FTLB) , SERF, and Science and Technology Facility (S&TF), representing 50% of total site energy use. In FY 2013, energy and water audits were performed on four NREL buildings: Outdoor Test Facility (OTF), Thermal Test Facility (TTF), Integrated Biomass Research Facility (IBRF), and Shipping and Receiving (S&R)—representing 7% of total site energy use.

NREL's 2012 and 2013 EISA (Energy Independence and Security Act of 2007) audits were performed using in-house expertise to evaluate mechanical, water, and plug load systems. For 2013 audits, Sustainable NREL partnered with NREL researchers to test a building audit tool currently under development. Simuwatt was used to provide standardized data, processes and analysis to develop an investment-grade energy audit of NREL's buildings and identify potential energy and water conservation measures for implementation. Simuwatt was created using a local software developer, Concept 3D, to develop a Building Component Library—an online reporting of energy data on individual building components and Energy Conservation Measures (ECMs) that can be used to create building energy models using NREL's Open Studio and Energy Plus tools, with data broken down into separate components that represent parts of a building. The tablet-based Simuwatt application enables energy auditors to conduct audits that cost 75% less than traditional audits and helps to store data in a consistent and reusable format.

NREL provides publicly available guidelines, checklists, and data collection forms to help businesses, government agencies, tribes, and other organizations incorporate energy-efficient products and operations and maintenance practices into existing buildings. These materials are also used by NREL to conduct our in-house EISA audits. The EISA evaluations are used to identify potential energy and water conservation measures for implementation. Measurement and verification will be implemented for conservation measures as required to fully understand energy and cost savings associated with their implementation.

NREL has identified a path forward to uphold compliance with EISA by identifying covered facilities that will be audited over the next four year cycle. NREL will conduct ASHRAE (American Society of Heating, Refrigerating, and Air-Conditioning Engineers) Level Two/ Three audits on all buildings using in-house expertise. As new LEED buildings are constructed, they will be commissioned, bringing these facilities into EISA compliance. Once the next four-year cycle of EISA audits is complete, NREL will have assessed over 80% of the site energy use.

Energy Conservation Measures (ECMs)

As a result of the EISA audits numerous ECMs were identified for all facilities. Assessments for prioritized selection included scope of work, schedule, the value gained for improved building system performance, and fiscal feasibility

The National Wind Technology Center (NWTC) has approximately 9.2 MW of installed wind turbine capacity. Senator Mark Udall and NREL Director Dan Arvizu get a close look of the nacelle of this 2.3 MW, 80 meter wind turbine.

considerations. Three projects implemented in FY 2012 included: S&TF cool Recovery, S&TF secondary chilled water pumps speed control, and SERF air compressor replacement.

Renewable Energy

Supplemental to utilizing energy efficient technologies for offsetting increased energy consumption, when feasible, NREL installs on-site renewable energy generation on both the STM and NWTC sites. To date, NREL has met and exceeded the federal goal for 20% of annual electricity consumption from renewable sources. NREL's on-site renewable systems, including PV arrays and wind turbines, generated a total of 4,794 MWh in 2012, supplying 18.8% of NREL's power needs. In FY 2012, NREL installed three PV arrays at the STM site:

- RSF II, roof mounted 408 kilowatt (kW)
- Parking Garage southern façade and roof mounted 1,153 kW
- Southern Site Entrance Building, roof mounted 15.28 kW.

NREL MAJOR ON-SITE RENEWABLE ENERGY FROM WIND AND SOLAR PHOTOVOLTAIC SOURCES

Location	Source	Date Installed	System Capacity	FY12 Energy Produced (MWh/yr)	FY13 Energy Produced (MWh/yr)
STM ST&F	Roof top PV array	2009	94 kW	137.8	111.7
STM Mesa top	Ground mounted PV array	2008	720 kW	1,263	1,174.4
STM RSF I	Roof top PV array	2010	449 kW	606.7	526.5
STM visitor parking	Roof top PV array	2011	524 kW	305	297.6
STM RSF II	Roof top PV array	2012	408 kW	463.6	529.5
STM parking garage	Roof top and southern façade mounted PV array	2012	1,153 kW	0	987.5
STM SSEB	Roof top PV array	2012	15.28 kW	0	13.1
NWTC site	Ground mounted PV array	2009	1000 kW	1,607.4	1,688.4
NWTC site	NREL research turbines	1994	1376 kW	25.9	25.9
NWTC site	Siemens wind turbine	2010	1500 kW	2495*	2,572*
NWTC site	Alstom wind turbine	2011	2300 kW	741*	1,264*
NWTC site	Gamesa wind turbine	2012	3000 kW	702*	599*
NWTC site	DOE GE wind turbine	2009	1500 kW	363	654

*Excluded from NREL's power generation because RECs are not retained

NREL's on-site renewables systems generated a total of 6,330 MWh in 2013, supplying 30% of NREL's power needs. NREL retains the renewable energy certificates (RECs) from the small wind research turbines and DOE-owned wind turbine at the NWTC. NREL purchases RECs from Gamesa and Alstom to help meet greenhouse gas (GHG) Scope 2 carbon neutrality.

NREL's wood-chip fueled RFHP utilizes forest thinnings from Front Range Healthy Forest Initiative activities and other wood wastes to displace natural gas usage for space heating. In FY 2012, the RFHP produced 10 BBTU. In FY 2013, production efficiency increased significantly producing 19 BBTU of hot water, displacing 24.4 BBTU of natural gas.

Space for additional PV arrays will be allowed on future buildings, including the ESIF and Cafeteria. These projects will exceed the Transformation Energy Action Management (TEAM) Initiative goal of acquiring at least 7.5% of each site's total annual electricity and thermal consumption from on-site renewable sources by FY 2010 and exceeds the EPACT 2005 goal of 20% for 2020 and beyond.

NREL also has a contract with Western Area Power Administration to purchase RECs to offset campus electricity use. This purchase also fulfills the U.S. Green Building Council's (USGBC) Leadership in Energy and Environmental Design (LEED) credit requirements for the RSF, IBRF, Cafeteria, and ESIF. Through collaborative efforts with DOE and Western, an opportunity to procure energy from a new off-site wind farm project was discussed in September 2012. National Wind, LLC is in the process of submitting a proposal to NREL to provide 30 MW generation and green attributes (RECs) of wind-powered-energy for sale through a power purchase agreement on behalf of NECO Wind, LLC. A significant detail to be determined is the mechanism for the sale and delivery of power from NECO to NREL that complies with Colorado statutes governing power procurement. In 2013, a solar garden prospect to install a 1MW solar array at the NWTC was discussed.

Renewable Energy Certificates (RECs)

In FY 2012, NREL purchased 23,037 MWh of RECs and 40,848 MWh in 2013 through the Western Area Power Administration's Federal Agency Master Purchase Agreement to cover all the electricity used on-site and achieve carbon neutrality for indirect (Scope 2) GHG emissions associated with site operations. NREL's purchased RECs represent the renewable attributes of renewable energy systems built in other locations. Through the purchase of RECs, NREL supports those renewable facilities and earns the right to claim the associated renewable generation attributes, offsetting the environmental impacts of our operations. The RECs purchased under this agreement are from new renewable energy projects derived from wind resources installed after January 1, 1999. NREL's REC purchase is intended not only to offset electricity purchases from the grid, but also to provide replacement RECs for those RECs that the laboratory sells to fund its on-site renewable energy systems through power purchase agreements (PPAs).

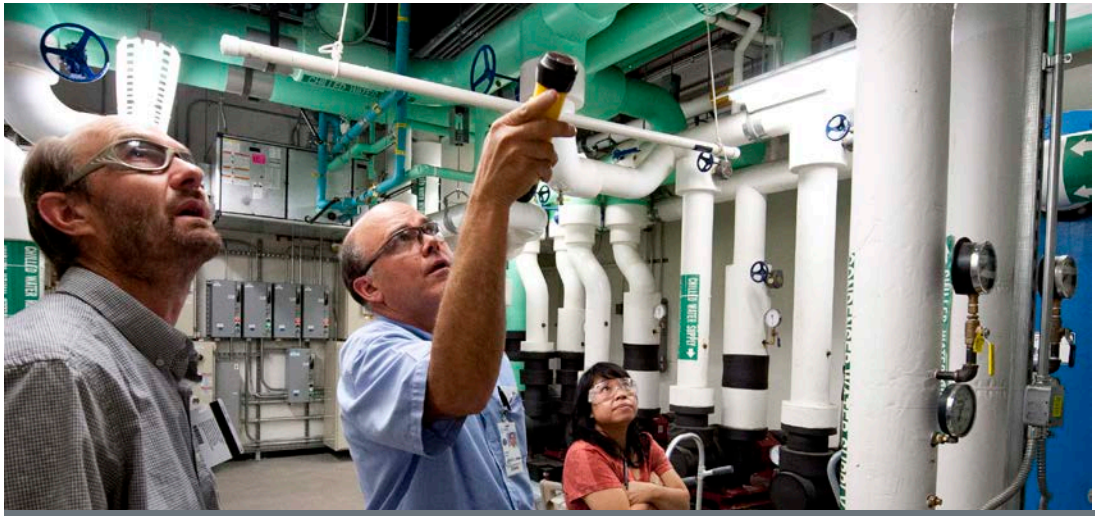
NREL takes advantage of its extensive on-site renewable energy systems to raise funds that are directed to campus energy efficiency and renewable energy projects. This is accomplished through two main mechanisms. NREL sells the RECs associated with its large PV arrays to our local power utility, which are used to meet the state of Colorado's Renewable Portfolio Standard requirements. The sale of RECs is financially advantageous for organizations, which can use the proceeds to reinvest in energy efficiency and renewable energy projects on-site as well as purchase RECs at a much lower cost that can be used to achieve carbon neutrality goals. Additionally these sales to Xcel Energy, the local power utility, are used to meet the state of Colorado's Renewable Portfolio Standard requirements. An additional mechanism is offered by the power utility, where rebates are provided based on energy demand savings associated with new high-performance building design. These rebates are directed to energy efficiency improvement measures for the new building.

Metering

NREL's electrical metering includes more than 200 advanced electric meters in all major facilities and on major process loads. To support DOE's metering requirements, NREL's design standard specifies that all new facilities include a main building electric meter and electrical submeters that record heating, ventilation, and air conditioning (HVAC), laboratory process, and lighting loads. All NREL facilities that use natural gas have building gas meters. Energy Dashboard data system directly records 85% of natural gas use.

NREL's new data center, located in the LEED Platinum RSF, is independently metered and connected to the DOE Energy Dashboard system.

All of the facilities that require water on the STM site have dedicated utility water meters. There are also submeters for all make-up water systems for cooling towers, boilers, deionized water, and evaporative cooling sections in all facilities where applicable. In-house staff maintains the submeters and record weekly data. All new facilities at the STM site will require a main building utility water meter, which will be supplied and installed by the water utility. As an NREL design standard for new and renovated



NREL meters electricity, gas, and water usage. The lab uses more than 20 advanced electric meter systems in all major facilities and digital meters are connected to an energy dashboard. The Web-accessible dashboard has data analysis tools that allow for continuous tracking of energy generation and consumption.

spaces, water submeters are required at make-up water systems that support mechanical HVAC equipment and laboratory processes. An irrigation meter is also required for all newly constructed facilities, which use water on a short-term basis for plant establishment. NREL is moving towards submetering high-use water systems with new construction.

NREL's design standards require installation of BTU meters on chilled water and heated water systems for all new facilities that are tied into the main centralized heating and cooling plants. In 2012, NREL added additional chilled and heated water meters to the DOE Energy Dashboard system.

The NWTC metering upgrade plan focuses on NWTC metering infrastructure improvements including installing and replacing new power quality meters with less susceptibility to setting loss/errors and improved communication using TCP/IP rather than Modbus, alarm reporting, and remote meter resetting and calibration.

NREL developed a Tiered Approach to Meter Infrastructure at the NWTC to define criticality of data based on:

- Tier 1 (Critical) includes meters supporting DOE financial obligations such as PPAs and Net Metering for wind and PV. Service Level Agreement (SLA) target: Data Quality: 98–100%/Data Availability: 99%–100%
- Tier 2 (High) includes meters supporting main building meters or high priority meters—particularly if there are annual review/reporting requirements tied to the meters. Service Level Agreement targets (to be determined)
- Tier 3 (Low) includes meters supporting requirements not covered in Tier 1 or Tier 2 including submeters and low priority meters. Service Level Agreement targets (to be determined).

Expectations for these elements will provide more reliable and available metering data communications plus improved quality of data.

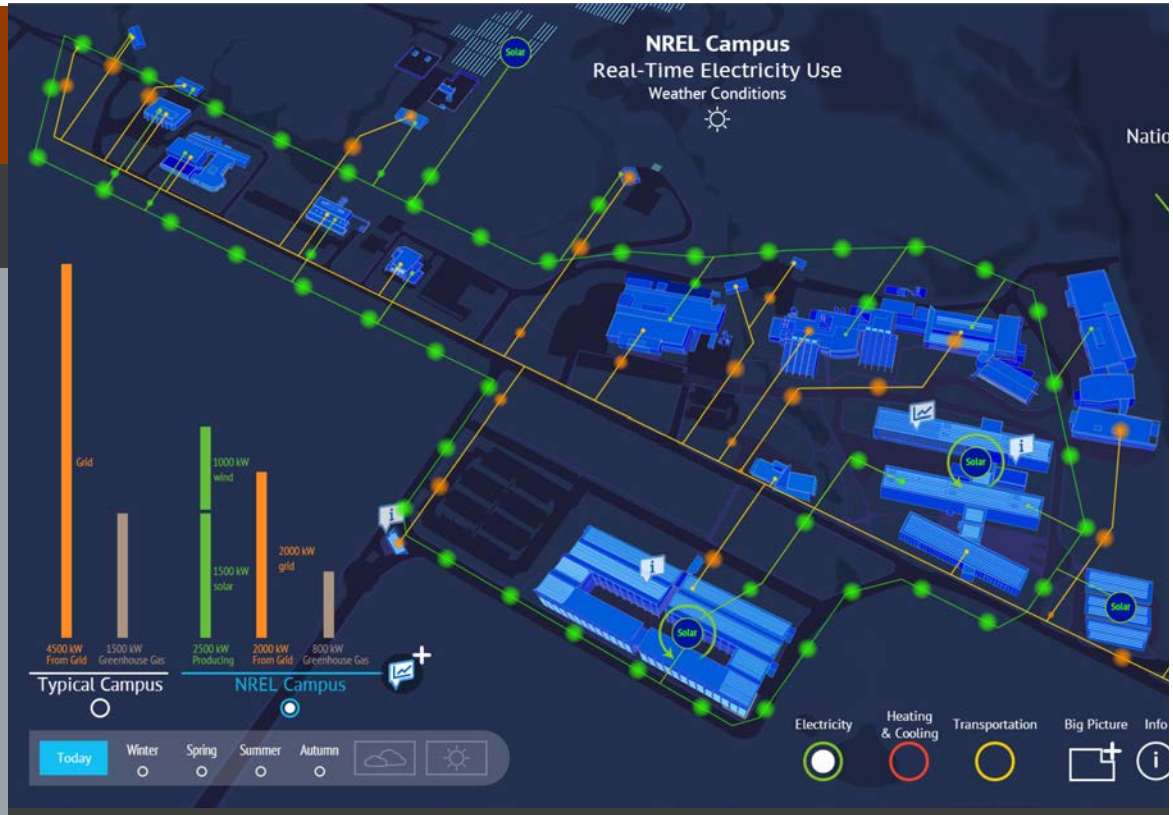
In FY 2013, NREL connected 13 NWTC electric submeters to increase data quality and added 27 new meters in the ESIF. These enhanced capabilities will help to simplify direct monitoring of NREL's energy consumption and reporting for development of DOE data reporting. Enhanced energy enterprise management capabilities will also support the analysis of GHG reduction and energy efficiency opportunities, calculation of REC purchase quantities and return on investment for energy improvements, and provide educational support and outreach to help NREL uphold DOE's mission for energy efficiency and renewable energy. In addition, NREL is working to conserve and optimize water efficiency for campus irrigation by using a WeatherTRAK® smart irrigation system to automatically adjust landscape watering based on plant needs and daily local weather conditions.

Human Side of NetZero Energy

Achieving a Net Zero Energy Campus

NREL's long-term goal is to operate as a net-zero energy campus. To achieve this, NREL is paying equal attention to the human side of net energy—fostering awareness, engagement and understanding of energy accountability—and technical factors to increase efficiency and deploy on-site renewable energy.

NREL's philosophy for achieving net-zero energy buildings is to minimize its energy consumption first, and then integrate on-site renewable technologies to offset energy demand requirements. In order for a building to operate at its potential, attention must be paid to performance and addressing issues as they arise.



Campus Energy Model for Control and Performance Validation

NREL Researchers and energy engineers are collaborating to create a platform for a real-time campus-scale energy simulation that enables test bedding of new control and optimization algorithms.

SMART BUILDINGS OR SMART PEOPLE

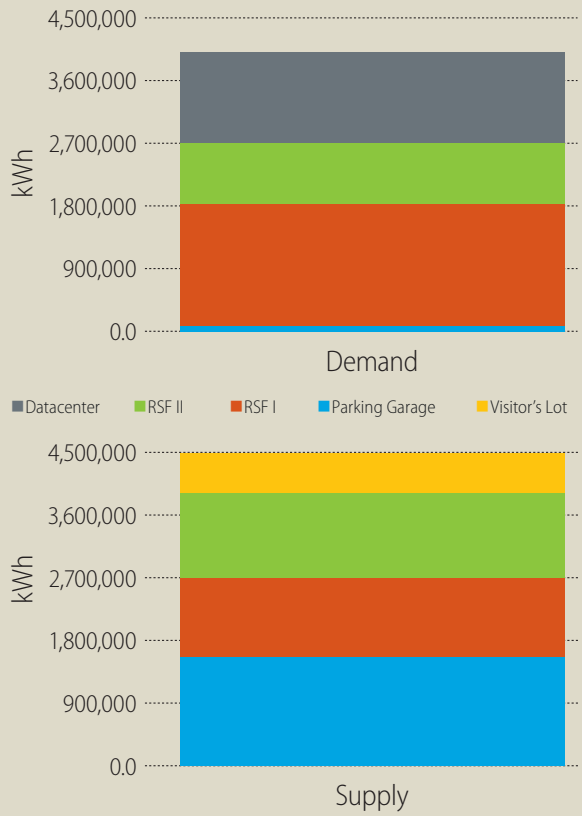
As equipment gets smarter and controls more aspects of their own operation, the interface with users becomes more—not less—important. A frustrated user can disable the most energy-efficient settings in order to get the desired results and can easily turn a net-zero energy building from peak to poor performance. Could that be why more manufacturers are using folk labels to instruct people to operate "smart" thermostats, lighting systems, or appliances?

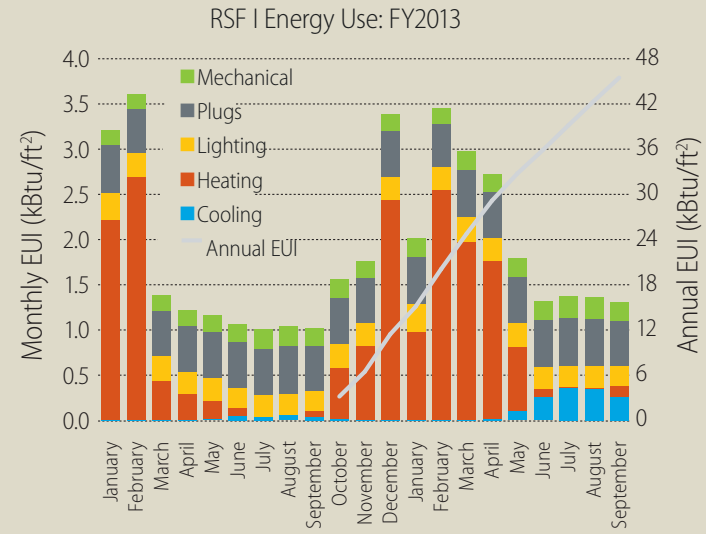
NREL'S FIRST NET ZERO BUILDING

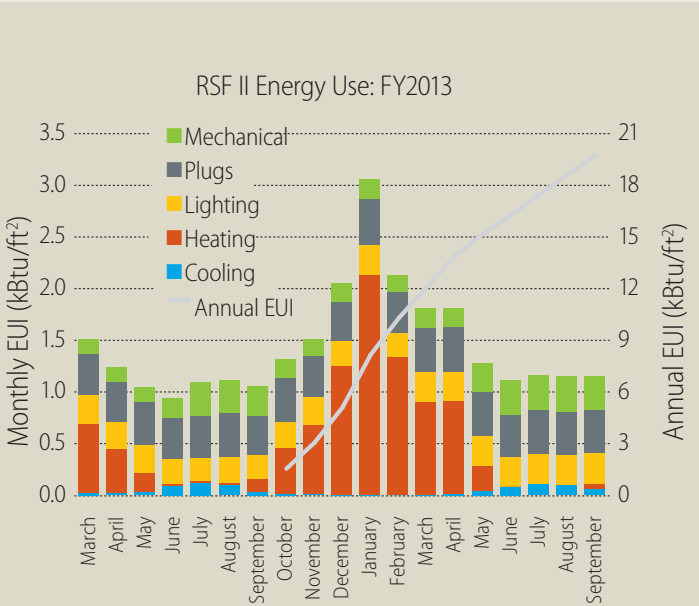
The Research Support Facility (RSF) is the first campus building to demonstrate an annual net zero performance. Several key processes are essential to its continued success.

Measurement and Verification

All energy end uses and on-site energy renewable energy systems are sub-metered. A rich set of actual energy use data has been gathered, analyzed, and compared to the predicted performance from the final as-built energy model. For the RSF operations team, evaluating the measured end use profiles against the modeled predictions has been essential in aligning operational deficiencies with the energy model end use budgets.

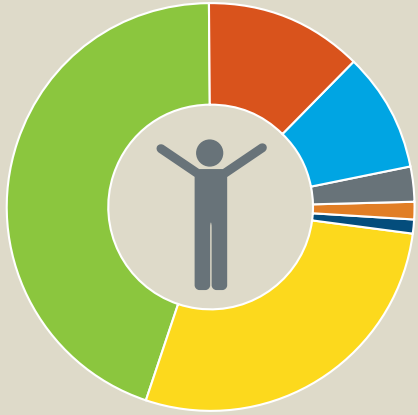






This graphic illustrates the degree to which occupants can influence and affect energy use for process and plug loads for lighting and equipment categories.

WHAT ENERGY DOES AN OCCUPANT INFLUENCE?



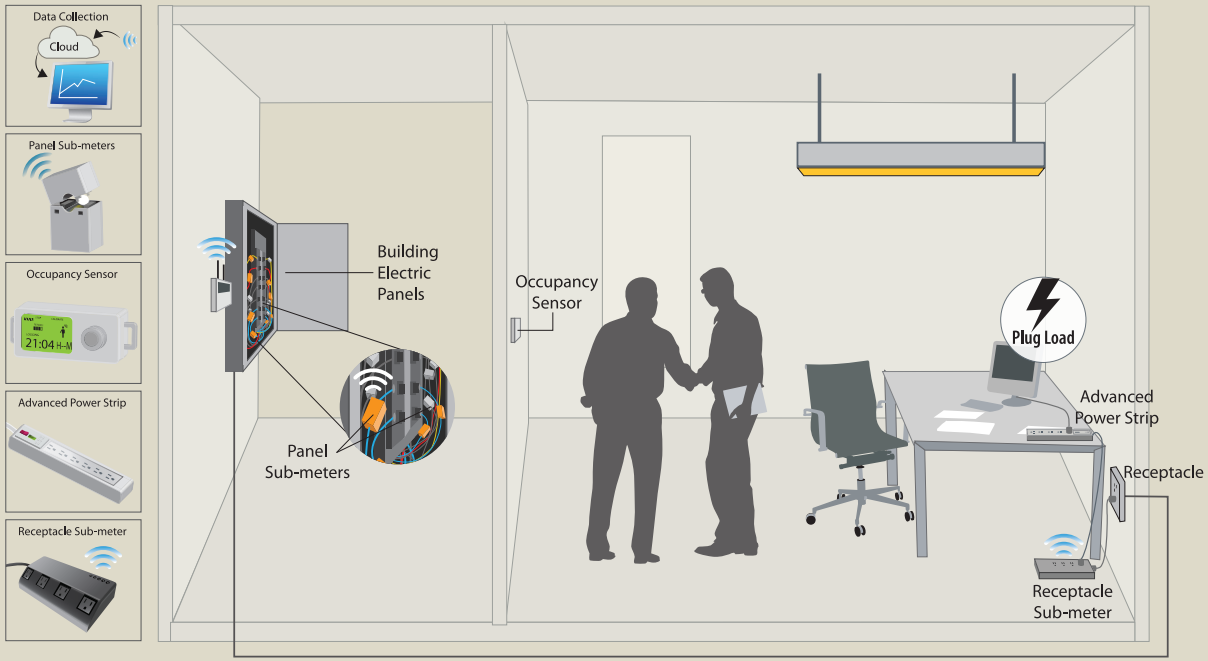
- **Heating** 12.5%
- **Cooling** 9.5%
- **Fans** 2.8%
- **Pumps** 1.5%
- **DHW** 1.0%
- **Lighting** 28.0%
- **Equipment** 44.7%

Building Occupants' Influence on Energy Use

Key to sustaining long-term performance is acknowledging how building occupants influence the amount of energy consumed. Occupants can control between 50% and 60% of the energy used in office buildings: lighting, plug loads and environmental system controls. Individual occupants and the choices they make—opening, closing, overriding, plugging in, turning up, leaving on—directly affect the amount of energy used. Technology and building automation only take sustainability so far before facilities managers have to rely on occupants to support energy goals. In a high performance building where every watt counts, NREL engages and enables staff to understand their interaction with equipment and system features. Several methods illustrated in the RSF occupant engagement program were deployed to heighten awareness and participation.

Building Agent

- **Comfort survey.** Building Agent software continuously surveys building occupant comfort and the data collected helps operations personnel understand the interface between occupants and equipment and their environs in order to enhance employee well being and productivity.
- **Windows.** About two-thirds of the buildings windows can be manually opened or closed. The Building Agent alerts occupants when the windows should be opened or closed to not adversely affect temperature or humidity levels.

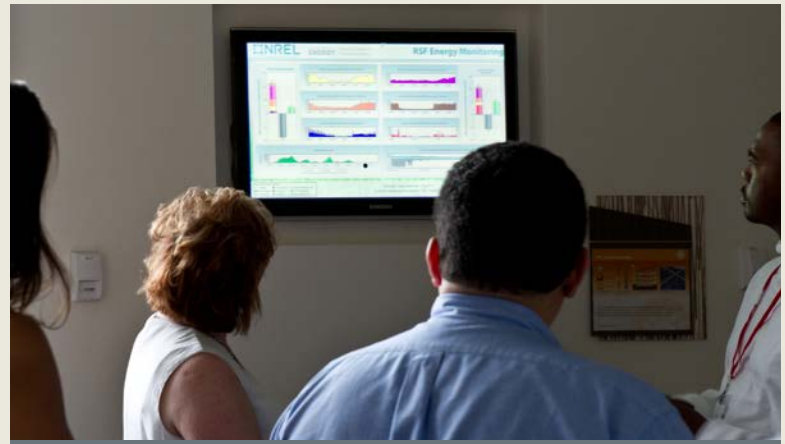


Equipment and Power Management

The Office of the Chief Information Officer deploys work station equipment to meet stringent EPEAT Gold and Energy Star Standards and manage power usage. Substantial energy savings best management practices include utilizing:

- Default settings to power down or place workstation computers into standby or sleep mode when not actively in use.
- Smart plug strips that automatically disconnect power to equipment when not in use.

Significant cost-savings is captured at the workstation. The cost to operate 1,325 energy efficient workstation systems that operate at 70 watts in the RSF is $2,478 daily. The cost to operate 1,325 typical workstations systems that operate at 460 watts is $16,298. Annually that is a cost savings of $3,593,200.



RSF lobby display monitors are used to inform occupants of the buildings real-time energy use performance.

Water Management

Multi-Year Goals:

- Reduce potable water intensity by 26% by FY 2020 from a FY 2007 baseline.

In FY 2012, the Central Arroyo Detention Basin was constructed. Its purpose is to provide water quality and stormwater detention storage for both the 95th percentile 24-hour storm and the 100-year, one-hour storm event. The basin was designed for detention rather than retention to comply with Colorado water law.

Water Management

Strategic Intent

NREL is committed to using water as efficiently as possible on campus. Given the location in the arid west, water is treated as a particularly precious resource. NREL implements all available measures to reduce potable water consumption. However, at this time state water law does not allow on-site collection and reuse of gray water sources and no municipal reuse water lines are in the vicinity of our campus. NREL will continue to explore opportunities as they become available to utilize non-potable water sources for the campus.

FY 2012 PERFORMANCE STATUS

Water Intensity

Water intensity was 21.1 gallons/ft^2 in FY 2012 and 22.9 gallons/ft^2 in FY 2013 for indoor and outdoor use. Water intensity in baseline year FY 2007 was 27.5 gallons/ft^2. Overall, potable water intensity has been reduced 16% between 2007 and 2013.

In both fiscal years, NREL has undertaken an effort to perform additional Energy Independence and Security Act of 2007 (EISA) building audits on our campus. These audits are used to identify energy and water savings opportunities within and around our buildings. Information from the water audits will also be used to develop recommendations for future funding needs and building retrofit projects targeted at reducing campus potable water use.

Indoor Potable Water

In FY 2012, NREL's indoor potable water use was 15,126,200 gallons and 22,441,800 gallons in FY 2013. NREL's indoor water intensity use was 16 gallons/ft^2. NREL has established best practices in design standards and operating procedures to promote the efficient use of potable water on campus. NREL's design standard calls for high efficiency, low flow, or low flush fixtures in all new and existing buildings. To conserve water, NREL also limits the use of once through cooling to devices that must operate at zero pressure and cannot be reconfigured to operate on building process cooling water.

NREL's potable water usage on the STM campus is metered for each building. The NWTC has potable water trucked into the site because there are no wells or potable water supply available. NREL has installed submeters on all high-intensity water devices including cooling towers, evaporative coolers, and autoclaves.

EISA audits were performed on seven of NREL's buildings from 2012–2013. Audits were performed using in-house expertise to evaluate mechanical, water, and plug load systems. Water audits considered the age and water efficiency of indoor fixtures such as faucets, toilets, urinals, showers, water heaters, and drinking fountains as well as outdoor water use for irrigation systems. Information from the water audits will be used to develop recommendations for future funding needs and building retrofit projects targeted at reducing campus potable water use.

Outdoor Potable Water

Colorado rainwater harvest laws prohibit capturing stormwater for reuse, thus NREL does not have any reuse water sources. NREL's water utility provider, Consolidated Mutual Water, can only deliver potable water at this time.

Irrigation is necessary to establish landscape plants in Denver's semi-arid climate, including several acres of newly-planted xeriscape. By comparison, in FY 2007, no water was used for irrigation. NREL is working to conserve and optimize water efficiency for campus irrigation by using a WeatherTRAK® smart irrigation system to automatically adjust landscape watering based on plant needs and daily local weather conditions. After plant materials become established, irrigation systems are taken offline and the areas planted in native species are adaptive to local climate conditions. In FY 2012, NREL used 4.78 million gallons of water to irrigate these new areas, and 408,200 gallons in FY 2013.

Zero Water Gas Scrubber

In January 2012, a gas scrubber that had operated continuously since 1993 was decommissioned. This scrubber used 2.5 gallons per minute around the clock. Over a year it consumed 1.3 million gallons, as much as one eighth of NREL's annual water usage. In its life, this scrubber passed 22 million gallons of potable water though a three eighty inch copper tube. Its replacement does not use any water.

Stormwater

STM Campus

Previously in FY 2011, NREL examined all STM drainage basins for compliance with EISA 438. The resultant modeling effort led to construction in FY 2012 of the Central Arroyo Detention Basin, which provides water quality and stormwater detention storage for both the 95th percentile 24-hour storm and the 100-year, one-hour storm event (the latter being required by the local drainage district) within the STM campus middle drainageway basin. The basin was designed for detention rather than retention to comply with Colorado water law.

Construction of the basin was completed in August 2012. To date, the basin has received runoff from several low- and high-volume storm events and has successfully collected and filtered stormwater runoff prior to its release off-site and eventual discharge to Lena Gulch. This is accomplished through a combination of drop structures and forebays as well as planting installations that include native grasses, trees and bushes, as well as pre-vegetated mats. Improvement in stormwater water quality has been determined through collection of field turbidity measurements at all points entering the basin as well as at the discharge point. In addition to verification of overall improvement in stormwater discharge quality from the site, the water quality measurements have also enabled NREL to identify and resolve upstream sources of sediment to the basin.

Water Management Plan

NREL's baseline 2003 Water Management Plan was last updated in FY 2009. Since then, the campus has grown substantially with eight new high performance buildings, extensive site and landscape restoration, new roadways, and the new High Performance Computer (HPC) located in the Energy Systems Integration Facility (ESIF). An updated Water Management Plan is necessary to address this new water use regime. In FY 2013, NREL will undertake an effort to update this plan to include strategies and actions that will help NREL meet water reduction goals.

Success Story

NREL'S CENTRAL ARROYO POND SUCCESSFULLY DETAINS STORMWATER

NREL's STM campus recently experienced heavy rainfall storms during the month of September 2013. On September 9th and for the next seven consecutive days, the 24-hour accumulated precipitation totaled 6.97 inches. The NREL central arroyo pond performed successfully in detaining these back-to-back storm events that were captured from a campus tributary area of approximately 210 acres.

Although each individual storm event was small, collectively it produced a large amount to detain and prevented significant damage and replacement costs at NREL and to property owners in our adjacent community. The highest water surface elevation recorded indicates that the water volume storage was equivalent to 9.28 acre-feet. NREL's pond is constructed to provide water quality and stormwater detention storage for the 100-year, one-hour storm approximately equivalent to 11.25 acre-feet.

ESIF | SUPER COMPUTER UTILIZING WATER COOLING VERSUS AIR COOLING

NREL's 10,000 square-foot, $10 million HPC data center, located in the ESIF, is designed to be one of the most energy-efficient data centers in the world thanks to the use of an innovative warm-water liquid cooling system. The state of the art data center has an ultimate build-out capacity for 10 MW and currently operates at about 1 MW.

Designed to provide a petascale (one million billion calculations per second) of computing ability, the HPC data center is expected to achieve an annualized average power usage effectiveness (PUE) rating of 1.06 or better (typical data centers achieve a rating of approximately 1.80). PUE is defined as the ratio of total power to run the data center facility—information technology (IT) equipment; lighting; heating, ventilation and cooling; uninterruptible power supply systems, etc.—to the total power drawn by all IT equipment.

After careful analysis, NREL chose the warm-water liquid cooling system because water has approximately 1,000 times the cooling capacity of air, making it more efficient to pump the energy needed to move liquid in a cooling system versus the energy needed to run a fan to move cooling air, the typical cooling mechanism for data centers. Warm-water liquid cooling systems also offer the ability to support higher load densities than are possible with traditional air cooling systems, which means the HPC data center can incorporate more servers in a smaller space, further enhancing computing capabilities. Additionally, the warm-water cooled system provides a more even distribution of cooling

ESIF WATER USE AND SAVINGS (WHEN COMPARED TO A TRADITIONAL DATA CENTER)

Data Center	Compute Energy kW	PUE	Annual energy use kWh	Water use at power plant (M gallons)	Water savings at power plant (M gallons)	Water use on-site (M gallons)	Water savings on-site (M gallons)	Total Water use (M gallons)	Total Water savings (M gallons)	Site water savings from 30% energy reuse (ERE = 0.7)	Total water savings after 30% energy reuse (M gallons)
Typical	1,000	1.80	15,768,000	17.34	0	6.65	0	23.99	0	1.99	
ESIF	1,000	1.06	9,285,600	10.21	7.13	3.92	2.73	14.13	9.86	1.17	11.04

compared to an air cooled system, increasing the useful life of the data center's equipment.

How the System Works

Water is supplied to the HPC data center servers at approximately 75°F—a higher temperature than the 50°F mechanically cooled chilled water supplied to a typical air cooled data center. The higher initial water temperature eliminates the need for compressor-based cooling systems and allows for the use of highly efficient cooling towers instead of chillers (baseline measurements indicate that chiller power can represent as much as 70% of total energy consumption). The cooling towers are located on the ESIF roof and are larger than towers in typical data centers to help NREL achieve a goal of 0.022 kW/ton for operational energy use.

To cool the server racks, the 75°F water is circulated through heat exchangers located on the racks, which capture the server heat directly. That waste heat brings the water temperature up to 95°F or warmer, which is then used directly as the primary source of heating for the ESIF's laboratories and offices simultaneously pre-cooling the chilled water. The waste heat is even looped under the front plaza and walkway outside the ESIF to help melt snow and ice in the winter, improving safety while saving energy.

Using server waste heat to heat the ESIF instead of rejecting the heat out the cooling towers, saves both energy and water in the cooling towers. If 100% of the heat could be used on-site and no heat needed to be rejected to the towers, then the towers would not use any water or tower fan and pump energy.

Saving Energy and Water—With Water

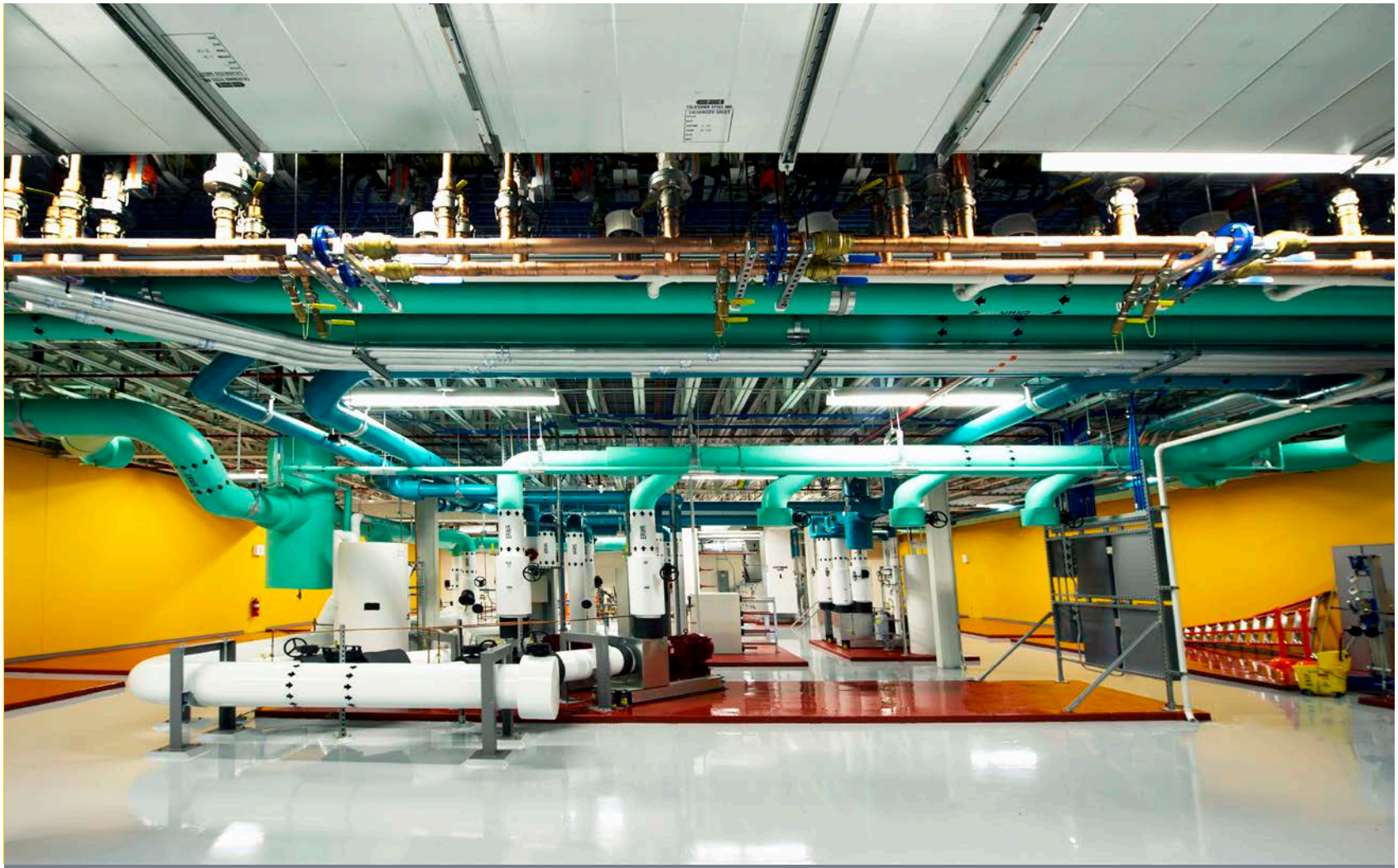
Although it seems counterintuitive, saving energy by using the warm-water cooled system at the ESIF saves water both at the thermal (fossil fuel or nuclear) electric power plant and on-site. For example, an average data center using 1 MW of computer energy achieves a typical PUE of 1.80. The ESIF HPC data center, with a PUE of 1.06, actually saves 7.1 million gallons of water at the thermal power plant and 2.7 million gallons at the site for a total of 9.8 million gallons (see the table on ESIF Water Use and Savings for more details). Additionally, the ESIF reuses about 30% of the server waste heat annually from the HPC data center for an additional expected water savings of 2.7 million gallons, resulting in 11 million gallons of expected annual water savings.

Significant Cost Savings are Achievable

NREL's HPC data center will support the lab's breadth of research, leading to increased efficiency and lower costs for research on clean energy technologies including photovoltaics, wind energy, electric vehicles, building technologies, and renewable fuels.

Not only will the HPC data center be crucial to advancing NREL's mission, enabling scientists to address challenges that have been intractable to date, the new system will provide fairly significant cost savings. NREL experts estimate that the HPC data center could provide approximately $1 million in annual operating cost savings compared to a traditional data center thanks to an anticipated $800,000 in electrical energy savings and $200,000 in thermal energy savings from reuse of the server waste heat.

Written by Devin Egan



ESIF's high performance computing data center uses an innovative warm-water cooling system. Water has approximately 1,000 times the cooling capacity of air, which is the typical cooling mechanism for data centers.

Environment and Pollution Prevention

Multi-Year Goals:

- Demonstrate excellence in quality, environmental protection and safety by attaining Ancillary Services in the United States: Independent System Operation (ISO) 9001, ISO 14001, and OHSAS 18001 registration.
- Participate in the Sustainable Sites Initiative (SITES) Pilot Program.
- Develop a site-wide landscape maintenance program.
- Develop a monitoring program to evaluate the performance of several landscape elements and practices including stormwater quality and quantity controls, snow management materials and techniques, and weed and fire management methods.
- Incorporate bird-friendly glass in building designs.
- Divert from landfills at least 50% of non-hazardous solid waste, excluding construction and demolition debris, by the end of FY 2015.
- Divert from landfills at least 50% of construction and demolition materials and debris by the end of FY 2015.
- Meet procurements requirements by including necessary provisions and clauses (sustainable Procurements/ Biobased Procurements).

Composting and NREL's 4Rs philosophy of reducing, reusing, recycling and rebuying enable NREL to divert solid waste from landfills—and support the lab's near-zero waste goal.

Environment and Pollution Prevention

Strategic Intent

Since its inception, NREL has strived to be a good steward of the environment through our research and operations. As a premier resource for renewable energy information, research, and technology, NREL has a unique role in supporting the nation's energy and environmental goals. NREL has a positive environmental presence, both in the operation of the laboratory facilities and in the major impacts to global conditions by lab research.

ENVIRONMENTAL MANAGEMENT

NREL's Environment, Health, and Safety (EHS) program has a long history of protecting our air, water, and land while working to reduce waste and impacts to the surrounding environment and cultural resources. The laboratory's Environmental Management System (EMS) supports effective environmental stewardship of our sites and minimization of the potential environmental impacts of the laboratory's activities. Through the EMS structure, the laboratory complies with environmental requirements, seeks to protect and enhance the vegetation, wildlife, and natural resources of the lab sites and encourages continuous improvement in environmental protection.

FY 2012 PERFORMANCE STATUS

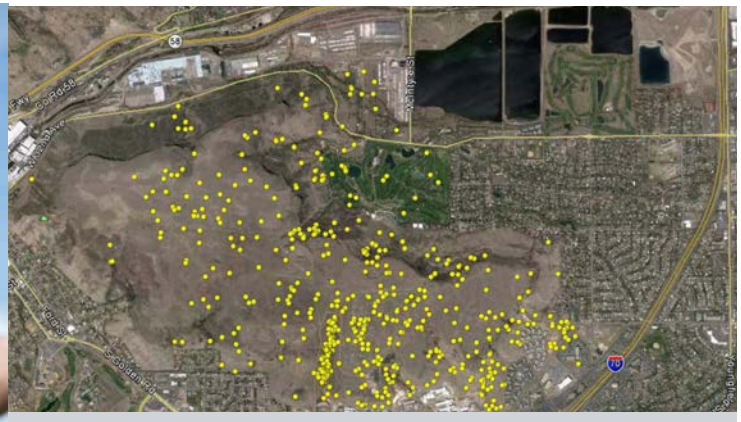
Environmental Stewardship

Biodiversity and natural resource management are achieved by following NREL's established policies and procedures, periodically performing updates to procedures to incorporate new or changed regulatory requirements, and to practice adaptive management by incorporating lessons learned. The flow down of institutional and regulatory requirements provides a framework for daily management of NREL's activities through:

- Integration of biodiversity considerations in analytical tools such as environmental site impact assessments. NREL's EHS conducted several National Environmental Policy Act (NEPA) reviews for all on-site construction activities focusing on avoiding, minimizing, and mitigating impacts to natural resources.
- Engagement with relevant stakeholders. NREL EHS shared information with federal, state wildlife, and public agencies.
- Formation of a methodology for establishing biodiversity. NREL's EHS conducted seasonal surveys to determine the presence of any wetlands, endangered species, or nesting birds prior to on-site construction activities. Mitigation actions were put in place to avoid adverse impacts to these resources during construction activities. In addition, any onsite species mortalities are evaluated to determine if mitigation actions can be put in place to avoid such mortalities in the future.
- Setting specific targets and objectives. The laboratory sets specific environmental objectives, targets, and actions annually and tracks progress of actions regularly using the Reliance EtQ software system.
- Monitoring and evaluating processes from an internal quality assurance viewpoint as well as in NEPA reviews.
- Public reporting. Reporting to appropriate agencies is conducted according to the NEPA process. Additionally, local newsletters and NREL Public Affairs distributions keep the community informed.
- NREL Lab-level policies for the management and conservation of natural resources include:
  - Policy 6-2.21 Natural Resources Conservation and Avian Protection Plan
  - Policy 6-2.2 National Environmental Policy Act Implementation
  - Policy 6-2.12 Weed Management
  - Policy 6-2.19 Sustainable Landscape Design
  - Policy 6-2.20 Environmental Management System.

Wildlife Conservation

NREL biologists partnered with the U.S. Department of Agriculture and the Colorado Division of Parks and Wildlife to trap and collar an adult male coyote (Canis latrans) in May 2012. This effort was part of a larger study to observe the behaviors of urban coyotes and develop management strategies to avoid or reduce harmful human-coyote interactions in the Denver metropolitan area. The collar was recovered in January 2013 and provided regular GPS points for the previous six months. A map of the GPS points is presented on the following page. The collared coyote primarily stayed on top of South Table Mountain (STM) and used adjacent ravines. The coyote frequented the ravine adjacent to the mesa top access road just west of the STM site and infrequently visited the STM site via the middle drainage, crossing south through the site to Lena Gulch.



Tracking of a collared coyote shows areas visited at STM, including NREL's campus, over a six month period.

Wildlife Surveys

Several comprehensive wildlife surveys have been conducted on the STM site, starting with the original study in 1987. Additional surveys were done in 1999 for the establishment of a conservation easement of 172 acres within NREL's existing 300 areas of the STM Campus property. Surveys to update existing data were completed in 2005 and in 2011. Mammals identified during the surveys included mule deer, elk, coyotes, red foxes, raccoons, striped skunks, mountain lions, rabbits, and various smaller mammals. More than 50 species of birds have been recorded on the STM site by the formal wildlife surveys and supplemental employee observations. A number of raptor species have been recorded at or above the STM site, especially during spring migration. Two raptor species are resident at the site: American kestrel (Falco sparverius) and red-tailed hawks (Buteo jamaicensis). Reptiles and amphibians inhabit the area as well. Most notably, the western diamond-backed rattlesnake is routinely encountered around the campus area and Woodhouse's toads are locally abundant in seasonal ponds on the mesa top.

INTERNATIONAL UNION FOR CONSERVATION OF NATURE (IUCN) RED LIST

2012	Total # Avian Species	Avian Species in Affected Habitats	FWS Conservation Listing	Total # Avian Species	Avian Species in Affected Habitats
Least Concern	92	33	Species of Concern	14	4
Vulnerable	0	0	Endangered	0	0
Near Threatened	1	0	Threatened	0	0
Endangered	0	0	Delisted	2	0
Critically Endangered	0	0	Candidate	1	1
2013	**Total # Avian Species**	**Avian Species in Affected Habitats**	**FWS Conservation Listing**	**Total # Avian Species**	**Avian Species in Affected Habitats**
Lease Concern	93	33	Species of Concern	14	4
Vulnerable	0	0	Endangered	0	0
Near Threatened	1	0	Threatened	0	0
Endangered	0	0	Delisted	2	0
Critically Endangered	0	0	Candidate	0	0

Comprehensive wildlife surveys have been conducted at the National Wind Technology Center (NWTC) site as well. When the NWTC was included as part of Rocky Flats Environmental Technology Site, ecological studies were conducted within the NWTC boundaries which included bird surveys, small and large mammal surveys, and vegetation studies (RFETS 1995). Surveys to update existing data were completed for vegetation in 2000, for bats and birds in 2003 and in 2011 for avian use. Mammals identified during the surveys included mule deer, elk, coyotes, bobcats, red foxes, raccoons, long-tailed weasels, striped skunks, mountain lions,

More than 50 species of birds have been recorded by formal wildlife surveys and employee observations at the South Table Mountain campus. An Earth Day guided tour of the Lena Gulch wetlands areas provided an opportunity for employees to appreciate the native landscape and wildlife.

rabbits, and various smaller mammals. More than 60 species of birds have been recorded on the NWTC by the formal wildlife surveys and supplemental employee observations. A number of raptor species have been recorded at or near the site, especially during spring migration. These raptor species include red-tailed hawk, American kestrel, prairie falcon, ferruginous hawk, great horned owl, golden and bald eagles. Note that due to the lack of a well-established prey base for eagles at the NWTC, no eagles have been reported using habitats at the NWTC, but have been reported in the adjacent airspace of the Rocky Flats Wildlife Refuge south and east of NWTC. Reptiles and amphibians inhabit the area as well. Bull snakes inhabit the grasslands and are frequently seen. During spring, in ditches and ephemeral drainages, chorus frogs can be heard.

To identify species or species groups that may be at risk from NWTC operations and development, NREL completed a year-long survey in 2011 to document avian use and to document bird and bat mortalities. Avian-use surveys included breeding bird surveys during the spring and summer, raptor migration surveys during the spring, and weekly avian site-use surveys (including raptors and non-raptors) over the entire year. Avian and bat mortality surveys were also conducted weekly over the entire year. In addition, wildlife surveys, including bat surveys were conducted during 2010 and 2011. Results from these surveys were discussed in the 2011 Environmental Performance Report: www.nrel.gov/docs/fy12osti/54980.pdf.

Landscape Management

NREL is committed to responsible stewardship of our natural ecosystems, native wildlife and vegetation, and important cultural resources. Natural resources at the STM are managed appropriately to ensure our research needs are met while protecting native wildlife and vegetation. NREL's weed control program is an integral part of our landscape management activities NREL's weed control program is based on the fostering of desired plant species and communities, rather than on simply eliminating weeds. For example, preventive programs are implemented to keep a management area free of weed species that have not yet become established, even though there are nearby sources of weed seeds.

NREL uses an integrated weed management approach that incorporates various types of weed control methods including herbicide treatment, mechanical practices (e.g., mowing), biological practices (e.g., organism specific to weed species eradication), cultural practices (e.g., reclamation of disturbed areas), and prevention (e.g., limiting or eliminating driving of vehicles off established roadways). The effectiveness of control methods is periodically assessed, and adaptive management techniques used to modify methods accordingly. The use of multiple strategies for control and specific use and timing of herbicides has been successful in significantly reducing onsite populations of diffuse knapweed and Canada thistle. The weed control program maintains the flexibility needed to respond to changes in weed populations from year to year. Periodic mapping of weed infestation areas

Many wildlife species have been surveyed at both NREL campuses—National Wind Technology Center and South Table Mountain—including those shown here.

assists in targeting weed control efforts. NREL also uses a certified weed-free, native grass seed mix for re-seeding of disturbed areas following construction activities.

NREL's Weed Management Program was updated in FY 2012 and FY 2013 and includes the latest strategies and best practices incorporating Integrated Pest Management philosophy. NREL worked in cooperation with the Jefferson County weed control coordinator and surrounding landowners to improve the management of listed noxious weeds at its sites. NREL treated 30 acres of grasslands at its STM campus to control Canada thistle, Scotch thistle, myrtle spurge, and diffuse knapweed and 64 acres at its NWTC campus to control diffuse and spotted knapweed and Canada thistle, all state-listed noxious weeds. Improved weed management will result in enhanced wildlife habitat, dominated by native species and assist in maintaining native biodiversity. The Weed Management Program is scheduled for revision on a five-year basis.

In FY 2012, NREL continued its participation in the SITES Pilot Program, an interdisciplinary partnership led by the American Society of Landscape Architects, the Lady Bird Johnson Wildflower Center, and the United States Botanic Garden, working to foster a transformation in land development and management practices. The benefit of participation in this program is an opportunity for STM construction projects to incorporate the guidelines presented by the SITES program to create NREL performance benchmarks for sustainable land design, construction, and maintenance practices. In FY 2013, NREL received certification and was awarded three stars out of four.

In FY 2013, a Landscape Maintenance Plan was implemented as part of the SITES program, which provides guidance on proper landscaping maintenance and materials in support of:

- Plant stewardship
- Invasive species management
- Organic materials management
- Soil stewardship
- Irrigation and water use
- Stormwater management features and best management practices
- Materials management
- Recyclable materials
- Landscape maintenance equipment
- Snow and ice management
- Adaptive management
- Monitoring.

Water Quality

Water quality is closely linked to the surrounding environment and land use. Our water resources are of major environmental, social, and economic value to NREL; and if water quality becomes degraded, this resource will lose its value. Water quality is important not only to protect public health; it also sustains ecological processes that support native fish populations, vegetation, wetlands and wildlife, including birds. NREL has established water quality objectives to manage the interactions and interconnections between surface water and groundwater, the atmosphere, landscape features, human activities and wildlife health.

Several best management practices are utilized in the construction of our facilities that dually function to enhance water quality. Per Energy Independence and Security Act (EISA) Section 438, low impact development practices continue to be incorporated into new construction and have included:

- **Porous pavements.** Porous paver materials were installed in the courtyards of the new RSF north wing, the hardscape areas surrounding portions of the Energy Systems Integration Facility (ESIF), and the new parking garage. NREL's monitoring activities evaluated two other existing systems, filterpave and pervious concrete which were installed in the STM surface lot in 2010. The filterpave system has performed very well. FILTERPAVE® porous pavement is made from 100% post-consumer recycled glass. Each square foot of FILTERPAVE® saves 90 glass bottles from landfills. This pavement system is twice as porous as other hard-surfaced

porous pavements (38%) and produces a greater reduction of stormwater runoff and better resistance to clogging and maintenance requirements. In late spring of 2012, a maintenance top coat was reapplied per the manufacturer's recommendation. Unfortunately the pervious concrete underperformed with large expanses decomposing. As part of the collaborative pervious pavement research and pilot project efforts, Urban Drainage and Flood Control District, who monitors these types of installations, visited late summer 2012 and agreed the product was an inferior performer. NREL will explore more conventional concrete installations with multiple cut joints for enhanced infiltration and pavement system performance and longevity.

- **Landscaping stabilization materials.** Pre-vegetated and slope stability mats were installed in the Central Arroyo Detention Basin. These materials are designed to improve slope stability during the restoration phase and to speed vegetation establishment.
- **Native prairie grasses, shrubs and trees.** Throughout the STM campus where small outdoor projects take place, NREL has planted native vegetation to prevent wind erosion as well as erosion and sedimentation from stormwater and snowmelt on steep slopes.

POLLUTION PREVENTION AND WASTE REDUCTION

As an early adopter of recycling, with a program established in 1980, NREL has a long history of creating a culture that supports waste reduction. NREL is working to further our efforts by establishing a near-zero waste campus that emphasizes source reduction and resource recovery, making efforts to minimize waste each step along the way.

NREL works toward near-zero waste by promoting sustainable decision making that considers product life from cradle to cradle. Making the 4Rs philosophy of reducing, reusing, recycling and rebuying integral to our operations, NREL balances environmental, social, and financial considerations.

FY 2012 PERFORMANCE STATUS

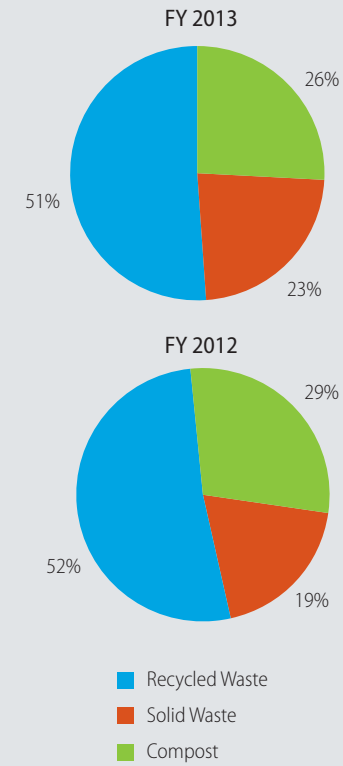
Campus Waste

Waste Diversion

In FY 2012, NREL diverted 81% of its campus waste from the local landfill and 77% in FY 2013. NREL's Near-Zero-Waste Initiative helped support this reduction by providing training on recycling and composting to employees.

New in FY 2012, NREL also included biomass waste from the IBRF and the new cafeteria (Café) on the STM campus. The Café, which opened in June 2012, increased composting campus-wide by an additional 4% from the previous fiscal year.

A waste audit was performed in Research Support Facility (RSF) kitchens and break rooms with results indicating that the recycling and composting programs are successful. On average, only 9% of the recycling collections were contaminated with trash or compostable materials and 18% of the compost collections were contaminated with either recyclables or trash. The trash audit showed a higher contamination rate with approximately 49% compostable or recyclable materials found in the trash. This provides useful information for targeting future education and training.



STM Campus Waste Diversion FY 2012 and FY 2013

NREL recycled 1,471 pounds or 196 pounds of 196 gallons of used cooking oil in FY 2013 from Café operations. The diversion of waste oil makes efficient use of this resource for the production of clean-burning alternative fuel, while saving packaging, greenhouse gases, and the need for fertilizers and pesticides in growing new alternative fuel sources.

Opportunities for Staff to Bring Recycling Items from Home

NREL organizes the following events for staff members biannually:

- Electronics recycling to dispose of hard-to-recycle personal items such as computers, printers, and monitors
- Document shredding and recycling to dispose of sensitive personal documents in a safe environmentally friendly manner.
- A used book, CD, and DVD drive, which benefits a deserving school or other nonprofit organization in the community. Fifty percent of the proceeds from items sold go to a school. Those items that cannot be sold are redistributed to a literacy-focused non-profit organization, including libraries and schools. Those items that cannot be sold or redistributed are recycled. This event was so popular that a permanent bin has been installed near the parking garage for employees to recycle their used books, CDs, and DVDs.

Since FY 2011, NREL has participated in Environmental Protection Agency (EPA) Federal Green Challenge and WasteWise Programs for federal waste prevention and resource conservation. NREL continues to replace computer printers, copiers, scanners, and fax machines with ENERGY STAR®-certified multifunction devices (MFD) on campus—effectively reducing the need for standalone equipment. Only MFDs are allowed in all new facilities. Defaults on all computers and printers are set for double-sided printing. In FY 2012, NREL reduced paper usage by 35% exceeding its self-imposed goal of 5%. All paper used in 2012 contained at least 30% post-consumer fiber. As a new introduction to promote paper manufactured from responsible renewable resources, NREL used copy paper available from sugar cane. This Cane Fields product is made from 80% sugar cane waste, or "bagasse," and 20% Certified Plantation Fiber instead of trees from forests. In FY 2013, NREL's paper usage increased 31% from the previous year, with a current use of four reams of paper per person. This increase is attributed to the ESIF construction project requiring a larger number of printing projects than normal. All paper used at NREL contains at least 30% post-consumer fiber. In FY 2013, NREL piloted the use of 50% and 100% recycled content paper in printers. The 100% recycled paper was found to be problematic in the MFDs. The 50% recycled content paper worked in the MFDs but is not cost effective to be used lab-wide at this time. All cartridges from the MFDs are sent back to the manufacturer or a subcontractor to be recycled or reused.

Pollution Prevention

Sustainable NREL and the EHS Office continued the Pollution Prevention Initiative Program—providing NREL staff with the opportunity to submit their ideas on the reduction of waste, materials, water, air emissions, and energy use. The project ideas submitted by staff are being evaluated for feasibility and further consideration.

In FY 2012, two pollution prevention assessments were initiated:

- Promote the use of the NREL Office Supply Depot—a location where staff currently drops off unwanted office supplies for others to reuse. This helps NREL save money and helps the environment by reducing purchases of new office supplies and reducing the amount of materials that would otherwise end up in a landfill.
- Evaluate the lab's waste diversion to determine if key waste streams, such as wood and metals, are consistently being diverted from the landfill.

NREL achieved an estimated reduction of 337,580 pounds of equivalent carbon dioxide (CO_2) emissions annually by switching from sulfur hexafluoride (SF_6) to nitrous oxide (N_2O) for all fume hood testing. SF_6 is the most potent of the six commonly accepted greenhouse gases, with a global warming potential (GWP) 23,900 times that of CO_2 when compared over a 100-year period. SF_6 is also extremely long-lived, is inert in the troposphere and stratosphere, and has an estimated atmospheric lifetime of 800–3,200 years. N_2O has been proven as a successful alternative tracer gas for testing fume hoods. With a GWP of 310, N_2O produces far fewer greenhouse gas emissions than SF_6. Conducting a fume hood test using N_2O results in roughly 33,758 pounds less of CO_2 equivalent emissions per test due to its significantly lower GWP—77 times less CO_2 emissions than if SF_6 is used.

Chemicals

NREL relies on several systems to reduce the quantity of toxic and hazardous chemicals and materials acquired, used, or disposed of including a Chemical Management System and Excess Chemical Inventory. NREL conducts annual training on chemical safety and hazardous waste management for all lab workers and a formal hazard identification and control process is used to minimize the risks associated with any new or changed lab process. Annual goals for pollution prevention are set as part of NREL's EMS. NREL also works toward DOE's goal to use alternative chemicals and processes by

giving preference to environmentally preferable products (EPP), including bio-based products, EPEAT electronics, and low- or no-volatile organic compound paints.

In FY 2012, several of NREL's laboratories were remodeled. During this process, the EHS Office encouraged researchers to scrutinize chemical inventories for excess hazardous materials that could be removed from use or identified as surplus for use in other labs. NREL also continued to track refrigerants and fluorinated compounds purchased, and maintained a chemical inventory using its Chemical Management System. Regular reviews of Safe Operating Procedures and Readiness Verifications (for new activities or activities with changing scope of work) were also conducted to include consideration of potential GHG impacts from chemical purchase, use, storage, and disposal.

In FY 2013, NREL continued to maintain its chemical inventory system at a high level of accuracy and broad functionality for all users. Training programs continued to promote the use of materials with lower toxicity wherever possible and emphasize the availability of the excess chemical inventory. With the addition of ESIF, a major new research facility, new technologies for chemical tracking are being evaluated for better management of chemical inventories. A detailed evaluation of the chemical life cycle at NREL was created in FY 2013 to better understand the laboratory's investment in inventory maintenance and chemical waste management.

Sustainable Acquisition

NREL continues to work to implement new policies and programs that increase the acquisition of sustainable products and engage in contracts consistent with EO 13514. In FY 2012, Policy 10-1: General Procurement was finalized and included a sustainable acquisition section. Purchase card (PCard) and purchase request procedures were also finalized and implemented in FY 2012, requiring consideration of a sustainable product before purchasing. Performance associated with these new policies and procedures are monitored through NREL business systems, contractor tracking reports, and basic ordering agreements. The business systems are being updated to capture sustainable acquisitions.

In FY 2012, NREL participated in the EPA's Federal Green Challenge, which is a national initiative for federal agencies to lead by example in reducing the federal government's environmental impact through sustainable materials management. As part of NREL's participation in this program, NREL pledged to increase EPP for campus activities by 5% in FY 2012 from a FY 2011 baseline. In order to meet the Federal Green Challenge goal, NREL identified the following targets for FY 2012:

- Reduce usage of office paper by 5%. We successfully reduced our paper usage by 24,365 pounds or 35% from the FY 2011 baseline.
- Green Cleaning Plan. With the green janitorial contract in place, 100% of cleaning products used by janitorial staff were biobased and 100% of paper products used were made of recycled-content materials.
- Meeting and Event Services. Meetings, trainings, and conferences at NREL were generally catered by small local food service businesses (85%) offering only "green" catering. In June 2012, an on-site Café opened providing catering services for all NREL meetings and events. Depending on the event, the use of reusable dishware, silverware and glassware or compostable plates, cups and utensils is required. The Café also provides reusable dishware, silverware, and glassware and compostable takeout containers, plates, cups and utensils.

In FY 2012, NREL purchased over 99% of its desktop computing devices as EPEAT-compliant. Because of NREL's purchasing policy and staff participation in adhering to recommended equipment when purchasing, 97.8% of the lab's computing equipment purchased in FY 2012 is EPEAT gold certified, 1.8% is silver certified, and only 0.4% does not align with FEC standards. NREL maintains a database of vendor sustainability practices to track vendors not governed by EPEAT standards. Only those vendors whose manufacturing, distribution, and operations practices meet or exceed EPEAT standards are selected for business with the lab.

In FY 2012, NREL purchased more than $300,000 in green supplies, including toner cartridges and copy/printer paper from the CADDO office supply catalogue and General Services Administration (GSA). PCard purchases included: recycle, compost and waste bins made with 35% recycled content; laboratory supplies; and signage. The CADDO catalogue, which includes earth-friendly office supply products, manufactured from recycled content facilitates green purchases for staff.

Federal Electronics Challenge

For the second year in a row, NREL's Federal Electronics Challenge (FEC) Team has earned the FEC Platinum-level Award, which recognized their actions to help the federal government improve its sustainable practices. In FY 2011, NREL raised the bar and was the only DOE facility to receive the Platinum-level; In FY 2012, NREL was one of three.

NREL achieved the Platinum-level award by completing many projects, including implementing several basic ordering agreements to help manage energy-efficient computing equipment requirements and costs. In fact, 99% of desktop computing devices purchased at NREL comply with Electronic Product Environmental Assessment Tool (EPEAT) and ENERGY STAR requirements. Other projects included creating a database to track lifecycle data for electronic equipment, ensuring the environmentally friendly disposal of electronics, and reviewing and revising NREL's policies to make our information technology environment even more energy efficient.

In addition to these activities, NREL also drafted a case study documenting NREL's electronics life-cycle management and sustainability practices. The study documents the decline in NREL's overall power consumption at the desktop level by about 78%.

CREATING A MULTI-PURPOSE AMENITY

Central Arroyo Detention and Water Quality Pond

NREL is committed to preserving and enhancing the campus environment while constructing new laboratories, offices, and site supporting facilities. These actions include the protection and enhancement of on-site water resources and improving its water quality.

Multiple construction projects have recently occurred on the STM campus. When building these laboratory facilities, the building's foot print area removes open space and increases the amount of roof space and impervious land areas on our site. These outcomes increase the amount of stormwater to capture and detain so it does not impact our neighbors. This responsibility required the creation of an integrated water resource management system. The Central Arroyo Detention and Water Quality Pond is a significant component within this system.

The Central Arroyo Detention and Water Quality Pond detains stormwater runoff from these areas, reduces peak flow events, and finally discharges downstream to Lena Gulch in a controlled manner. This constructed wet and dry meadow covers more than five acres and can detain more than three million gallons of stormwater. To optimize performance, NREL utilized unique materials that accelerate the revegetation establishment, reduce operation and maintenance issues, reduce invasive weed species and enhance water quality.

Two very unique construction materials were used to promote quick establishment of the constructed wet meadow and enhance water quality functions:

- **Forebays.** These structures are key components to hosting initial stormwater flows and provide an open area for dirt to settle. Runoff from upstream areas of the STM campus discharges and collects into three forebays. These areas function to reduce flow velocity, as well as trap potentially polluted sediment and debris which are removed annually by a skid loader, so they do not

In addition to providing water quality and stormwater detention storage, the Central Arroyo Detention Basin provides a multi-purpose amenity. Vegetation surrounding a one-third-mile loop supports a local wild life habitat and a connection with aesthetic beauty and the natural environment for pedestrians.

transport and impact receiving waters to Lena Gulch. Infiltration and pollutant uptake functions of plants are enhanced because wetland plugs are planted in a continuous grid of pervious holes formed into the concrete.

- **Pre-vegetated wetland mats.** Twelve months prior to the installation of the pond, coconut coir mats were pre-planted with transitional wetland species to create an accelerated planting product. This innovative filter material provides a broader surface area to diminish channel downcutting from stormwater erosion, forms a series of shallow basins to enhance infiltration, and its native plants biodigest excess nutrients like nitrogen and phosphorous. The material is installed similarly to laying out carpet disallowing areas of barren soil. This greatly lessens erosion and mitigates weed competition. The use of this material further replicates riparian ecosystem functions by providing wildlife habitat, substrate for biota occurrence, groundwater recharge, reducing peak storm events, and reconnecting migration corridors between the mesa top and Lena Gulch.

Complementary to this primary function of stormwater collection are other design considerations to create an aesthetic multi-purpose campus amenity:

- **Insects, birds, and mammals.** The surrounding vegetation community pond perimeter and patches provide an important local wildlife habitat. Nectar bearing forbs support pollinators such as bees, butterflies, and hummingbirds. Rodents and other small mammals provide food for local owls and raptors. Migratory songbirds use this habitat for breeding and/or winter habitat. Other species frequently using this habitat include mule deer, coyote, raccoon, and red fox.
- **Native plantings.** Installing native trees, shrubs, and grasses are vital for multiple reasons. These plantings provide aesthetic beauty and connection to the natural environment, demand less water use, share a symbiotic relationship with local wildlife, exhibit more disease resistance, and require lower long-term maintenance.
- **Pond perimeter trail.** A one-third mile loop supports a pedestrian-oriented "walking campus" that encourages outdoor physical activity to improve the health and well-being for staff. Along the trail are benches to take in scenic views, observe wildlife, or relax. Interpretive signs identify features to educate the purpose and unique features of the pond.
- **Camp George West firing line.** NREL's STM campus was previously used as Camp George West, a training installation established in the 19th Century for the Colorado National Guard. Remnants of a Camp George West firing line have been preserved and relocated in the upland area of the pond. This firing line was used for military rifle target practice until the end of World War II.

Stakeholder Initiatives

Multi-Year Goals:

- Cultivate an employee culture focused on reduction of electricity, natural gas and water use, process and fugitive emissions, waste, commuting, and business travel.
- Use a collaborative, integrated planning and design process that initiates and maintains an integrated project team in all stages of a project's planning and delivery.
- Host and sponsor educational and partnering activities to share knowledge and promote the adoption of energy efficiency and renewable energy technologies.

An NREL staff member and a student look at the class materials for the Power and Energy Engineering Practice School. The practice school is a collaborative effort between NREL and the Colorado Schools of Mines.

Stakeholder Initiatives

SUSTAINABLE INNOVATION THROUGH EMPLOYEE ENGAGEMENT

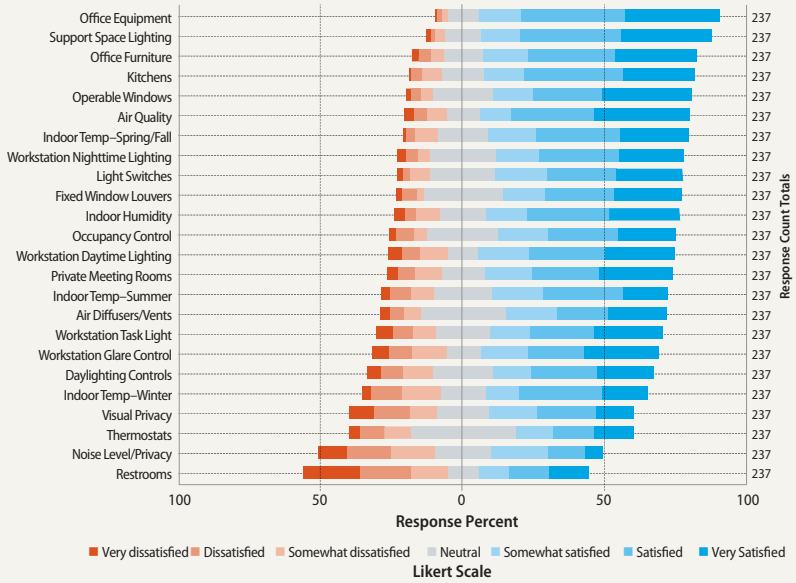
Parallel to our mission of developing and deploying clean energy technologies is motivating and empowering NREL employees' sustainable actions that foster energy and environmental stewardship. NREL seeks to nurture this behavior in our employee population individually as well as collectively to minimize waste, use less energy and water, and minimize depletion of (and impact to) natural resources. NREL recognizes in order to implement sustainable innovation and attain successful outcomes, it is critical to have an employee engagement program that builds participation and ownership. Even though each campaign's program varies, its foundation is replicable and comprised of the following key elements:

- Communicate campus goals and objectives.
- Present relevant data that illustrates the necessity of change or initiative.
- Educate how sustainability initiatives correspond to sustainable behavior change.
- Offer webinars, workshops and guidelines to identify actions for enablement.
- Retrieve feedback from employees to enhance program participation and achieve continual improvement.
- Communicate performance targets and their results.

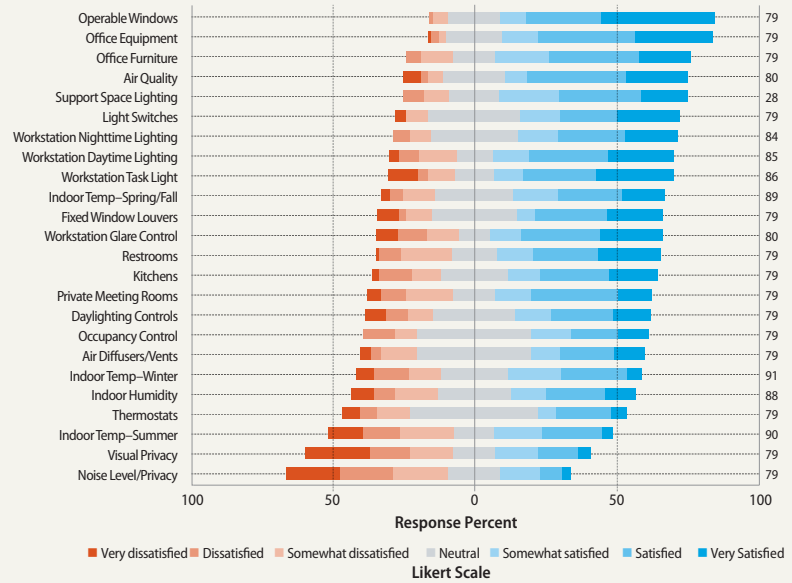
Strategic Intent

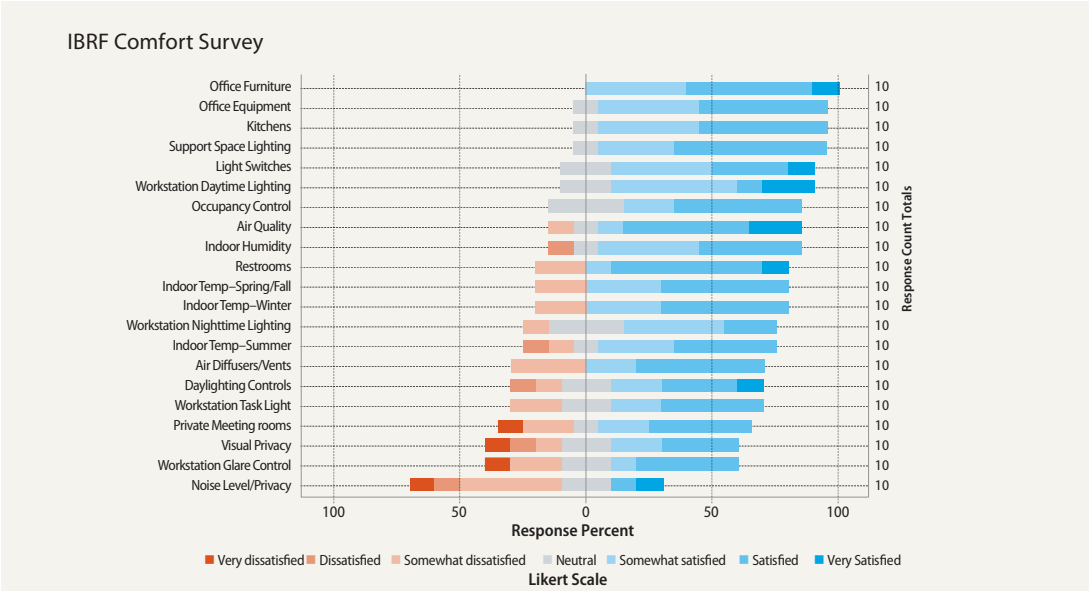
NREL goes beyond prescriptive management approaches and protocols to drive reductions in energy, water, waste, and greenhouse gases necessary to meet NREL's elevated performance standards. This leadership creates an environment that enables NREL employees to operate as agents of change to create a stronger, more sustainable community external and internal to NREL. NREL focuses our efforts on educating and finding ways to share our knowledge and resources to be an asset to our local, national and global communities.

RSF I Comfort Survey



RSF II Comfort Survey





During FY 2012 Sustainable NREL, the Research Support Facility (RSF) Building Area Engineer, and the Commercial Buildings Tools Group continued to develop the Building Agent platform—an interactive comfort survey—of RSF building occupants to investigate and assess building environmental conditions and employee workstations. Several environmental conditions were identified from occupant feedback and physical modifications were executed to resolve their concerns.

Issues addressed included:

- Installation of pull shades and frosted film applied to window to mitigate the impact of glare
- Installation of a bypass loop valve in heating and cooling loops to produce more consistent temperature control and performance in the RSF A wing
- Sound masking system adjusted to address individual or wing-wide acoustic needs
- Air quality testing to ensure proper limits are being attained and sustained
- Installation of sit-to-stand workstations to enhance employee ergonomic working environs.

In FY 2013, comfort surveys were deployed for RSF II and IBRF through the Building Agent program. Results indicate that high noise volume and lack of privacy remain priority issues in these buildings' open work environment.

Other program initiatives that stimulated increased participation entailed the adjustment of shuttle schedules to generate increased ridership, installation of more bicycle stations, waste audits to identify improved measures for recycling and composting, new employee-led recreation classes, and relocating smoking areas for improved air quality around building perimeters.

NREL Integrated Project Teams

NREL utilizes integrated project teams (IPTs) in various development programs/projects for review and decision making. The emphasis and structure of the IPT is on the involvement of all stakeholders (users, technical experts, management, and contractors) in a collaborative forum. This gathering of a multi-disciplinary group has demonstrated effective project results by being involved in the early stages of development. Within Site Operations, IPTs are created with members from its facilities and sustainability group and researchers from the Science and Technology directorate to inform and collaborate on systems engineering methodologies and solutions for implementation. The team evaluates collectively to inform life-cycle decisions because the product or system development activities change and evolve over its life. For the development of our campus and building energy efficiency and renewable energy projects, NREL is at an advantage being a national leader in the clean-energy industry. The group dynamic is extremely beneficial and enriching discussion is the real application of innovative technology. Education and knowledge sharing is key in nurturing, developing, and expanding NREL's core competencies.

Partnering to Amplify Impact

Partnerships are essential to accomplishing the NREL mission. Projects beyond DOE, our primary customer, bring resources, experiences, and knowledge that sustain the relevance of the laboratory and amplify its impact. NREL partners extensively with those who provide complementary resources that can mature and then implement the knowledge and innovations of the laboratory in the marketplace where the impact on national goals is realized. This work can also help attract and retain staff by offering a diversity of interesting research topics and by building professional networks and channels to impact. All major partnerships, including work for others, are discussed because of their importance in creating leverage beyond the laboratory's prime sponsor, DOE's Office of Energy Efficiency and Renewable Energy (EERE).

Partnerships are essential in accomplishing the NREL mission. At an annual NREL Industry Growth Forum (left), investors, entrepreneurs, scientists, and policymakers participated in panel discussions and networking opportunities. The ESIF (right) is one of several facilities available to industrial, university, and government researchers for collaborative research.

Creating an External Forum

NREL has test and user facilities available to industry and other organizations for researching, developing, and evaluating renewable energy and energy efficiency technologies. NREL's newest laboratory, the 182,500-square-foot Energy Systems Integration Facility (ESIF), opened November 2012, and is the nation's first facility to assist both public- and private-sector researchers focus on utility-scale clean energy grid integration. This partnering facility will provide industry partners the opportunity to work with NREL and insert their individual technologies into a controlled integrated energy system platform to test and optimize the technologies to reduce the risk of early market penetration.

ESIF houses more than 15 experimental laboratories and several outdoor test beds, including an interactive hardware-in-the-loop system that lets researchers and manufacturers test their products at full power and real grid load levels. A megawatt-scale test facility, ESIF will help NREL speed the commercialization and deployment of renewable energy and energy efficiency technologies for the U.S. electric power system. This facility also features a petascale supercomputer that can support large-scale modeling and simulation at one quadrillion operations per second.

ESIF is aimed at overcoming generation, transmission, distribution and end-use challenges to support a cleaner, affordable and more secure U.S. energy mix, including research into next generation building technologies, microgrids, energy storage batteries and utility-scale renewable energy. As the cost of clean-energy technologies continues to come down, seamless and efficient grid integration will help make these resources and products even more affordable, while giving Americans more control over how they use energy in their homes and businesses.

"ESIF is an excellent example of the impact that federally-funded research can have on solving national problems beyond the scope of private investment. And, it demonstrates the importance of partnerships among the federal government, industry, and academia," NREL Director Dan Arvizu said. "With NREL's 35-year focus on developing competitive renewable energy and efficiency technologies, we're pleased to take a leadership role in this next frontier of energy research."

Electric car at Fort Bliss, Texas Army base. NREL is helping the U.S. Army with a new program that will have Army installations across the country thinking green—all the way to net zero. The Army Net Zero Initiative establishes energy baselines, estimates energy efficiency and alternative energy potential, evaluates grid interconnection, and develops an implementation plan.

UTILIZING NREL EXPERT ADVISOR PROJECT TEAMS

NREL experts have a broad range of experience in the deployment and market transformation of energy efficiency and renewable energy technologies. Spanning more than 30 years of direct experience, NREL has helped stakeholders understand and accelerate technology deployment in both the United States and internationally. The articles below demonstrate how expert advisor teams have contributed to the success of the projects discussed.

Army taps NREL in its pursuit of net zero energy

Teams of NREL energy experts are working with U.S. Army installations across the country to reach "net zero"—producing as much energy on-site as is consumed over the course of a year, with a preference for renewable energy sources.

For the Army, shifting to net zero energy is imperative. A 2008 report from the Defense Science Board found that U.S. military installations have inadequate backup power supplies to deal with extended power outages, creating unacceptable risks for critical military defense capabilities. Meanwhile, the U.S. Department of Defense (DOD) was already facing mandates to reduce its energy use and draw on more renewable energy, with a requirement to produce or procure at least 25% of its electricity consumption from renewable energy sources by 2025. These combined influences led the Army to launch its Net Zero Energy Initiative (NZEI) with an installation pilot program in early 2011.

NREL has been involved with the project from the outset, working with the office of the Honorable Katharine Hammack, Assistant Secretary of the Army for Installations, Energy, and Environment, to define net zero and select bases for the pilot, according to NREL's senior project leader Samuel Booth.

Of the dozens of Army installations that applied to the program, nine that are pursuing installation-wide net zero energy goals were selected to be pilot sites:

- Fort Bliss (Texas)
- Fort Carson (Colorado)
- Fort Detrick (Maryland)
- Fort Hunter Liggett (California)
- Kwajalein Atoll (Republic of the Marshall Islands)
- Oregon Army National Guard (Oregon)
- Parks Reserve Forces Training Area (California)
- Sierra Army Depot (California)
- West Point (New York)

NREL's current role in the program is to provide project development support to help the pilot installations implement the net zero energy strategies the laboratory's technical experts helped them develop in FY 2012.

Projects vary by installation, but NREL is engaged in energy efficiency projects such as building controls, lighting, heating, ventilation and air conditioning (HVAC), and sea water air conditioning, as well as renewable energy technologies, including: wind, solar photovoltaics (PV), solar water heating, biomass, and geothermal. NREL also assists with financing mechanisms, such as energy savings performance contracts and the DOD Energy Conservation Investment Program.

The pilot program is expected to demonstrate best practices, funding models, processes, and policies in net zero energy projects that can be replicated not just in military settings, but at federal sites across the country.

"In fact, NREL's Army NZEI work already is being replicated in similar support to the U.S. Navy's NZEI program, and NREL worked with the U.S. Air Force on the development of an NZEI policy," Booth said.

Learn more about NREL's work with the Army NZEI project at www1.eere.energy.gov/office_eere/pdfs/48876.pdf.

Written by Shelley Gonzales

PV panels installed at the Montessori School on St. Thomas. The U.S. Virgin Island pilot project has achieved significant milestones, one of which is retrofitting 12 USVI schools with energy-efficient upgrades guaranteed to save the government more than $11 million over 10 years.

NREL Helps Virgin Islands Chart Course to a Clean Energy Future

Like many island communities, the U.S. Virgin Islands (USVI) is nearly 100% dependent on fossil fuel to meet its energy needs. This leaves the territory vulnerable—not only to pollutants that threaten the environment, but also to global oil price spikes that wreak havoc on the economy.

Faced with utility rates four to five times higher than those seen in the continental United States, USVI Gov. John P. DeJongh Jr. came to NREL in February 2010 with a vision of leading the territory to a clean energy future by developing its considerable renewable resources. But there were a variety of hurdles to overcome, including a faltering economy, a lack of adequate technical expertise, the challenge of maintaining reliable energy service across isolated island grids, and the need for unbiased, expert guidance in clean energy deployment.

Amidst the challenges, the governor saw an opportunity for the territory to reduce its reliance on fossil fuels while emerging as a pioneer in forging a new kind of energy economy.

In support of the U.S. Department of Energy (DOE)-funded Energy Development in Island Nations (EDIN) initiative's USVI pilot project launched in 2010, NREL has provided a broad spectrum of technical assistance, including:

- Conducting energy resource assessments and technical analyses
- Providing a diverse set of stakeholders with quality education and training
- Assisting the utility in requesting and reviewing renewable energy project proposals.

In June 2010, EDIN-USVI formed working groups tasked with developing a holistic strategy for achieving the USVI's goal of reducing its fossil fuel use 60% by 2025. With leadership from NREL analysts, engineers, and project managers, the working groups were able to realistically assess the territory's renewable resources and develop a road map for achieving its ambitious goal through energy efficiency improvements and renewable energy development. And by tapping in to DOE funding and NREL policy, project management, and financing expertise, they were able to navigate the uncharted waters of clean energy project development, mitigate the risks associated with investing in renewable technologies, secure project financing, and attract highly qualified developers.

Among the most significant milestones the USVI has reached are:

- Retrofitting 12 USVI schools with energy-efficient upgrades guaranteed to save the government more than $11 million over 10 years
- Implementing a net-metering program and adopting transparent interconnection policies and procedures
- Installing a 451-kW solar PV system, the first large scale PV project in the territory, at the St. Thomas airport
- Signing a power purchase agreement in June 2012 with three companies to install a total of 18 MW of solar PV on St. Thomas and St. Croix in 2013
- Installing anemometers and SODAR units at the most promising wind sites NREL identified.

The 9 MW of solar generation slated for St. Croix alone represents nearly 20% of the island's peak demand, an unprecedented level of renewable energy penetration for a community of its size. And the wind resource testing is an important step forward for the territory as well. The "bankable" meteorological data collected over the next year will be essential to securing the financing needed to develop a utility-scale wind project. It will also help the utility understand the fluctuations in wind resources as it incorporates increasing levels of renewable generation.

"Island systems are some of the first grids to achieve high penetrations of renewable energy," said NREL Project Lead Adam Warren. "With these data and our modeling efforts, we can learn how to effectively integrate nondispatchable sources of power without affecting grid stability. And NREL's expanding energy systems integration capabilities will play an important role in helping isolated grids meet their renewable energy goals."

In turn, the lessons learned in the USVI will assist NREL in developing viable solutions to the systems integration challenges involved in increasing renewable energy penetration on a much broader scale.

By adopting and pursuing one of the most aggressive clean energy goals in the United States, the USVI has taken bold steps to increase its energy security, protect its environment, and strengthen its economy. In so doing, it has also seized an opportunity to lead, charting a course for other islands to follow as they journey toward energy transformation.

Written by Karen Petersen

NREL Works toward Green Prosperity in Indonesia

On Nov. 18, 2011, the Indonesian government and the Millennium Challenge Corporation (MCC) signed a compact to reduce poverty in Indonesia by stimulating economic growth through the use of renewable energy. With a commitment of $600 million over five years, the compact focuses on three activities: community-based nutrition improvement, modernization of government procurement, and a Green Prosperity project that promotes low-carbon economic growth by expanding renewable energy power generation, and improving natural resource management and sustainable land use.

Since a significant portion of the funding will be allocated toward grants and loans for qualified projects, MCC requested NREL's technical assistance with project selection, evaluation, and development. NREL is currently creating a set of project selection criteria, performing prefeasibility studies, and building economic models to evaluate the eight types of projects of interest:

- Micro, mini, and small hydropower (on- and off-grid; new generation and upgrades)
- Biowaste-to-energy, including palm oil factory methane capture
- Solar PV generation (on- and off-grid)
- Household biogas production
- Integrated hybrid power generation with local mini-grid development
- Smallholder agriculture intensification programs for the sustainable production of prominent food or industrial crops, related certification programs, and associated value chain investments that contribute to energy efficiency or other forms of reduced carbon footprint
- Watershed management programs, whether comprehensive in nature or focused on a particular issue or opportunity
- Community forestry (in both protected and productive forests) and agroforestry.

Some unique challenges exist for NREL—all projects must satisfy a variety of stringent technical, economic, environmental, and social requirements. For example, every project must be technically sound and perform sustainably for 20 years, deliver a 10% economic rate of return with distributed benefits, demonstrate poverty reduction, show positive environmental impact, and embrace under-represented groups as agents and recipients during both the project development and operation phases.

One such potential project NREL is evaluating is an integrated micro-hydro, forestry/watershed management, and agricultural project in the village of Rantau Suli in Jambi. Currently, several small, migrant communities are located above the proposed hydro sites. NREL's prefeasibility study assesses whether present forest activities by these communities are likely to cause a problem during the lifetime of the hydro installation(s) as well as determines what sustainable economic activities might replace any presently unsustainable ones. If the project is found feasible, the plant will power Rantau Suli's households, clinics, schools, and businesses, and perhaps more importantly, be used to process locally produced patchouli oil, cinnamon, and coffee, which will allow farmers to increase incomes by bringing a higher value product to market.

NREL's work in Indonesia represents a unique opportunity to employ the country's wealth of renewable energy resources to benefit poor and rural populations, enabling residents to access new economic activities and amenities previously unattainable. With NREL's technical assistance in identifying projects that can be widely replicated, Indonesia can meet its economic and sustainability goals.

Written by Melissa Butheau

NREL is evaluating an integrated micro-hydro, forestry, watershed management, and agricultural project in the village of Rentam Sali in Jambie, Indonesia.

VOICE OF NREL

Planning for Resiliency: Sustainable Communities, Companies, and Agencies

As the global demand for energy increases rapidly every year—driven by strong economic growth, expanding populations, and rocked by uncertainties of what adverse effects climate change may bring—finding the answer to the question of energy security has become all the more important.

Andy Walker, principal engineer, Integrated Applications Center

In response, many communities, government agencies, and companies are now taking small steps towards becoming more sustainable, many times by way of diversifying their dependence on fossil fuels to include alternative sources of energy. Other short- and long-term benefits that come with investing in renewable energy or energy efficiency technologies—like cutting the cost of doing business, meeting federal energy requirements, or even boosting their "green" marketing strategies—tend to add to immediate motivations.

In Business, the Bottom Line Matters

While planning for the future is always important, in the near term companies are usually concerned with how incorporating renewable energy technologies like wind or solar—or taking efficiency measures to cut their carbon footprint—will affect their bottom line, says NREL's Andy Walker, a principal engineer within the Integrated Applications Center.

"Mostly, private companies are interested in the rate of return," Walker said. "If you can show that if they invest so many millions in this, and that they can save this many thousands on their utility bill each month, then compare that with their hurdle rate and how many tax credits they'll get on the project, they are more likely to invest."

Walker is part of a team that works with federal, state, and local governments, as well as private industry and organizations, to deploy commercially-available energy efficiency and renewable energy technologies. The team does this by evaluating the economics of the potential project, screening the site of the project to determine what technology would work best, then developing a business case and helping the client with procurement strategies.

"Basically, we help agencies move renewable energy projects all the way through the pipeline—from looking at their inventory of real property and screening them for their best renewable energy opportunities—to writing specifications for the equipment and testing that if it gets built," he said.

Most recently, Walker said he worked with cellular provider Verizon Wireless, who sought NREL's help to evaluate the business case of possibly equipping each of their more than 40,000 cell phone towers with photovoltaics. The company had two goals: to ensure that they could guarantee more reliable cell service, and to take a step towards meeting the company's self-imposed goal of 50% reduction in carbon intensity by 2020. While cellphone towers already have batteries and back-up generators, an on-site solar or wind energy system can extend the autonomy of the site indefinitely. Towers that are powered by on-site renewable energy are also promoted by global industry as a means of extending mobile phone coverage beyond the extent of utility systems.

In recent years, Walker said he has observed companies like Verizon Wireless, just one among many companies and agencies, that are beginning to make a slow, but noticeable shift towards taking sustainability seriously.

"I think they went through a period of denial, where they said that their responsibility was only to their shareholders to do the cheapest thing possible, regardless of the environment," he said. "Then there was a roller coaster ride of overenthusiasm and then they turned overly cynical, but now I think it has leveled out to the point where people are now taking positive measures and seeing that it does work."

"Assigning a price of carbon used for planning purposes is becoming an increasingly common business tool, as much to promote efficiency and clean energy projects as to quantify risk."

Considering Renewables to Rebuild Better

Many are realizing there's a new reality: a changing climate is driving more extreme, destructive weather that has already begun to threaten the economic prosperity and safety of many communities. But while there isn't a silver bullet approach to ensuring resiliency, one thing is for sure—the communities that are better prepared for uncertainties are also better able to recover and adapt.

"Disaster recovery, in my mind, is the single-largest opportunity to start over," said Mary Werner, Lead Program Manager for NREL's Buildings Program. "You have these communities that have gone through this really awful, tragic time, but it also presents a real opportunity to rebuild right. That's where incorporating building energy efficiency and the renewables come in—we have an opportunity to make a huge impact in those areas."

For the first time following Hurricane Sandy in 2012, NREL was funded by the Federal Emergency Management Agency (FEMA) to participate in disaster recovery strategic planning efforts between federal, state, and local agencies. Werner was part of a team

of NRELians who were tapped to deploy to New York and New Jersey to provide expertise to agencies in the energy aspects of sustainability, as well as coordinate key stakeholders to ensure the inclusion of renewable energy and energy efficiency into the planning process.

"It's sometimes difficult to get energy on their radar because you're talking to them after they've just lost their houses, their jobs, and their cars. Thinking about rebuilding sustainably is not their first priority," Werner said. "That's why we have to make it easy—we can't just give them information and expect them to analyze it and make a decision."

In New Jersey, this included putting together one-page fact sheets about different kinds of renewables and energy efficiency measures to incorporate during rebuilding efforts. The fact sheets included a section with non-technical, general descriptions of the technology or measures, information on how much it would cost or save, and rebate or incentives being offered in the state.

NRELian Eliza Hotchkiss, a project leader within the Integrated Applications Center who was stationed in New Jersey along with Ian Metzger (an engineer within IAC), took a more hands-on approach in the recovery effort. Hotchkiss and Metzger worked one-on-one with graduate design students at Rutgers University, graduate architecture students and professors at The College of New Jersey, as well as other universities, to come up with new sustainable designs for rebuilding different communities, including Seabright, New Jersey, a coastal town heavily-impacted by the storm.

"We talked with the students about the possibility of creating net zero communities, using renewables in their design, and energy efficiency measures in terms of building codes, and how those things would impact energy conservation as a whole," she said. "Basically, we tried to give them slightly more creative suggestions—like using porous pavement, or creating modular buildings that could float in a flood area—

Mary Werner, Lead Program Manager for NREL's Building Program, and Eliza Hotchkiss, Project Leader, Integrated Applications Center

and let them run with it and figure out how they could implement those designs in the community."

Hotchkiss and Metzger also demonstrated a number of NREL-developed tools from Energy Plus and IMBY, to the JEDI model so that students would know where to find decision-making tools that could improve the business case for their plans and suggestions.

By the time the NREL team's stint was over, Hotchkiss said the students were planning to present their plans to the mayor and the city council to review the designs and determine what the costs would be.

"The students were all very engaged and excited about incorporating sustainable elements into their designs, and I think the city was open to rebuilding differently," she said. "I think we accomplished what we came to do— to begin thinking outside the box and leverage the resources and funding available to the state and local communities."

Rising to the Sustainable Challenge

Though the trend to become more sustainable is on the rise, being able to pin-point what motivates communities, companies, and agencies to make a true commitment remains a challenge, Werner emphasized.

"What motivates people to incorporate sustainability really varies," she said. "From the residential standpoint, we have the early adopters who want to do it because it's the right thing to do, and then on the other end of the spectrum you have the people who do it because it saves them money, and then you have some people in the middle.

"But there is one thing we've found to be true across the board: it has to be simple to do, or else they usually won't do it."

Operating Sustainably Gives NREL a Leg Up in Leading the Clean Energy Revolution

NREL may be best known for its development and advancement of renewable energy and efficiency technologies, but just as importantly, there's also a long-standing tradition of translating that commitment to our mission into action when it comes to sustainable practices.

From the lab's efforts to integrate energy efficiency and resource conservation practices into its campus operations; to moving energy-saving technologies from research and development to the marketplace; or continuing to challenge and influence public opinion, sustainability is at the core of NREL's success in leading the nation toward a clean energy future.

Setting the Vision to Create Impact

Having vision and direction are essential for any organization to have any meaningful impact. That's where NREL's Bill Farris plays an important role. As associate lab director of Innovation Partnering & Outreach, it's his job to help make connections and promote NREL's technologies through industry partnerships, and take the pulse of the marketplace in order to determine the direction of how to fulfill a certain need or communicate the lab's successes. Even the organization's acronym gives a hint to what they are all about—as IPO is a play on the common business term, "initial public offering."

Bill Farris, Associate Lab Director, Innovation Partnering & Outreach

"IPO includes communications, commercialization, economic development and our partnership agreement teams. They are all under one umbrella," Farris said. "My directorate is the one that handles many of the exports of NREL—whether it's the intellectual property we're helping to export to market, writing press releases around those technologies, writing web or media content that we're exporting to the public, or signing a partnership agreement that supports technology transfer."

"Being able to tell our impact stories is incredibly important—they're complicated, and they do not happen overnight—but it's a crucial part of being an effective leader in our mission space and to have the kind of impact we're looking to have in the future."

Farris sees that taking a sustainable approach is a key factor in the lab's ability to create a successful impact—not only in terms of resource conservation and energy efficiency measures—but translating that into every aspect of doing business.

"I personally think it's important to maintain a long-term view, and in my opinion, it's one of the most important things that defines sustainability," he said. "In the context of an organization like NREL, it comes down to how we treat our people, conduct our business, advance our mission, or even invest in building our facilities right."

"Going into situations with the attitude that we're going to be in it for the long term will only benefit us in the future."

The Nature of Doing Business, Sustainably

In a changing world where companies are expected to do more with less, making sustainability an integral part of day-to-day operations has become key in setting themselves up for success. At NREL, that shift is happening in large part due to the lab's Contracts & Business Services organization, led by Office Director Randy Combs.

"In my world, we see sustainability through laws and regulations that have come down through our prime contract, and we incorporate those into our contracts with requirements language around sustainable expectations," Combs said. "In some cases, there can be a higher cost when you write in a sustainability requirement, but most of the time it's more beneficial to pay a little more to go green."

Randy Combs, Office Director, Contracts & Business Services

Over the years, the contracts Combs' group drafted has helped the lab demonstrate its commitment to sustainability on campus. These contracts have led the lab to purchasing only computer hardware and appliances with the highest energy efficiency ratings; or requiring in the janitorial contract that cleaning supplies must meet a certain sustainability requirement and that information is reported to the lab on a quarterly basis. Finally, contract language with the food vendor for the onsite Café mandates that mainly compostable or recyclable products are offered.

Another way Combs and his group have pushed the "green" mindset in the lab is by supporting a sustainable procurement program, which encourages the purchase of products that can be recycled or composted at the end of their life. In FY 2010, NREL's purchase of recycled products grew roughly 350% over the last couple of years as a result of green procurement practices.

"The lab's sustainability objectives become clear once you read our forms or go through the process of buying something," he said. "There's even a question that requires staff to answer about the kind of product they're buying—and if they're not buying green, we want to know why."

However, the way an organization views sustainability is everything, Combs insists.

"This kind of thinking is certainly driven from the top down with executive orders, but it's successful because it's embraced here at the laboratory," he said. "Before working here, some of the sustainability measures we take might seem crazy, but we all adjust, and realize this is the better way to go about doing things.

"I visit a lot of different businesses, and no one does it like us—NREL is really leading the way."

Pushing the Limits

If you've ever looked at a wind turbine—modern megawatt machines pushing the limits of the skies—only then could you begin to get a sense for the determined personality needed to push limits for the technology as a liaison between the research world, industry, and the general public.

Playing that part at NREL's National Wind Technology Center, the nation's premier wind energy technology research facility, is Center Director Fort Felker. On a day-to-day basis, Felker provides mentoring and leadership for the technical staff on research and development projects, and at a higher level maintains partnership efforts with industry to show NREL's value in developing and testing new technologies. But the driver for his actions—both professionally and personally—ultimately comes down to reducing the carbon footprint, he says.

Fort Felker, Director, National Wind Technology Center

One of the ways he does this is by proudly displaying big "wind-powered" stickers on the plug flaps of his electric car (all of the electricity his car uses is either generated by wind turbines or offset with wind credits).

"Like a lot of American males, I used to have a fondness for many forms of motorized entertainment; I used to have a fast car, and fly a really nice airplane that used a lot of gasoline—but I have made a personal decision to not take part in recreation that relies on burning fuel to make you happy, which is why I now own an electric car."

"It serves as an example to the whole staff, as well as the general public, that there is another option to driving a gas-powered vehicle."

At a more public level, Felker also plays an important role in promoting education, while cutting through misconceptions, about wind power.

"We need to get people to start thinking about wind differently; it's not a niche thing anymore, and it's not uneconomical—in many cases, it's the cheapest, most sustainable type of power that you can put on the grid," he said.

Beyond being an affordable clean energy source, Felker emphasized that one sustainability benefit people don't realize is that wind energy is the only energy supply technology that uses virtually zero water.

"I think this is a really important sustainability benefit about wind energy that is rarely appreciated, especially as we are experiencing increasing droughts and water shortages nationwide," he said. "Our energy system is actually the number two user of water in the U.S. behind agriculture."

"So to the extent that wind energy comes online, it not only displaces fossil fuels that generate carbon dioxide, but it also eliminates the need to consume water—a two-for-one bonus, if you will."

But while he feels hopeful about the future of clean energy and the move for the nation to become more sustainable, Felker maintains that there is always room for improvement.

"I think that the broader population has a good awareness of many sustainability issues," he said. "We've made great progress on composting, lowering energy consumption, and recycling, but I think many people still do not take enough personal accountability for their own carbon footprint."

"We've all got to make a shift in our priorities; I think we can do better."

From the Ground Up: Achieving High-Performance Facilities and Behavior Change

It's hard to believe that even a place like NREL went through an era where sustainability was not viewed as integral to our mission as it is today—a time before a composting program, a campus with ultra-efficient buildings, or where recycling bins with tiny attached trash cans under every staffer's cube was the norm.

But believe it or not, that time was not too long ago. Things began to change in 2001, when NREL considered a redesign concept for the Science and Technology Facility (S&TF) with sustainability in mind. However, it wasn't until 2003, when former Director Richard Truly commissioned a report called the General Development Vision (GDV), that a sustainable master planning concept for the entire NREL campus was put into motion.

"I think about the time when we developed the GDV plan and Richard Truly started the Sustainable

Nancy Carlisle, Director, Integrated Applications Center

NREL program, to me, that was what really signaled a turning point at NREL," says Nancy Carlisle, Center Director for Integrated Applications.

"Prior to this time, there seemed to be a disconnect between our mission and what people were trying to do in the labs," Carlisle said. "The campus wasn't considered integral to the marketing or messaging of the work we did at all".

With a degree in both urban planning and architecture, experience in the buildings program teaching people how to design facilities that use less energy, and the co-development of the federally-recognized brainchild, Labs for the 21st Century Program under her belt—Carlisle was singled out by Truly in 2003 to lead the effort to build-out the campus in a more sustainable way. Her ideas first led to improved sustainability in the the current design of the Science & Technology building (and the lab's first U.S. Green Buildings Council Leadership in Energy and Environmental Design (LEED) Platinum rating), before going on to author the GDV report.

"You can see that the master plan that we laid out in the report in 2003 is pretty similar to the way that the campus ended up being built," she said.

A stackable parking garage (similar to the one we have today); a walkable, pedestrian-friendly campus; and the "lazy-H" layout for the Research Support Facility (RSF)—with narrow wings and daylighting, among other features that have contributed to the building reaching net-zero energy—are all elements of Carlisle's original plan that have played into NREL's modern-day sustainable campus.

"There is a quote from an NREL staffer in the GDV that has always stuck with me, because it describes the importance of our actions as a laboratory," Carlisle said. "It states, 'Our research is so important but it will not bring us half the notoriety as a cutting edge, environmentally sound, high performing campus. That may be the best teaching and outreach tool we can offer the public.'"

Building—and Maintaining—a Better Workplace

Throughout its history, NREL has been recognized nationally for its cutting-edge work in renewable energy and energy efficiency research and development. But, fast-forward to 2009, and you'll notice there's another thing NREL has been quietly earning praises for: its sustainability efforts.

Jake Gedvilas, Building Area Engineer

Thanks to a comprehensive Campus Master Plan which outlines extensive efforts to design all new buildings to meet Gold or Platinum LEED certification, increase building densities, preserve and enhance open space, and establish a walkable campus, NREL is demonstrating how to put its mission values into action more than ever.

NREL's RSF, in particular, has been a crown jewel of the campus for showcasing net zero energy office design. In its short time in operation, sustainable elements such as rooftop solar panels on its distinctive "lazy-H" shape, an underground "thermal labyrinth" that mimics a cave to help heat and cool the building, and distinctive daylighting features have helped make the office building the "workplace of the future" it was envisioned to be. But, as Building Area Engineer Jake Gedvilas will tell you, it takes much more than innovative design to maintain the facility's aggressive energy usage goals.

On a day-to-day basis, Gedvilas acts as the "living laboratory" puppet-master of sorts—constantly monitoring the building's energy intensity data by metering the electricity and water usage, and making adjustments as necessary. "I try to operate the building first and foremost with efficiency in mind—looking at how we're using resources and energy, minimizing waste, and so forth," Gedvilas said.

On first take, Gedvilas' job might seem pretty straightforward, but add nearly 1,200 building occupants to the mix, and you can begin to imagine how keeping the building at net-zero energy usage can get very complicated.

"Changing the culture and habits of those who occupy the building is another big part of what I do, and it's not the easiest.

"Basically, it comes down to trying to get people to think about something other than their own comfort, and to broaden their view of how their personal behaviors affect their neighbors and the environment."

For this very reason, taking the time to educate staff—on multiple occasions if necessary—and allowing for some flexibility have been the best tools in his arsenal, Gedvilas says.

"Working in an environment like this is a behavioral and cultural change for most people, so there should be some flexibility in how the building is run," he said. "After all, even if you build the most efficient building in the world, but people don't use it correctly or respect it, what have you accomplished?

"There has to be a balance between what the building is trying to accomplish, and what the individual is trying to accomplish in their everyday work. It can be done—there just needs to be a willingness for everyone to modify their behaviors a little for the good of the whole."

Creating a Sustainable-Minded Culture

At the end of the day, cultivating a sustainability-minded organization is as much about changing behaviors and shaping culture as it is about building LEED-certified facilities. And in most work environments, the place where much of that begins is the Human Resources (HR) department.

Vickie Pokaluk, Trainer, Human Resources

True, HR may not be the obvious group to encourage this sort of change towards a more sustainable mindset, but dig deeper and it makes sense. HR has its hands on a lot of levers within organizations that influence behavior—from recruitment and hiring; to incentives, promotions, and training.

Heading up the sustainability charge within HR at NREL is lead soft-skills trainer Vickie Pokaluk. A large part of Pokaluk's job revolves around leading all New Employee Orientations for incoming staffers, which includes a significant focus around the lab's sustainability efforts and a tour of the RSF.

"In my trainings, I really try to ingrain the importance of sustainability in our new staff," Pokaluk said. "I see a large part of our role as being the modelers of the right behavior we want to see on campus. For me, this can come down to the types of materials that I buy for our trainings—which are all compostable—little things like making sure the lights are off after we leave a conference room, or using reusable white board name tents instead of paper.

"Many of them look at me like I'm nuts at first, but by the end of the orientation I try to make sure they at least understand why we do what we do here, and I would say many of them end up thinking it's pretty neat."

But while education is a major component of cultivating a sustainable-minded workforce, Pokaluk says there are several factors that will determine whether that behavior can be sustained: firstly, the initial workplace conditions at the start of the effort, and finally, the manner that the change is introduced.

"The one issue that companies tend to forget when it comes to implementing change initiatives is the impact on their people. How is it going to affect their people, their workday, and how they do what they do?" she said. "If you never take the time to really look at how the change will impact your staff and what they will have to do differently, it will never get fully adopted because they will resist.

"Once there's awareness about what the individual and organizational benefits will be, people tend to start accepting the changes and don't resist as much.'"

However, while there is no "silver bullet" approach, Pokaluk believes a shift toward total organizational change is already taking root.

"Ultimately, an organization needs to develop the awareness, the knowledge, and the desire to implement a successful change effort," she said. "I think we've done a good job creating awareness and knowledge around sustainability here at the lab, and really cultivating a desire for it, too.

"We're not totally there yet—but we're certainly on our way."

Written by Kendall Septon

GRI Key Performance Indicators

Xavier Urquijo from Summit Ridge Middle school waits for the start signal as he joins ninety-seven teams from 28 Colorado middle schools to race solar and lithium ion powered vehicles they designed and built themselves in the Junior Solar Sprint and Lithium Ion Battery car competitions hosted by DOE/ NREL at Dakota Ridge High School.

KEY PERFORMANCE INDICATORS

GRI Indicator	Indicator Title	2012	2013
ENVIRONMENTAL PERFORMANCE			
MATERIALS			
EN2	Percentage of materials used that are recycled input materials	We don't track an overall value for recycled inputs. However, all paper is 30% recycled content.	
ENERGY			
EN3	Direct energy consumption by primary energy source		
	Natural gas	73.4 BBtu	71.7 BBtu
	Propane	111 Gal	113 Gal
	Gasoline	591 Gal	9,248 Gal
	Diesel	1,978 Gal	4,104 Gal
	E85	17,641 Gal	18,397 Gal
EN4	Indirect energy consumption by primary source (BBtu)	70.7 BBtu	72 BBtu
	Non-renewable	54.8 BBtu	50.4 BBtu
	Renewable	15.9 BBtu	21.6 BBtu
EN5	Energy saved due to conservation and efficiency improvements	4,881 MMBtu in FY12	1,269 MMBtu/year saved from FY13 improvements
EN6	Initiatives to provide energy-efficient or renewable energy based products and services, and reductions in energy requirements as a result of these initiatives	36 electrical charging stations have been constructed in the garage. High performance building technologies are integrated into new construction, (MWh PV and MWh wind turbines), conducting energy audits for existing buildings to identify and prioritize ECMs.	Performed controls optimization for HVAC systems and replaced T12 bulbs with energy efficient fixtures, reducing electricity and natural gas use; resulting in 1,269 MMBtu/year and $24k/year in energy savings
EN7	Initiatives to reduce indirect energy consumption and reductions achieved	Utilized the sale of RECs for reinvestment in energy efficient technologies; wind production exported to the grid is credited back to STM utility bill annually	Performed controls optimization for HVAC systems and replaced T12 bulbs; 326 MWh/year in energy savings
WATER			
EN8	Total water withdrawal by source	18 million gallons	22.6 million gallons
BIODIVERSITY			
EN13	Habitats protected or restored	STM Conservation Easement: 71.6 hectares; NWTC conservation management areas: 63.4 hectares	
EN14	Strategies, current actions, and future plans for managing impacts on biodiversity	See Environment and Pollution Prevention section of Materiality Assessment chapter	
EN15	Number of IUCN Red List species with habitats in areas affected by operations, by level of extinction	See Environment and Pollution Prevention section of Materiality Assessment chapter	
EMISSIONS			
EN16	Total direct (scope 1) and indirect (scope 2) greenhouse gas emissions (metric tons of CO_2 equivalent)	21,390.2 MT CO_2e	4,057 MT CO_2e
EN17	Other relevant indirect (Scope 3) greenhouse gas emissions (metric tons of CO_2 equivalent)	7,218.4 MT CO_2e	7,047 MT CO_2e

KEY PERFORMANCE INDICATORS

GRI Indicator	Indicator Title	2012	2013
EN18	Initiatives to reduce greenhouse gas emissions and reductions achieved	As part of NREL's alternative commuting program 19% participated in the telework program: 15% participated in the AWS 9/80 (eight 9-hour workdays and an 8-hour day in a two-week period) and 10% participated in the AWS 4/10 (Four 10-hour work days). Renewables Fuel Heat Plant has reduced our GHG emissions by 18% since 2008 and 77% of campus waste was diverted from the landfill.	FY 14 GHG Reduction goals include: 1: Continuing to optimize RFHP performance to reduce campus natural gas consumption 2: Improve refrigerant and fugitive gas reporting processes 3: Continue to purchase RECs to offset all Scope 2 emissions 4: Deploy an updated commuter survey for NREL staff 5: Explore the feasibility of implementing improved data collection methods for assessing ground travel and commuting impacts 6: Continue to offer alternative commuting programs 7: Develop a Scope 3 GHG reduction strategy
EN19	Emissions of ozone-depleting substance by weight	NREL utilizes these chemicals in facility operations and scientific research. These amounts consumed are extremely low. The recorded totals below represent the purchased ozone depleting substances from a three-year rolling average: Refrigerants 36.328 lbs, HFC 13.314 lbs, PFC .031 lbs and SF6 4.306 lbs.	Three-year rolling averages for: Refrigerants: 78.333 lbs; HFC: 0 lbs; PFC: 0.31 lbs; and SF_6: 0 lbs
EN20	NO,SO, and other significant air emissions by type and weight	NOx emissions = 16.28 MT ; SO_2 emissions = 0.22 MT ; CO emissions = 6.35 MT ; VOC emissions = 1.09 MT ; PM10 emissions = 2.37 MT	NO_x emissions = 13.83 MT; SO_2 emissions = 0.036 MT; CO emissions = 6.02 MT; VOC emissions = 0.47 MT; PM10 emissions = 3.16 MT
WASTE			
EN22	Total weight of waste by type and disposal method (metric tons)		
	Recycled	423 MT	503 MT
	Recycled demolition	Construction waste for lab renovation is recycled, but not traced by volume	478 MT
	Landfilled	200 MT	231 MT
	Composted	326 MT	254 MT
	Regulated hazardous waste	0	0
EN23	Total number and volume of significant spills	There was one reportable NREL spill during 2012. Approximately 90 gallons of lubricating oil spilled from the Alstom wind turbine at the NWTC on February 17, 2012. The spill involved approximately 1.2 acres of surface area and was reported to Colorado. The spill did not enter jurisdictional water and was not reported to the EPA. Remediation efforts centered on promoting natural bio-degradation of the oil. Remediation was deemed complete in June, 2013 following several joint NREL/DOE field inspections.	There were no reportable spills for any NREL locations during 2013.
EN24	Weight of transported, imported, exported, or treated waste deemed hazardous under the terms of the Basel Convention Annex I, II, III, VIII, and percentage of transported waste shipped internationally	0	0
EN25	Identity, size, protected status, and biodiversity value of water bodies and related habitats significantly affected by the reporting organizations discharges of water and runoff	See Environment and Pollution Prevention section of Materiality Assessment chapter	
EN26	Initiatives to mitigate environmental impacts of products and services, and extent of impact mitigation	NREL staff has a responsibility to incorporate the principles of environmental protection into their activities detailed in Policy 6.2, Environmental Management. The Hazard Identification and Control Program identifies and analyzes existing, planned, and unplanned hazards in NREL's facilities and operations. The risk associated with each hazard is then assessed so that logical, effective controls can be designed and implemented. NREL's chemical inventory contains thousands of chemicals, many exotic and highly toxic. It is imperative that their entire life cycle at NREL, from ordering through disposal, is properly documented via the Chemical Management System. The Chemical/Hazardous Materials Release Procedure details what to do in the event of a spill or release into the atmosphere of a chemical/hazardous material where the hazard severity is unknown or cannot be immediately controlled safely. NREL's chemical management function also consults workers on the safe use of chemicals and maintains the lab's chemical inventory.	

KEY PERFORMANCE INDICATORS

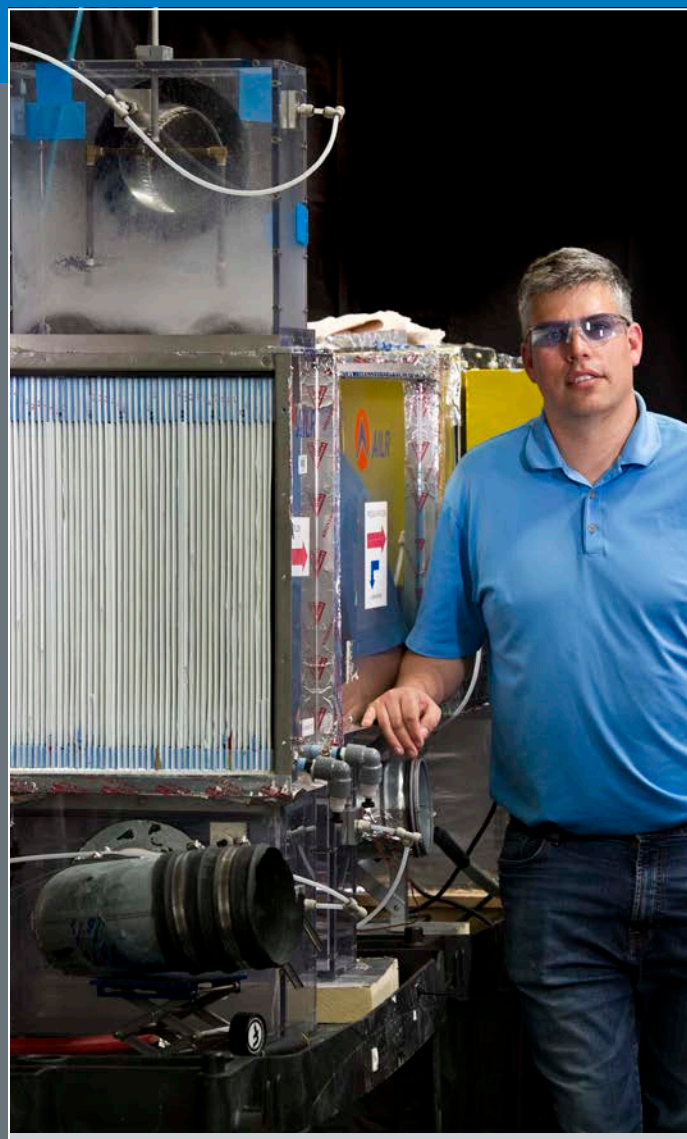
GRI Indicator	Indicator Title	2012	2013
COMPLIANCE			
EN28	Monetary value of significant fines and total number of non-monetary sanctions for noncompliance with environmental laws and regulations	0	0
TRANSPORT			
EN29	Significant environmental impacts of transporting products and other goods and materials used for the organization's operations, and transporting members of the workforce	0	0
OVERALL			
EN30	Total environmental protection expenditures and investments by type	$1,350,614	$1,513,080
HUMAN RIGHTS			
INVESTMENT AND PROCUREMENT PRACTICES			
HR3	Total hours of employee training on policies and procedures concerning aspects of human rights that are relevant to operations, including the percentage of employees trained	NREL requires training for all new employees in the "human rights" categories of Diversity, Harassment (334), and Drug/Alcohol Awareness.	
SECURITY PRACTICES			
HR8	Percentage of security personnel trained in the organization's policies or procedures concerning aspects of human rights that are relevant to operations	100%	100%
LABOR PRACTICES AND DECENT WORK			
EMPLOYMENT			
LA1	Total workforce by employment type, employment contract, and region	STM: 1,509 employees; NWTC: 106 Employees; DC: 16	DC Office: 14 Reg; NWTC: 82 Reg, 1 Temp, 6 RPP; STM: 1,305 Reg, 72 Temp, 137 RPP; Total: 1,617
LA2	Total number of new employee hires and employee turnover	215 New Hires; FY12 turnover: 6.8% (regular employees only)	HR did not track in FY13
LA3	Benefit provided to full-time employees that are not provided to temporary or part-time employees, by significant locations or operations	Full-time and part-time employees are eligible for the following benefits that are not provided to temporary employees: Long Term Disability, Tuition Reimbursement, and Interest Free—Payroll Deducted Computer Loan Program	
OCCUPATIONAL HEALTH AND SAFETY			
LA6	Percentage of total workforce represented in formal joint management-worker health and safety committees that help monitor and advise on occupational health and safety programs	There are a total of 67 staff members that sit on various EHS committees: Safety and Security Council: 74 participants; Environmental Health Assessment Committee: 6; various safety panels: 61. This is equivalent to 2.9% of the total NREL workforce.	3% (67/2,211)
LA7	Rates of injury, occupational diseases, lost days, and absenteeism and number of work related fatalities by region	12 injury incidents; 2 lost work days	37 total injuries: 13 TRC injuries, which includes 8 DART injuries; 25 lost work days
LA8	Education, training, counseling, prevention, and disease-control programs in place to assist workforce members, their families, or community members regarding serious diseases	NREL is a smoke-free workplace. NREL strives to maintain an alcohol and substance abuse-free workplace as part of its commitment to provide a safe and healthful environment for its employees and other workers. All employees are required to take webinar training during employee orientation. NREL healthcare insurance providers regularly hold education, training, and counseling sessions for all NREL workforce for preventative care. NREL's occupational health activities (EHS office) promote and maintain the physical, mental, and emotional well being of employees and prevent or reduce potential exposure to health hazards in the workplace.	

KEY PERFORMANCE INDICATORS

GRI Indicator	Indicator Title	2012	2013
TRAINING AND EDUCATION			
LA10	Average hours of training per year per employee by employee category	A robust training program was implemented in 2012 and 2013, but hours were not recorded for either fiscal years.	
LA11	Programs for skills management and lifelong learning that support the continued education of employees and assist them in managing career endings	NREL has a Tuition Reimbursement program that allows qualified and approved employees to be reimbursed for up to 100% of their tuition costs in undergraduate and graduate degree programs. NREL currently offers training opportunities to staff to advance employee skill sets and learning objectives. NREL course offerings included: Managing Conflict (primarily for managers), Exploring Inclusion, Leading Across Generations (primarily for managers), Communicating Across Cultures (primarily for managers), Executive Forum Leadership Series (for managers only), Proposing to Win, Interviewing Today's Workforce, Increasing Personal Effectiveness, Effective Writing and Presentations, Focus: Achieving your Highest Priorities–Outlook® Edition, and 7 Habits of Highly Effective People®. Individual NREL centers have overhead funding that can be used to pay for training to advance employee skill sets and learning objectives.	
LA12	Percentage of employees receiving regular performance and career development reviews	100%	100%
SOCIETY			
COMMUNITY			
SO1	Nature, scope, and effectiveness of any programs and practices that assess and manage the impacts of operations on communities, including entering, operating, and exiting	To implement Executive Orders and expand Sustainable NREL initiatives, campus projects integrate physical boundaries, connect to transportation and utility systems, and protect ecosystems and open space. All of these elements have linkages that forge stronger community, neighborhood, and user relationships. NREL continues to coordinate with appropriate local and regional planning organizations and government agencies to improve land use, transportation, growth, and sustainability within the community. In FY 2012 and FY 2013; 1) completed new construction of the new South Entrance Road and completed a traffic mitigation report; 2) bicycle and pedestrian supportive infrastructure; 3) successful performance of the detention and water quality pond during severe weather storms; 4) hosted sustainable parking garage workshop with attendees from across the Denver Metro area; 5) completed construction of additional turn lane on Denver West Parkway at Denver West Marriot Boulevard; 6) participated in RTD's West Light Rail line service planning process; 7) provided shuttles connecting staff to RTD public transit services.	
CORRUPTION			
SO2	Percentage and total number of business units analyzed for risks related to corruption	The risk of all forms of fraud, including corruption is evaluated across the laboratory as follows: 1) the Enterprise Risk Management committee includes discussion of the potential for fraud, the probable impact if experienced, and the likelihood that it could occur several times each year. The Enterprise Risk Management committee covers all operations. 2) The Alliance Finance and Audit Committee considers all forms of risk in meetings three times each year.	
SO3	Percentage of employees trained in organization's anticorruption policies and procedures	NREL requires that all employees complete ethics training. If an employee does not complete the training, an escalating follow-up notification procedure provides prompt notification to the employee's manager(s) to assure timely completion.	
SO4	Actions taken in response to incidents of corruption	NREL maintains four anonymous reporting hotlines (three internal and one external) for employees and others to report good faith concerns and observations for potential investigation and resolution. During 2012 and 2013, no reports of incidents of corruption were received, hence no action was necessary.	
PUBLIC POLICY			
SO5	Public policy positions and participation in public policy development and lobbying	As a U.S. national laboratory, operated by a non-profit contracting organization for the federal Department of Energy, NREL does not lobby public officials nor engage in direct advocacy for policy. However, as the nations' premier research institution for clean energy technology, NREL and its scientists, engineers, and analysts are very actively engaged in providing science-based information on behalf of sustainable energy resources, sustainable energy generation and sustainable energy use. Given that NREL researchers frequently are leaders in their respective fields, NREL plays a vital role in most of the nation's and world's major non-governmental organizations dedicated to clean energy.	
SO6	Total value of financial and in-kind contributions to political parties, politicians, and related institutions by country	0	0
ANTI-COMPETITIVE BEHAVIOR			
SO7	Total number of legal actions for anti-competitive behavior, anti-trust, and monopoly practices and their outcomes	NREL did not experience any legal actions for anti-competitive behavior, anti-trust, or monopoly practices in 2012. Note: As a Federally Funded Research and Development Center (FFRDC), NREL has one primary business client, the U.S. Department of Energy (DOE). DOE provides comprehensive oversight of NREL operations. Both NREL and DOE policies maximize compliance with laws and regulations plus sound business practices.	
COMPLIANCE			
SO8	Monetary value of significant fines and total number of non-monetary sanctions for noncompliance with laws and regulations	NREL was not fined, nor did we experience any significant non-monetary sanctions for noncompliance with laws and regulations in 2012 and 2013. Note: As a Federally Funded Research and Development Center (FFRDC), NREL has one primary business client, the U.S. Department of Energy (DOE). DOE provides comprehensive oversight of NREL operations. Both NREL and DOE policies maximize compliance with laws and regulations plus sound business practices.	

KEY PERFORMANCE INDICATORS

GRI Indicator	Indicator Title	2012	2013
ECONOMIC			
EC1	Direct economic value generated and distributed, including revenues, operating costs, employee compensation, donations and other community investments, retained earnings, and payments to capital providers and governments	Revenues: $513.4 M Employee Compensation: $141.3 M Operating Costs: $365M Donations of: 46 k	Revenues: $383.3 M Employee Compensation: $156.3 M Operating Costs: $221.4 M Donations of: 46.7 k
EC2	Financial implications and other risks and opportunities for the organization's activities due to climate change	Our research is one fundamental step in NREL's work to mitigate climate change by advancing low carbon energy alternatives. Esteemed NREL researchers also worked to spread the climate change message to local agencies and communities by delivering presentations with an aim of demystifying climate change. In FY 2012, NREL began participation in DOE's Climate Adaptation Planning Working Group. NREL provided knowledge and input to the draft *DOE Preliminary High Level Analysis of Vulnerability to Climate Change*.	In FY 2013, NREL initiated work to conduct a climate change vulnerability assessment and develop a resiliency plan for our campuses. NREL has been undertaking research efforts to understand current climate science projections for the region and is actively working to develop appropriate methodologies that allow for comparative climate change risk analysis and prioritizing of climate change resiliency actions for our campuses in support of EO 13653 released in November 2013. NREL co-authored a report for DOE that analyzed vulnerabilities of the energy sector to climate changes and extreme weather events. Under NREL's Climate Neutral Research Campuses Initiative, the Climate Action Planning Tool was developed.
EC3	Coverage of the organization's defined benefit plan obligations	NREL meets all required funding obligations. As we moved into PPA regulations, and higher funding targets, NREL chose to make higher than the minimum required contributions to spread out anticipated higher contributions. NREL funding for the retirement plan in FY 2012 was over $20M.	NREL meets all required funding obligations. NREL funding for the retirement plan in FY 2013 was over $5M.
EC4	Significant financial assistance received from government	NREL received no financial assistance from the government.	
EC8	Development and impact of infrastructure investments and services provided primarily for public benefit through commercial, inkind, or pro bono engagement	NREL does not have investments or services primarily for public benefit.	



Eric Kozubal, one of the R&D 100 Award recipients displays a first generation prototype DEVAP air conditioner that demonstrates a proof of performance. The new technology predicts an energy savings of 40% to 80% for light commercial buildings. Ron Judkoff, Jason Woods, and J. Burch in partnership with AIL Research and Synapse Product Development (LLC) were also recipients.

Awards and Honors FY 2012

R&D 100 AWARDS

NREL won two R&D 100 Awards—bringing the total to 52 awards since 1982.

Desiccant-Enhanced Evaporative Air-Conditioning (DEVAP). The DVAP cycle cools commercial buildings at a small fraction of the energy use of a traditional cooler, provides superior comfort in any climate, releases far less carbon dioxide, and could cut costly peak electricity demand by 80%--without using harmful refrigerants. Recognition to NREL's Eric Kozubal, Ron Judkoff, Jason Woods, and J Burch in partnership with AIL Research and Synapse Product Development (LLC).

SJ3 Solar Cell. SJ3 solar cell is the highest-efficiency concentrator solar cell—43.5% at 418-suns—using a lattice-matched multijunction architecture that has near-term potential for cells with near-50% conversion efficiency. Recognition to NREL's Dan Friedman, Jerry Olson, John Geisz, Aron Ptak, Bob Reedy, Brian Keyes, Steve Johnson and Sarah Kurtz in partnership with Solar Junction.

LEADERSHIP AWARDS AND HONORS

FierceEnergy.com named Dick DeBlasio, NREL Chief Engineer for Renewable Electricity and End Use Applications, to the online publication's "Fierce 15" for his leadership on smart grid technology and his guidance as chair of the EEE Standards Association P2030 Working Group.

Dan Arvizu was elected National Science Board Chair. The 25-member body advises the president and Congress on science and engineering issues, and is the policy-setting and budget-approving body for the National Science Foundation.

NREL named Howard Branz and Michael Himmel to its Research Fellows Council, the laboratory's top advisory council comprised of internationally recognized NREL scientists and engineers.

American Solar Energy Society honored Trudy Forsyth with the Women in Solar Energy Award for her promotion and education of women in the renewable energy industry.

Awards and Honors FY 2012

SCIENCE AWARDS AND HONORS

The Geothermal Energy Association Honors Award was presented to Desikan Bharathan for his notable achievements toward the advancement of geothermal energy technology.

The Colorado Governor's Office honored Matt Keyser with the 2012 Governor's Award for High-Impact Research.

The Institute of Electrical and Electronics Engineers (IEEE) honored Sarah Kurtz with the PVSC38 William Cherry Award for researching high-efficiency cells and photovoltaic (PV) reliability, with special emphasis on concentrator PV.

The IEEE Standards Association honored Tom Basso and Connie Komomua with its Standards Medallion Award for their significant contributions to develop the IEEE Standard 2030.

Colorado Gov. John Hickenlooper presented Matthew Keyser, Center for Transportation Technologies and Systems (CTTS), with the 2012 CO-LABS Governor's Award for High Impact Research in the category of Foundational Technology for developing the Large-Volume Battery Calorimeter (LVBC). The LVBC can detect heat loss and determine efficiency in the large batteries used to power electric vehicles. It's the only isothermal calorimeter capable of measuring the thermal efficiency of batteries for advanced vehicle technologies.

The University of Massachusetts Clean Energy Award was presented to Walt Musial for initiating NREL's offshore wind energy research program.

DOE AWARDS AND HONORS

DOE's Office of Basic Energy Sciences selected Kristin Alberi for its DOE's Early Career Research Program.

DOE honored two NREL Engineers for Outstanding Contributions and Exceptional Achievement Awards in hydrogen, fuel cell, and advanced vehicle technology projects. Matthew Thornton contributed to the development of an integrated modeling framework for the Hydrogen Storage Engineering Center of Excellence. Michael Ulsh helped reduce the cost of manufacturing polymer electrolyte membrane fuel cells.

The Secretary of Energy Achievement Award was presented by Deputy Secretary Daniel Poneman to NREL and the DOE Golden Field Office for demonstrating exceptional results in completing a project within cost and schedule.

Technical Excellence Award was presented at DOE's 2012 Information Management Conference in recognition of NREL's cross-functional team that designed and built the Research Support Facility (RSF) data center. Recognition to: Bob Hansen, Paul Torcellini, Kevin Donovan, Shanti Pless, Chuck Powers, Otto VanGeet, and Craig Robben..

SUSTAINABILITY AWARDS

The DOE Office of Health Safety and Security recognized NREL as its GreenBuy Program Gold Winner for two years running.

Green Fleet Magazine recognized Wendy Dafoe as Sustainability All Star for alternative fuels and advanced vehicles data center management.

DOE presented NREL with the Sustainability Award for Comprehensive Energy Management. Recognition to: Chris Gaul, Sal Sferrazza, Jennifer Daw, Shanti Pless, and Michelle Slovensky.

The Wirth Chair Sustainability Award was presented to NREL, CSU, and the Governor's Energy Office Wind for Schools collaboration.

NREL won the DOE EStar Award for Comprehensive Energy Management. The winning team—Chris Gaul, Michelle Slovensky, Shanti Pless, Sal Sferrazza (pictured) and Jennifer Daw—demonstrated leadership in energy management by modeling and documenting the feasibility and cost effectiveness of renewable energy technologies.

NREL WINS 2012 DOE ESTAR AWARD FOR ENERGY MANAGEMENT

Recognizing the lab's innovation and commitment to sustainability, DOE recently presented NREL with the EStar Award for Comprehensive Energy Management. The winning team—Chris Gaul, Sal Sferrazza, Jennifer Daw, Shanti Pless, and Michelle Slovensky—demonstrated leadership in energy management by modeling and documenting the feasibility and cost effectiveness of renewable energy technologies.

The team was recognized for their implementation of the four steps that make up NREL's management energy methodology:

- Measuring. Metering our energy consumption and collecting the data
- Portfolio Assessment. Finding opportunities to save energy and estimating how much energy each opportunity could save
- Establishing Targets. Taking action to target the opportunities
- Monitoring and Improvement. Tracking progress by analyzing data to assess effectiveness of energy savings efforts.

These steps are used to manage both passive components including:

- Plug loads (energy used by office equipment, lighting, etc.). 64 watts per office cubicle compared to 300 watts for a typical workspace
- Equipment modifications or retrofits. Strategies that reduce energy through energy efficiency
- Programs and educational outreach. Informing building occupants on how to save energy in workspaces
- Building occupancy survey. Data regarding occupant comfort used as a basis for building modifications.

Active components:

- On-site renewable energy systems including wind, photovoltaic, solar thermal, and the RFHP
- High-performance and net-zero energy building energy modeling to inform design process for new buildings and decisions about energy efficiency and renewable energy technologies and applications
- Site metering of hot and chilled water, electricity, and natural gas
- Energy dashboard system simplifies direct monitoring of NREL's energy consumption and reporting.

NREL's energy management leadership, with its strong emphasis on environmental stewardship, provides a replicable example to other federal facilities and the commercial building sector.

Awards and Honors FY 2013

R&D 100 AWARDS

NREL won three R&D 100 Awards in FY 2013—bringing the total to 55 since 1982.

Image Processing Occupancy Sensor (IPOS). NREL's IPOS combines an inexpensive camera with computer vision algorithms to detect and assess the presence of people in residential, commercial, and government buildings, accurately determining when the lights should be dimmed, when climate settings should change, and when security should be alerted. This can directly improve energy savings. Recognition to: Luigi Gentile Polese, Larry Brackney, and Alex Swindler.

Isothermal Battery Calorimeters (IBCs). IBCs, developed by NREL and NETZSCH, measure heat to design longer-lasting and safer batteries at an affordable cost—providing a level of accuracy and functionality not seen in other calorimeters. With forecasts of more than half a million hybrid and electric cars this year—and with manufacturers needing to meet increased fuel efficiency requirements—the IBCs allow auto manufacturers to address safety and efficiency issues long before drivers have to rely on the battery packs to get them home safely. Recognition to: NREL's Matt Keyser, Ahmad Pesaran, John Ireland, Dirk Long, and Mark Mihalic; and NETZSCH's Peter Ralbovsky, Jean-Francois Mauger, and Gilles Widawski.

Mono-crystalline Solar Cells. TetraSun, now a division of First Solar, Inc. has developed an innovative solar cell architecture that converts a greater percentage of sunlight to electricity. The company has also reduced the typical manufacturing cost of high-efficiency solar cells with a more streamlined, simplified process flow and the elimination of certain costly materials. NREL performed characterization and reliability measurements on modules manufactured with TetraSun cells and collaborated with the company's technical team to develop and implement modifications to the measured modules, contributing to improved product performance and reliability. Recognition to: TetraSun's Oliver Schultz-Wittmann, Denis DeCeuster, Adrian Turner, and Doug Crafts; and NREL's Harin Ullal, Peter Hacke, Chunsheng Jiang, Richard Mitchell, Mowafak Al-Jassim and Martha Symko-Davies.

SCIENCE AWARDS AND HONORS

The Electrochemical Society honored Byron Pivoval, Hydrogen Technologies and System Center, with its Charles W. Tobias Young Investigator of the Year Award for outstanding scientific work in fundamental or applied electrochemistry, or solid-state science, by a young scientist or engineer. Pivovar was recognized for his work advancing polymer electrolyte fuels and liquid fed fuel cell systems.

The European Section of The Electrochemical Society (ECS) honored Arthur J. Nozik, NREL Research Fellow Emeritus, with the Heinz Gerischer Award for his outstanding contribution to the science of semiconductor electrochemistry and photoelectrochemistry including the underlying areas of physical and materials chemistry of significance to this field.

The Japan Society of Coordination Chemistry recognized John Turner, NREL Research Fellow, with the Lectureship Award for his pioneering work in the fields of solar hydrogen and fuel cells and for being an international spokesman for hydrogen production via photoelectrochemical water splitting.

Ian Metzger was named by the American Society of Heating, Refrigeration and Air Conditioning Engineers (ASHRAE) as its New Face of Engineering. The program, part of National Engineers Week, and co-sponsored by ASHRAE, promotes the accomplishments of young engineers by highlighting their engineering contributions and the resulting impact on public welfare. Metzger provided commissioning oversight for two NREL high performance buildings: the RSF and the ESIF.

SAE International honored John Rugh, CTTS, with the 2013 Forest R. McFarland Award for his outstanding contributions toward the work of the SAE Engineering Meetings Board in the planning, development and dissemination of technical information.

The Utility Variable-Generation Integration Group (UVIG) Awards:

Achievement:

- Debra Lew and Gregory Brinkman, Strategic Energy Analysis Center Team, recognized for determining the impact of cycling operations due to wind and solar generation on operations and maintenance cost and emissions of coal plants for the ***Western Wind and Solar Integration Study.***
- Maureen Hand and Trieu Mai recognized for their groundbreaking contributions in the examination of electric power system operation with very high shares of wind, solar and other renewable power options through the ***Renewable Electricity Futures*** study.

Leadership:

- Brian Parsons was recognized for his steadfast vision and strong leadership in managing the NREL wind integration activities and in promoting collaboration among the DOE, NREL and UVIG renewables integration programs.

The Institute of Electrical and Electronics Engineers (IEEE) honored Keith Emery, Principal Scientist with the prestigious William Cherry Award for his testing and characterization laboratory bringing credibility to the measurement of efficiency of solar cells and modules.

The Materials Research Society (MRS) honored David Ginley, Research Fellow, with its Woody Award for his extraordinary volunteer contributions of time and effort to the success of the society. During his 20-year association with MRS, Ginley has served as board member, secretary, treasurer, vice president, and president.

LEADERSHIP AWARDS AND HONORS

The Colorado Cleantech Industry Association honored Charles Teplin with its Excellence in Communications Award for his outstanding contributions to technology transfer.

Dan Arvizu, NREL Director and Chair of the National Science Board was one of five Hall of Fame recipients of the U.S. News STEM Solutions 2013 National Conference in Austin, Texas. Honorees were recognized as pioneers in their fields of science, technology, engineering, and math and for helping lead the national effort to better prepare students and workers in the STEM fields.

Dick DeBlasio accepted the IEEE Region 5 Outstanding Large Company Award on behalf of NREL. This prestigious award honored NREL's support for IEEE members, Region 5 and the objectives of IEEE.

NREL has been recognized by the Denver Post as a "2013 Top Work Place." NREL is one of only 15 large Denver-area employers selected this year for this honor. NREL staff (75%) voluntarily took part in an independent survey which covered: organizational health, job satisfaction and engagement.

A University of Colorado's Leeds School of Business study noted that NREL, as one of Jefferson County's largest employers, had an economic impact on the county of nearly $274.6 million per year and an $814.8 impact to Colorado's economy overall in fiscal year 2012. NREL's staff includes nearly 1,700 regular employees and more than 1,000 visiting researchers, contractors and student interns.

SUSTAINABILITY AWARDS AND HONORS

Community Shares of Colorado's Workplace Giving Campaigns of the Year recognized NREL for its outstanding support through the employee giving campaign and overall contributions in recent years. NREL remains Community Shares of Colorado's most decorated corporate partner.

DOE recognized Chris Gaul, Sal Sferrazza, Jennifer Daw, Shanti Pless and Michelle Slovensky with the DOE Sustainability Award, Comprehensive Energy Management for NREL's innovation and commitment to environmental sustainability projects and programs that reduce environmental impacts, enhance site operations, reduce costs and demonstrate excellence in pollution prevention and sustainable environmental stewardship.

DOE honored NREL with its GreenBuy Award for excellence in Sustainable Acquisitions and Green Purchasing by attaining Leadership Gold—the highest award level. NREL was also acknowledged for using compostable materials in its cafeteria and meeting spaces, construction recycling, and recycling office materials as well as native plants in landscaped areas.

NREL's Parking Garage won the National Galvanizing Excellence Competition sponsored by AZZ Galvanizing Services, Denver for its cost effective, environmentally sound decision to use "Hot Dip Galvanizing" protective coating for the exposed structural and architectural steel.

NREL's Federal Electronics Challenge Team earned the Platinum Federal Electronics Challenge Award for supporting the federal government in improving its sustainable practices by implementing several Basic Ordering Agreements to help manage energy-efficient computing equipment requirements and costs. NREL's overall power consumption at the desktop level declined by about 78%.

The American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE) honored NREL with its 2013 ASHRAE Technology Award (first place) for the successful innovative building design of the net-zero energy RSF. Recognition to: NREL's Shanti Pless, Paul Torcellini, Otto Van Geet, Rob Guglielmetti, Jen Scheib and Ron Judkoff; and to Stantec Consulting Inc., which received the ASHRAE Award of Engineering Excellence for an outstanding project.

"From NREL's earliest beginnings, the laboratory's executive leadership has been passionate about the environment."

Message from the Sustainability Program Director

From Environmentalism to Sustainability—NREL's Leadership Drives Sustainability

NREL's pursuit of sustainability began with its inception as the Solar Energy Research Institute (SERI) during the height of environmentalism in the 1970s and has evolved into NREL's current sustainable business practices and employee culture. This biennial sustainability report for fiscal year 2012 and 2013 reflects the progress NREL has made during the last two years operating the laboratory by utilizing the most sustainable means possible. However, it is beneficial to look back further than the last two years to gain a broader understanding of the importance and impacts of NREL's mission. I want to take this opportunity to provide a brief look at events that were part of this evolutionary process and NREL's leadership role in moving the country toward a future of energy and environmental sustainability.

In the early twentieth century, the U.S. began taking an interest in the health of our environment. Galen Clark, Ulysses Grant, John Muir and others successfully lobbied congress and established Yosemite and Yellowstone as our first national parks and helped organize environmentally conscious grass-root organizations like the Sierra Club.

By the middle of the twentieth century, the prospering U.S. industrial economy began to overwhelm the nation with unregulated and unmanaged air, water, and environmental pollutants. Environmental pollution and degradation in our major cities became daily news citing: major oil spills and hazardous waste contaminations like the Love Cannel in New York, and Ohio's Cuyahoga River fire. These events and books like *Silent Spring* spurred national attention and action. Senator Gaylord Nelson (Wisconsin) and Representative Pete McCloskey (California) organized the first "National Teach-in on the Environment" or "Earth Day" and recruited Denis Hayes as the national coordinator. Twenty million Americans took part in the first Earth Day on April 22, 1970. The event was a catalyst for the promulgation of federal environmental regulations.[1]

1 Federal environmental regulations during the 1970's including the National Environmental Policy Act (NEPA) 1970, the Resource Conservation and Recovery Act (RCRA) 1970, the Clean Air Act amendments (CAA) 1970, the Clean Water Act (CWA) 1972, Marine Mammal Protection Act (MMPA) 1972, Endangered Species Act (ESA) 1972, and the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) 1980, along with the creation of the Environmental Protection Agency (EPA) 1970.

Nine years after Denis Hayes coordinated the first Earth Day he became the second Director of SERI, which in 1977 was designated as the DOE's National Renewable Energy Laboratory (NREL).

From NREL's earliest beginnings the laboratory's executive leadership has been passionate about the environment and NREL's mission: *Advancing renewable energy and energy efficiency and transferring knowledge and innovation to address the nation's energy and environmental goals.* NREL's mission is key to a sustainable national energy environment and to achieve that mission it is imperative we implement those principles here on our laboratory campuses. Our energy management expands to encompass a comprehensive analysis and decision-making process for all of the operations management and campus growth-related decisions. NREL is committed to operate as a "living laboratory" and to be a model of sustainability for other federal and commercial businesses to emulate.

In 1987 the United Nations Brundtland Commission defined "sustainable development" as meeting the needs of the present without compromising the ability of future generations to meet their own needs" and further defined sustainability as meeting economic, environmental, and social demands. At NREL we have adopted these definitions as one of our Missions and Values:

Leadership for societal impact

- Positively contribute to societies we serve nationwide and worldwide
- Demonstrate respect for our physical and social environment.

At NREL, we believe sustainability is the capacity to endure—economically, environmentally, and socially—maximizing the impact of our research and minimizing our use of resources. We work to go beyond compliance requirements to establish a sustainable culture.

In 1990, Twenty years after the first Earth Day in the U.S., Denis Hayes organized Earth Day globally in 141 countries. NREL too has become internationally recognized as the preeminent laboratory for renewable energy research. Denis Hayes and all of the NREL Laboratory Directors since have been greatly committed to our energy and environmental mission. NREL's seventh Director, Admiral Richard Truly, personally initiated NREL's formal Sustainability program in 2002 making it the oldest sustainability program within DOE. In addition, NREL's current Director Dr. Dan Arvizu and his executive management team: Dr. Dana Christensen, Deputy Director, Science and Technology; Bobi Garrett, Deputy Director, Strategic Programs and Partnerships; and Kenneth Powers, COO, Laboratory Operations have further advanced NREL's sustainability program to create a blueprint for cultural integration of sustainability—and incorporating it in our operations management, strategic planning, and long term campus decision-making. It is their support, direction, and dedication that inspires NREL employees, creates behavior change, and fosters adaptation of sustainable business principles. It is through NREL's executive leadership's vision that the laboratory is driven to exceed goals and expectations, focus on long-term environmental impact avoidance, discover innovative approaches to advance NREL's research and to advance our transparency and visibility as a leader in the field of sustainability.

– *Frank Rukavina, Sustainability Program Director, Chief Sustainability Officer*

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Photos by Dennis Schroeder: cover and page i, NREL 26678; page ii, NREL 26182; page 1, NREL 20729; page 4, NREL 25562; page 5, NREL 27661; page 7, NREL 22431; page 8, NREL 22390; page 12, NREL 26262; page 14, NREL 25931; page 17, NREL 27459; page 18, NREL 26580; page 20, NREL 21326; page 21, NREL 21333; page 22, NREL 21056; page 23, NREL 22411; page 24, NREL 26601; page 26, NREL 24505; page 28, NREL 20164; page 29, NREL 24570; page 31, NREL 21734 and 21721; page 35, NREL 19913 and 21030; page 36, NREL 23196; page 38, NREL 27735; page 41, NREL 27776; page 42, NREL 27228; page 44, NREL 20507; page 45, NREL 20511; page 50–51, NREL 22297; page 52, NREL 19335; page 55, NREL 22869 and 26374; page 59, NREL 29088; page 60, 29103; page 61, NREL 29107 and 29076; page 62, NREL 29036 and 29079; page 63, NREL 29080; page 64, NREL 29092; page 65, 2 NREL 25692; page 71, NREL 20266; page 73, NREL 22722; page 76, NREL 29017

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