

Annual Sustainability Report FY2015

INCORPORATES NREL SITE SUSTAINABILITY PLAN

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.

Sustainable NREL

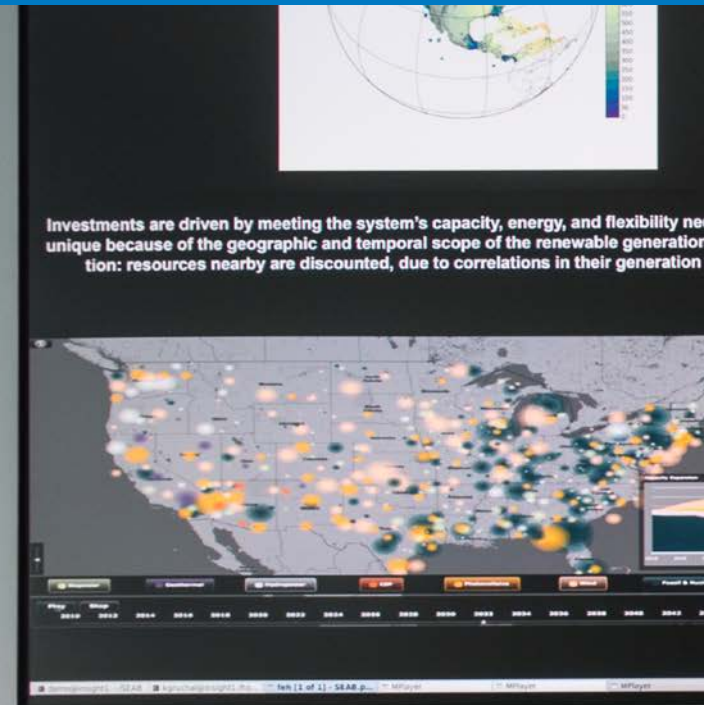
ANNUAL REPORT FY 2015

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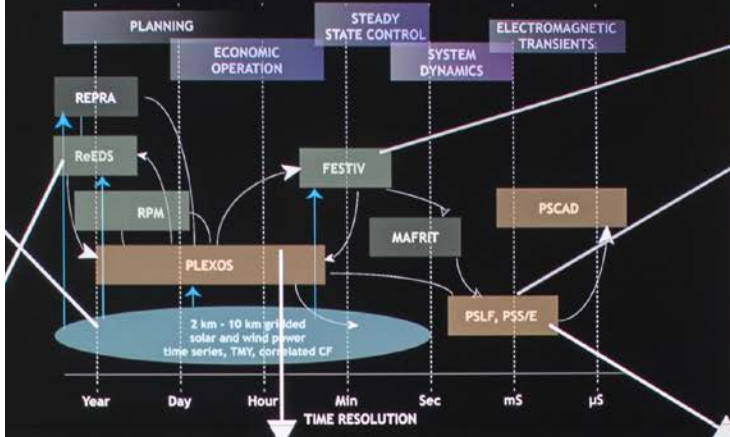
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Laboratory Program Manager David Mooney and Associate Lab Director Robin Newmark of the Energy Analysis and Decision Support center look at an advanced systems analysis of U.S. power systems with examples of high area renewables.

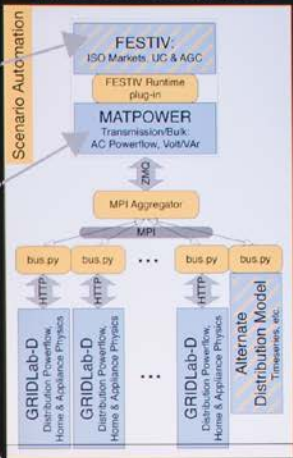
Cover photo: Members of the DHS sustainability team interact with an airflow visualization of dynamic interactive probing of vector fields, in the 3-D Visualization Lab in the ESIF at NREL.



NREL Grid Modeling Tools



Integrated Grid Modeling System



Objective: modernization through analysis of technical options, economic impact, and optimization.

We are designing our tools to:

- 1) represent the physics of the grid within defined spatial and temporal resolution and extent, which increases the productivity of each model;
- 2) exchange data easily by automating the transformation to higher/lower resolution or between optimized and simulated models, which prompts "what if" and "why" analysis;
- 3) scale to multiple computing architectures, including multi-core, multi-node (high performance computers), which expands integrated modeling - coming closer to real time predictive models;
- 4) adopt measured or synthetic grid operation data, which validates the model performance under known conditions and increases the fidelity of future system models.

Day-hour unit commitment and economic dispatch demonstrates how generation source work together to meet demand without violating the operating restrictions of various generation units: minimum generation output, time to turn on/off, etc.

Transmission capacity between regions informs the extent to which neighbors could rely on each other for diversity of energy resources. Here is a centrally dispatched power flow; in the future, we will be able to demonstrate multiple system planners with a single real time dispatch.



Nomenclature

AFV	alternative fuel vehicle	ft²	square feet	MWh	megawatt-hour
ANSI	American National Standards Institute	FTLB	Field Test Laboratory Building	N/A	not applicable
ASHRAE	American Society of Heating and Air-Conditioning Engineers	FY	fiscal year (October 1st – September 30th)	NEPA	National Environmental Policy Act
Btu	British thermal unit	gal	gallons	NREL	National Renewable Energy Laboratory
CRADA	cooperative research and development agreement	gCO₂e	grams of carbon dioxide equivalent	NWTC	National Wind Technology Center
DOE	United States Department of Energy	GE	General Electric	OCIO	Office of the Chief Information Officer
DOE-GO	Golden Field Office	GGE	gasoline gallon equivalent	PC	personal computer
DRCOG	Denver Regional Council of Governments	GHG	greenhouse gas	PCard	purchase card
E-85	high-level ethanol (85%) fuel	GSA	General Services Administration	PEV	plug-in electric vehicle
EIC	Energy Intelligent Campus	GSF	gross square foot	PPA	power purchase agreement
EISA	Energy Independence and Security Act	HPCDC	High Performance Computing Data Center	PUE	power usage effectiveness
EO	executive order	HPSB	high performance sustainable building	PV	photovoltaic
EMRI	Energy Management Readiness Indicator	HVAC	heating, ventilation, and air conditioning	REC	renewable energy credit
EERE	DOE's Office of Energy Efficiency and Renewable Energy	IESNA	Illuminating Engineering Society of North America	RFHP	Renewable Fuel Heat Plant
EnMS	Energy Management System	ILA	industrial, landscaping, and agricultural	RSF	Research Support Facility
EPA	United States Environmental Protection Agency	ISO	International Organization for Standardization	R&D	Research and Development
EPEAT	Electronic Product Environmental Assessment Tool	IT	information technology	RTD	Regional Transportation District
EPP	Environmentally Preferable Product	IT	information technology	S&TF	Science and Technology Facility
ESIF	Energy Systems Integration Facility	kW	kilowatt	SITE	Sustainability, Infrastructure Transformation, Engineering
ECM	energy conservation measure	kWh	kilowatt-hour	SPOFOA	Sustainability Performance Office Funding Opportunity Announcement
ESPC	energy savings performance contracts	LEED®	Leadership in Energy and Environmental Design	SSEB	South Site Entrance Building
FEMP	Federal Energy Management Program	MFD	multifunction device	SSPP	Strategic Sustainability Performance Plan
		MTCO₂e	metric tons of carbon dioxide equivalent	STM	South Table Mountain
		MW	megawatt	T&D	transmission and distribution
				USFWS	United States Fish and Wildlife Service
				Western	Western Area Power Administration

ACKNOWLEDGMENTS

Going beyond performance goals, objectives, and strategies, *NREL's Annual Sustainability Report, Fiscal Year 2015* reflects the human side of sustainability. The National Renewable Energy Laboratory's (NREL's) "living laboratory" culture embodies the value of employee participation to create the most sustainable laboratory environment possible. NREL successfully integrates sustainability into every aspect of its mission to deliver clean energy solutions to the nation.

I'd like to acknowledge NREL staff for engaging in initiatives that reduce energy waste and pollution, minimizing our carbon footprint. I would especially like to acknowledge those who collaborated on producing this report to tell the Sustainable NREL story.

Thanks to NREL's Leadership Team and to the many managers and staff members who provided technical content, data collection, and communication support, including the Sustainability group; Associate Lab Director - Energy and Analysis & Decision Support; Communications; Environment, Health & Safety; Energy Systems Integration; Finance; Human Resources; Integrated Applications Center; General Counsel; Mechanical and Thermal Engineering; National Wind Technology Center; Office of the Chief Information Officer; Public Affairs; Strategic Energy Analysis Center; and SITE Operations.

Special thanks to our annual report champions, Michelle Slovensky and Suzy Belmont, who fervently identify sustainability themes that raise the laboratory's awareness and responsibility and achieve greater synergy between staff, mission implementation, and our environment. Thanks also to Stakeholder Initiatives author, Ernie Tucker. Leigh Ramsey of Communications & Public Affairs provided project management support and production designer Anthony Castellano created the report design.

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

Frank Rukavina, Sustainability Program Director

NREL is a national laboratory of the U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy.

Message from the NREL Director

NREL's 2015 Annual Sustainability Report examines site sustainability planning by emphasizing NREL's attention to resiliency. In this broader context, our focus on resiliency and sustainability is part of the emerging concept of "planetary health." That idea is deeply rooted in the work of Alexander von Humboldt, a naturalist who lived from 1769-1859 and who is credited with showing for the first time that nature was a global force, with corresponding climate zones across continents. Indeed, Andrea Wulf's recent bestseller credited von Humboldt with "inventing" our concept of nature—and predicting dire consequences for failing to honor Earth's balance. He wrote of the destructive power of human choices he witnessed from deforestation, large-scale irrigation and pollution, warning "Mankind's mischief... disturbs nature's order."

Faced with these urgent challenges, we now are striving to amplify the elements that support planetary health—sustainability, resiliency, and stewardship—in NREL's mission. At its core, such a focus is nothing new. NREL has been fostering sustainability through research, and promoting energy efficiency and renewable energy by embracing both as long-term strategies in the lab's daily operational practices. More recently, NREL has emphasized adaptation and resiliency—qualities that allow us to anticipate, to respond to, and to recover from significant multi-hazard threats to both society and the environment.

Today there are increasingly high stakes facing us all, consequences scientists and visionaries such as Von Humboldt could only imagine. And we are responding. In this report, you'll find a discussion from various stakeholders about ways the lab is building up its resiliency:

- NREL's campus is becoming a working example of resilience with clean energy piloting;
- Researchers are showing that energy systems as a whole—and the grid—can be robust systems;
- Distributed intelligence in computing is strengthening cybersecurity to avoid failures in systems;



Dr. Martin Keller became the National Renewable Energy Laboratory's ninth Director on November 30, 2015 and is President of Alliance for Sustainable Energy, LLC.

- Increasing diversity of our transportation portfolio is furthering independence from petroleum and expanding biofuel use.

These are only a few of the examples discussed in this report. As we learn from both our successes and our failures, our research will combine with NREL's deployment capabilities to impact stakeholders and decision-makers in the United States and across the globe. By so doing, we'll further not only sustainability, but foster resiliency in ways others can adopt.

Such actions in turn can help re-knit the fabric of nature, and begin to restore the tapestry of planetary health. In this way, we truly honor the spirit of Von Humboldt and so many others who recognized that we all have a duty to live in harmony with nature—and that the best way to do so is to practice sustainability and to promote resiliency.



The eastern edge of NREL's STM campus.



Pete Johnson (top) and Trask Bradbury with Gemini Rope Access Solutions work together as they inspect the blades of a 3MW Alstom turbine undergoing testing at NREL's National Wind Technology Center (NWTTC).

Standard Disclosures

NREL ORGANIZATIONAL PROFILE

The 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 U.S. Department of Energy (DOE) for NREL's performance over a 5-year contract period that began in October 1, 2008, and was extended through September 30, 2017.

The Alliance's roles are to build on the strong foundation that NREL has built over the last 39 years, ensure the success of the laboratory's strategy to advance innovation across the clean energy portfolio, and push the frontiers on related science. This is accomplished through:

- Research and development (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.

Research and Development Initiatives

The Alliance works with EERE to advance the office's strategic goals. While the roles of the laboratory vary across each program, all of NREL shares a commitment to developing clean energy and energy efficiency technologies and practices, advancing related science and engineering, and providing knowledge and innovations to integrate energy systems at all scales.

Through this strategy for NREL, the Alliance aims to enable a transformation of energy systems that will support energy security and a vibrant economy and ensure stewardship of the environment.

The Alliance's efforts toward high mission impact require strategies that cut across individual programs and initiatives and bring a sharp focus to the primary mission of the laboratory. This is accomplished by:

- Creating an environment that stimulates creativity and that yields advances in foundational knowledge and market-relevant innovations that have potential for high impact
- Connecting the knowledge and know-how of the laboratory to the marketplace through partnerships that enable and amplify the impact of NREL's efforts.

NREL's 8th Lab Director Dan Arvizu (left) and NREL's 9th Lab Director Martin Keller spend their last and first day on the job together.



The Alliance also enables mission accomplishment through strategies to strengthen NREL's distinctive technical competencies and its operations, both of which provide a foundation for delivery. NREL's crosscutting strategies are applied to the laboratory's five major mission areas:

- **Energy Systems Integration**
- **Sustainable Transportation**
- **Renewable Generation**
- **Energy Productivity**
- **Strategic Analysis and Market Engagement.**

Foundational Capabilities

Underlying NREL's ability to produce mission outcomes are eight foundational capabilities that 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. This combination of these capabilities with the knowledge that has resulted from nearly four decades of experience 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 NREL's Leadership in Sustainability

In FY 2015, NREL had three directorates: Strategic Programs and Partnerships, Science and Technology, and Laboratory Operations. Together with associated offices and programs, these directorates helped 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 clean energy solutions. To this end, NREL has streamlined the way it does business and enhanced the entrepreneurial environment to provide greater access to capital and engage strategically with industry and stakeholders.

Partnerships are at the core of NREL's strategy. The laboratory collaborates with industry; academia; nonprofit organizations; federal agencies; state, local, and tribal governments; and international institutions to commercialize and deploy renewable energy and energy-efficient technologies. The laboratory engages with the private sector through a variety of research contracting mechanisms and licensing new technologies. Overall, federal investment in these partnerships has leveraged private funds by a factor of 8. 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 to tailor cost-effective solutions that are based on locally available resources. NREL's deployment program supports DOE's strategy to accelerate the market adoption of alternative energy solutions. NREL's comprehensive approach helps transform the way local communities use energy by identifying opportunities, building partnerships, and creating a foundation for technology implementation. NREL offers technical assistance: staff members help communities assess renewable options and provide training to help build a skilled workforce.

Science and Technology

The laboratory's science and technology teams work in the full range of 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 sustainable buildings, transportation, electricity 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 by managing a sustainable environment, 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 its environmental footprint by constructing and monitoring the performance of its 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 finding creative answers to today's energy challenges. From concept to the commercial marketplace, NREL's discoveries are transforming the way the world uses energy.

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:

- Revenue from the U.S. government and Work for Others Projects: \$387.4 million

- Total Alliance capitalization as of September 30, 2015*:
 - Debt \$0
 - Equity \$4.9 million
- Total Alliance assets*: \$80 million.

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 2015, NREL has used the Global Reporting Initiative (GRI) Sustainability Guidelines to highlight activities, progress, and accomplishments.

*These amounts do not include DOE assets or equity. The Alliance is the management and operating contractor of NREL.

South Table Mountain (STM) is a pedestrian and bike friendly campus. The laboratory has committed to consistently improving pedestrian and bicycle safety throughout the campus. This also reduces Greenhouse Gas (GHG) emissions and improves employee health and wellness.



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

- Implementing 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.

The chosen materiality assessment sections, per the GRI reporting format, represent key performance areas that are critical to achieving NREL's mission. A continuous stakeholder process is conducted to examine and identify achievements, challenges, and methods to enhance data collection that are vital to these sections. Stakeholders include our DOE and various NREL staff members who

represent 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 steps to collect data that are unique to each section. Planning actions were also derived from these beneficial group discussions for future performance indicators that would require intensive tracking and monitoring activities. Additionally, several NREL communication specialists were asked to write feature articles to highlight significant achievements.

Report Scope and Boundaries

NREL's facilities are primarily located on two sites: STM in Golden, Colorado, and the NWTC in Louisville, Colorado. Facilities on these two sites are owned by DOE. NREL also leases office space in the Denver West Office Park, the Renewable Fuels and Lubricants Laboratory in Denver, and an office in Washington, D.C.

NREL's STM site consists of approximately 999,796 gross square feet (GSF) facilities on 327 acres. Of these, DOE has granted a 177-acre conservation easement to Jefferson County, which provides hiking trails and permanent conservation status for the land. The remaining 152 acres are used for campus infrastructure and high-performance building facilities for laboratories, offices, and supporting mission functions. The NWTC site is located approximately 20 miles north of the STM site and has approximately 81,335 GSF facilities on 280 acres, and DOE has granted a 157-acre conservation easement.



Although some wind turbines at the NWTC help offset electricity use at NREL through on-site generation, NREL also hosts turbines for research purposes, including this 300-foot, 3-MW Alstom wind turbine.

As a DOE national laboratory, NREL works to meet environmental and energy-related regulatory requirements as defined by the Energy Policy Act of 2005; Executive Order (EO) 13423 and EO 13514; and the Energy Independence and Security Act (EISA) of 2007. These laws and regulations establish federal requirements that span energy efficiency, GHGs, high-performance buildings, renewable energy, water conservation, pollution prevention, sustainable acquisition, electronic stewardship, and vehicle fleets.

Data Collection and Metrics

NREL's sustainability metrics are built upon a wealth of data that fully encompass its campus operations. A large component of NREL's reporting focuses 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

the DOE Sustainability Dashboard (Dashboard), which allows access to up-to-date energy information.

On-site renewable energy production from the Renewable Fuel Heat Plant (RFHP), photovoltaic (PV) arrays, and wind turbines is also tracked in the Dashboard. Other on-site renewables are captured in tracking matrices that the Sustainable NREL Program uses to manage capacity, production, Leadership in Energy and Environmental Design (LEED) allocation, and Renewable Energy Certificate (REC) retention. NREL regularly reports these energy data to DOE headquarters in federal reporting tools and benchmarks its energy performance monthly to look for improvement opportunities.

In addition to energy data and water use, The Sustainable NREL Program tracks the performance of Scopes 1, 2, and 3 GHG emission sources. Scope 1 sources include NREL's vehicle fleet, refrigerants, fugitive gases, process, and

on-site combustion. NREL's Scope 2 sources are entirely composed of electricity purchases and on-site renewables. Information is tracked for Scope 3 emission sources, which include commuting, business ground and air travel, waste disposal, wastewater treatment, and transmission and distribution (T&D) 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 (FY) and entered into the DOE Consolidated Energy Data Report to calculate emissions—allowing for annual tracking of progress toward NREL's reduction goals.

SUMMARY TABLE OF GOALS AND TARGETS

DOE Goal	Baseline	Performance Status Through FY 2015	Planned Action and Contributions	Risk of Non-attainment: High (H), Medium (M), or Low (L)
Greenhouse Gas Reduction				
50% Scope 1 and 2 GHG reduction by FY 2025 from a FY 2008 baseline (FY 2015 target: 19%)	FY 2008: 23,965 MTCO ₂ e	26,699 MTCO ₂ e of Scope 1 and 2 emissions, an 11% increase from the baseline without RECs 3,516 MTCO ₂ e of Scope 1 and 2 emissions, an 85% decrease from the baseline including RECs to offset Scope 2 emissions	Continue energy efficiency improvements to reduce Scope 1 and 2 emissions Implement improvements to the RFHP to reduce Scope 1 stationary emissions	L—NREL will continue to meet or exceed this goal
25% Scope 3 GHG reduction by FY 2025 from a FY 2008 baseline (FY 2015 target: 6%)	FY 2008: 7,490 MTCO ₂ e	7,593 MTCO ₂ e of Scope 3 emissions, a 1% increase from the baseline without RECs 6,066 MTCO ₂ e of Scope 3 emissions, a 19% decrease from the baseline including RECs to offset T&D emissions	Continue to promote teleworking and alternative commuting practices in order to reduce Scope 3 emissions Reevaluate the <i>Scope 3 Greenhouse Gas Emission Reduction Plan</i> to identify other opportunities to reduce Scope 3 emissions	L—NREL will continue to meet or exceed this goal
Sustainable Buildings				
25% energy use intensity (Btu/GSF) reduction in goal-subject buildings, achieving 2.5% reductions annually, by FY 2025 from a FY 2015 baseline	FY 2003: 257,552 Btu/GSF FY 2015: 133,395 Btu/GSF	Energy use intensity reduced 48% from the baseline and increased 13% from FY 2014 to 133,395 Btu/GSF	Continue to pursue renewable energy and energy efficiency measures to reduce energy use intensity	M—Technical Risk: NREL will continue to strive for reductions in energy use intensity. With the increase of the HPCDC NREL may have difficulty achieving this goal in the future
EISA Section 432 energy and water evaluations	N/A	Conducted EISA audits on three facilities that use 0.6% of total energy Evaluations are 81% complete, comprehensive evaluation due 6/30/2016	Finalize the procedure for the savings reinvestment fund Perform EISA audits for four additional facilities	L—By June 2016, NREL will have assessed 100% of covered facilities
Meter all individual buildings for electricity, natural gas, steam and water, where cost-effective and appropriate ¹	N/A	100% of NREL's buildings have energy meters (including electricity, natural gas, and renewables where appropriate) 100% of NREL's buildings have chilled water meters 100% of NREL's buildings have hot water meters (NREL does not use steam) 95% of NREL's buildings have potable water meters	Attain third-party certification of ISO 50001. Select the EIC architectural platform for deployment in ESIF and FTLB	L—NREL will continue to meet this goal
At least 15% (by building count or GSF) of existing buildings greater than 5,000 GSF to be compliant with the revised Guiding Principles for HPSB by FY 2025, with progress to 100% thereafter	N/A	Six buildings (33%) of eligible buildings are compliant with the Guiding Principles for HPSB	Pursue opportunities to integrate ECMs within existing facilities for expanded building portfolio compliance with the Guiding Principles for HPSB. Continued monitoring for HPSBs to ensure energy optimization	L—NREL will continue to meet or exceed this goal

¹ Per NEPA (42 U.S.C Section 8253) the term "buildings" includes industrial, process, or laboratory facilities.

SUMMARY TABLE OF GOALS AND TARGETS

DOE Goal	Baseline	Performance Status Through FY 2015	Planned Action and Contributions	Risk of Non-attainment: High (H), Medium (M), or Low (L)
Efforts to increase regional and local planning coordination and involvement	N/A	<p>Continued to work with local governments to promote and encourage alternative transportation</p> <p>Worked with the RTD and MV Transportation to develop a new shuttle route for NREL employees to encourage commuting by alternative transportation</p> <p>Met with staff from the city of Golden and the Colorado School of Mines to discuss potential carshare and bikeshare opportunities</p> <p>Worked with DOE and Jefferson County Open Space to improve the Cretaceous Trailhead accessing South Table Mountain Park</p> <p>Coordinated efforts with the USFWS Rocky Flats Refuge officials to treat 102 acres for knapweed at the NWTC</p>	<p>Continue efforts to advocate for and improve access to alternative commuting options through regional and local organizations</p> <p>Roll out a pilot program using revised NEPA criteria and changes made before rolling out the program across the laboratory. The laboratory-level procedure will be updated, as well as the NEPA Handbook</p> <p>Meet with USFWS to develop a 2016 strategy to work cooperatively to manage noxious weeds</p> <p>Continue participation in regional events promoting alternative transportation such as Go-Tober and Bike to Work Day</p>	L—NREL will continue to meet this goal
Net Zero Buildings: Percentage of the site's existing buildings above 5,000 GSF intended to be energy and waste, or water net zero buildings by FY 2025	N/A	N/A	Install a solar PV array on the parking garage to retain net zero energy performance for the RSF complex if funding becomes available.	L—NREL is on track to meet this goal
Net Zero Buildings: Percentage of new buildings (>5,000 GSF) entering the planning process designed to achieve energy net zero beginning in FY 2020	N/A	N/A	Incorporate net zero energy designs in the planning process, where feasible, for all new facilities	L—NREL is on track to meet this goal
Data Center Efficiency: Establish a power usage effectiveness target in the range of 1.2-1.4 for new data centers and less than 1.5 for existing data centers	N/A	N/A	<p>Turn off up to 10 kW of legacy equipment in the RSF.</p> <p>Maintain a PUE of less than 1.20 in the RSF data center</p>	L—NREL will continue to meet or exceed this goal
Clean & Renewable Energy				
"Clean Energy" requires that the percentage of an agency's total electric and thermal energy accounted for by renewable and alternative energy shall be not less than: 10% in FY 2016-2017, working towards 25% by FY 2025	N/A	N/A	Increase the thermal output of the RFHP by 50%.	L—NREL is on track to meet or exceed this goal
"Renewable Electric Energy" requires that renewable electric energy account for not less than 10% of a total agency electric consumption in FY 2016-2017, working towards 30% of total agency electric consumption by FY 2025	N/A	<p>Renewable electric energy including RECs accounted for 135% of total electric consumption</p> <p>Onsite renewable electric energy consumed at NREL accounted for 19% of total electric consumption</p>	<p>Increase solar PV generation by over 1 MW with construction starting mid-2016</p> <p>Continue working with Xcel Energy to develop a green tariff to buy offsite wind</p> <p>Supplement on-site renewables with REC purchases, as necessary, to ensure electricity is 100% carbon neutral</p>	L—NREL will continue to meet or exceed this goal
Water Use Efficiency and Management				
36% potable water use intensity (gal/GSF) reduction by FY 2025 from a FY 2007 baseline (FY 2015 target: 16%)	FY 2007: 27.5 gal/GSF	Potable water use intensity reduced 42% from the baseline to 16 gal/GSF	<p>Divert heat from cooling towers to minimize the impact of the HPCDC</p> <p>Improve usage of the WeatherTRAK system</p> <p>Complete the update of NREL's <i>Water Management Plan</i></p>	M—Management Risk: NREL will see a substantial increase in water usage in FY 2016 from the addition of the clean room in the S&TF. NREL will continue to explore opportunities to reduce water intensity

SUMMARY TABLE OF GOALS AND TARGETS

DOE Goal	Baseline	Performance Status Through FY 2015	Planned Action and Contributions	Risk of Non-attainment: High (H), Medium (M), or Low (L)
30% water consumption (gal) reduction of ILA water by FY 2025 from a FY 2010 baseline (FY 2015 target: 10%)	N/A	NREL does not use ILA water	N/A	N/A
Fleet Management				
20% reduction in annual petroleum consumption by FY 2015 relative to a FY 2005 baseline; maintain 20% reduction thereafter (FY 2015 target: 20%)	FY 2005: 7,722 GGE of petroleum fuel	Petroleum consumption increased 17% from the baseline to 9,044 GGE	Explore the possibility of replacing diesel campus shuttles with AFVs Conduct a fleet reduction analysis to ensure NREL has a right-sized fleet Investigate the use of fleet telematics in accordance with EO 13693	H—Management Risk: Disposition of low-mileage AFVs to meet vehicle reduction goals and increased use of the diesel buses have increased overall petroleum use
10% increase in annual alternative fuel consumption by FY 2015 relative to a FY 2005 baseline; maintain 10% increase thereafter (FY 2015 target: 10%)	FY 2005: 7,507 GGE of alternative fuel	Alternative fuel use increased a cumulative 127% from the baseline to 17,007 GGE. This is a 53% increase from FY 2014	Continue to increase AFVs in an effort to increase alternative fuel consumption	M—Management Risk: Decreased use of fleet vehicles may reduce overall alternative fuel usage
30% reduction in fleet-wide per-mile GHG emissions reduction by FY 2025 from a FY 2014 baseline (FY 2015 target: N/A; FY 2017 target: 4%)	FY 2014: 574 gCO ₂ e/mile	N/A	Continue to increase AFVs in an effort to decrease the fleet-wide per-mile GHG emissions	L—NREL is on track to meet this goal.
75% of light duty vehicle acquisitions must consist of AFVs (FY 2015 target: 75%)	N/A	100% of light duty vehicle acquisitions consisted of AFVs	Continue to acquire GSA-leased replacement vehicles with AFVs if available and as required	L—NREL will continue to work with GSA and DOE to purchase AFVs for the fleet whenever possible
50% of passenger vehicle acquisitions consist of zero emission or plug-in hybrid electric vehicles by FY 2025 (FY 2015 target: N/A)	N/A	N/A	Continue to explore options for the acquisition of zero emission vehicles	M—Management Risk: GSA does not currently offer zero emission vehicles that meet NREL fleet classifications. NREL will continue to explore opportunities to acquire zero emission vehicles
Sustainable Acquisition				
Promote sustainable acquisition and procurement to the maximum extent practicable, ensuring BioPreferred (a United States Department of Agriculture program designation) and bio-based provisions and clauses are included in 95% of applicable contracts	N/A	100% of construction contracts meet sustainable acquisitions requirements 100% of custodial contracts meet sustainable acquisitions requirements	Conduct PCard trainings with Q&A sessions to be held in October 2016 Refine green purchase definitions with PCards Continue to require EPPs in contractor and custodial contracts Analyze supply chain improvement options	L—NREL will continue to meet or exceed this goal
Goal 7: Pollution Prevention & Waste Reduction				
Divert at least 50% of non-hazardous solid waste, excluding construction and demolition debris	N/A	Diverted 81% of nonhazardous solid waste from the landfill	Investigate additional measures with the Near-Zero Waste Materials Committee to achieve higher diversion rates and reduce overall waste Implement a sustainable supply chain pilot project	L—NREL will continue to meet or exceed this goal

SUMMARY TABLE OF GOALS AND TARGETS

DOE Goal	Baseline	Performance Status Through FY 2015	Planned Action and Contributions	Risk of Non-attainment: High (H), Medium (M), or Low (L)
Divert at least 50% of construction and demolition materials and debris	N/A	Diverted 75% of construction and demolition materials and debris from the landfill	Work with project managers to collect data each month about construction projects in an effort to increase diversion rates	L—NREL will continue to meet or exceed this goal
Goal 8: Energy Performance Contracts				
Annual targets for performance contracting to be implemented in FY 2017 and annually thereafter as part of the planning of section 14 of EO 13693	N/A	Targeting \$2 million as NREL's goal for performance contracting		
Electronic Stewardship				
Purchases: 95% of eligible acquisitions each year are EPEAT-registered products	N/A	98% of eligible electronic acquisitions met EPEAT standards	Continue to uphold best practices for electronic stewardship.	L—NREL will continue to meet or exceed this goal.
Power management—100% of eligible PCs, laptops, and monitors have power management enabled	N/A	Power management is enabled on 100% of eligible PCs, laptops, and monitors	Reduce overnight plug loads in the office wing of the ESIF by using state-of-the-art power strips. Educate staff on the importance of using power management settings through focused training classes and competitions	L—NREL will continue to meet this goal
Automatic duplexing—100% of eligible computers and imaging equipment have automatic duplexing enabled	N/A	100% of MFDs have automatic duplexing enabled 100% of eligible personal printers have automatic duplexing enabled	Continue to replace personal printers, scanners, and fax machines with MFDs	L—NREL will continue to meet this goal
End of Life—100% of used electronics are reused or recycled using environmentally sound disposition options each year	N/A	100% of electronics at their end of life were donated, resold, or recycled using environmentally sound disposition practices 33,441 pounds of electronics were recycled in FY 2015	Continue to donate, resell, or recycle electronics at their end of life	L—NREL will continue to meet this goal
Climate Change Resilience				
Update policies to incentivize planning for and addressing the impacts of climate change	N/A			
Update emergency response procedures and protocols to account for projected climate change, including extreme weather events	N/A		Convene the steering committee to review climate change conditions at the laboratory Develop task groups to address recommendations from the Resilience Action Plan	
Ensure workforce protocols and policies reflect projected human health and safety impacts of climate change	N/A	NREL's recent A Climate Change Vulnerability Assessment Report for the National Renewable Energy Laboratory and A Resiliency Action Plan for the National Renewable Energy Laboratory identified goals 10.1–10.4 as resilience options and will pursue these changes in FY 2016 and beyond	Coordinate a regional symposium to identify opportunities for local partnership in climate change resilience planning	L—NREL will address these goals in FY 2016
Ensure site/lab management demonstrates commitment to adaptation efforts through internal communications and policies	N/A			
Ensure that site/lab climate adaptation and resilience policies and programs reflect best available current climate change science, updated as necessary		NREL's recent climate change vulnerability assessment and resilience action plan used current climate science information provided by the Western Water Assessment, the Regional Integrated Science and Assessment climate science research team in the laboratory's region	NREL will continue to use the best available current climate change science to inform resilience policies and programs	L—NREL will continue to meet this goal

Greenhouse Gas Emissions

Goals and Achievements

50% Scope 1 and 2 GHG reduction by FY 2025 from an FY 2008 baseline (FY 2015 target: 19%)

- 3,516 MTCO₂e of Scope 1 and 2 emissions, an 85% decrease from the baseline including RECs to offset Scope 2 emissions.

25% Scope 3 GHG reduction by FY 2025 from an FY 2008 baseline (FY 2015 target: 6%)

- 6,066 MTCO₂e of Scope 3 emissions, a 19% decrease from the baseline including RECs to offset T&D emissions.

Climate change resilience planning

- NREL's recent *A Climate Change Vulnerability Assessment Report for the National Renewable Energy Laboratory* and *A Resiliency Action Plan for the National Renewable Energy Laboratory* identified resilience options and will pursue changes in FY 2016 and beyond.

NREL and DOE employees check out electric vehicles at the Earth Week Green Commuting Expo at the FTLB parking lot. The event included electric vehicles, electric bikes, and free bike tune ups.



Greenhouse Gas Emissions

FISCAL YEAR 2015 PERFORMANCE STATUS

NREL's operational boundaries include DOE-owned facilities, equipment, and the vehicle fleet and non-highway vehicles on both the South Table Mountain (STM) and NWTTC campuses. NREL has partial lease agreements for office, storage, and laboratory space in the Denver West Office Park, the Joyce Street facility, and the Renewable Fuels and Lubricants Laboratory, which are not under NREL's operational control. Energy data for these properties, however, are included in NREL's greenhouse gas (GHG) emissions as required. Moreover, GHG emissions from DOE's Golden Field Office (DOE-GO) operations are captured both within NREL totals and DOE Headquarters totals where appropriate.

As DOE's only national laboratory solely dedicated to researching and developing clean energy and energy efficiency technologies, NREL will continue to aggressively leverage its mission to ensure it meets and exceeds sustainability goals. At the same time, NREL will maintain state-of-the-art sustainable and resilient campuses for industry and other federal facilities to use as models.

Currently, NREL has three high-energy, mission-specific facilities that pose a challenge to the reduction of Scope 1 and 2 GHG emissions:

- The Solar Energy Research Facility consumes about 25% of all NREL energy
- The ESIF consumes about 16% of all NREL energy.
- The Field Test Laboratory Building (FTLB) consumes about 9% of all NREL energy

Housed in the ESIF is the high performance computing data center (HPCDC), the most energy-efficient data center in the world, featuring liquid cooling and waste heat capture and reuse. Even so, the HPC uses a significant amount of electricity, accounting for nearly one-fifth of the total electricity consumed on the STM campus.

NREL's preferred method of offsetting GHG emissions is through onsite production of renewable energy and energy efficiency technologies. NREL will, however, continue to purchase RECs to supplement onsite renewables and to ensure its electricity usage is 100% carbon neutral.

Scope 1

Scope 1 GHG emission sources include stationary, mobile, fugitive, and process emissions.

Stationary emissions (natural gas for heating facilities and for experiments) make up 96% of Scope 1 emissions and total 3,368 MTCO₂e. This is a 34% increase from FY 2014 and a 4% decrease from the baseline year of FY 2008. Although the 2014 to 2015 winter was a colder winter overall, there were a number of days that were too warm to run NREL's Renewable Fuel Heat Plant (RFHP), which offsets natural gas used for district heating. Because the start-up time for the RFHP is long, it is NREL's cost-effective practice to turn it on only when an extended period of cold temperatures is predicted. In FY 2015, a large fluctuation in temperatures kept the RFHP from running for approximately 42 days of the heating season, resulting in more natural gas use for heating.

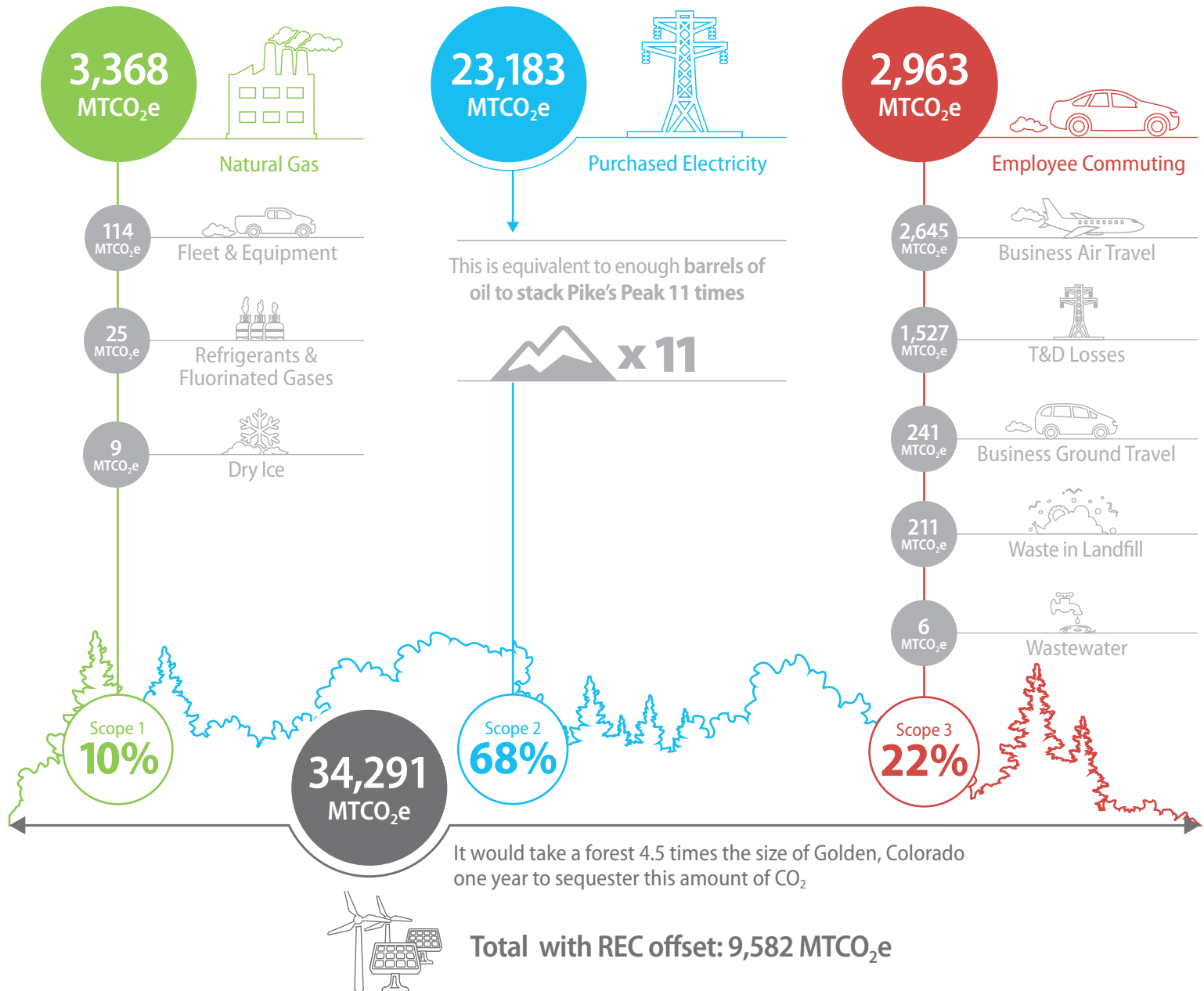
Strategic Intent

NREL is working to establish carbon-neutral campuses that efficiently use limited resources, reduce waste, and demonstrate 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.

Mobile emissions (vehicle fleet and non-highway vehicles, equipment, and diesel generators) account for 3% of Scope 1 emissions and total 114 MTCO₂e. This is a 34% increase from the baseline year of FY 2008 and a 58% decrease from FY 2014. Mobile emissions from backup generators and NREL fleet both dropped significantly because there was less construction on the campuses in FY 2015. In addition, six unleaded gasoline or unleaded-hybrid vehicles were replaced with E-85 vehicles.

Fugitive emissions (fluorinated gases, refrigerants, and onsite septic systems) account for less than 1% (0.7%) of Scope 1 emissions. In FY 2015, fugitive emissions were reduced by 99% from the FY 2008 baseline year and 98% from FY 2014 levels. This reduction resulted from a couple of factors. First, in FY 2014 NREL began recording fugitive emissions on an FY basis instead of a rolling three-year average. Second,

Greenhouse Gas Emissions: FY 2015



in FY 2015, no sulfur hexafluoride, a high GHG emitter, was added to NREL's inventory. Also in FY 2015, NREL began discussing improved processes for tracking refrigerants used in Sustainability, Infrastructure Transformation, Engineering (SITE) Operations. A new tracking system was subsequently developed and vetted in FY 2015 that allowed NREL to better record refrigerants purchased, in storage, and recycled. Currently, no method is in place to capture the total amount of GHG emissions not released into the atmosphere because of refrigerant recycling. NREL recycles all used refrigerants whenever possible. Tanks are recycled with a United States Environmental Protection Agency (EPA)-Certified Refrigerant Reclaimer to reduce the amount of emissions to negligible levels. NREL regularly

monitors equipment using refrigerants for leaks to minimize fugitive emissions.

Process emissions account for less than 1% (0.3%) of Scope 1 emissions, all emitting from dry ice usage in the laboratories. This is the same amount of emissions from FY 2014 and a 6% increase from the FY 2008 baseline.

Scope 2

The majority of NREL's Scope 2 emissions are associated with purchased electricity, totaling 23,183 MTCO₂e. This is a 24% increase from the FY 2008 baseline and a 4% decrease from FY 2014 levels. Committed to ensuring that the laboratory achieves Scope 2 carbon neutrality, NREL purchased Green-e-certified RECs in FY 2015 to offset all Scope 2 emissions that could not be avoided. NREL ensured that all RECs

purchased were generated within 10 years of FY 2015.

Scope 3

Scope 3 emissions are associated with transmission and distribution (T&D) losses from the power grid, business air and ground travel, employee commuting, contracted wastewater, and solid waste disposal for the campuses.

T&D losses account for 20% of all Scope 3 emissions sources, totaling 1,527 MTCO₂e. This is a 24% increase from the FY 2008 baseline and a 4% decrease from FY 2014 levels. This reduction is attributed to an overall reduction in electricity usage in FY 2015 resulting from new efficiency measures implemented on the campuses.

Success Story

NEW SHUTTLE ROUTE PROMOTES ALTERNATIVE TRANSPORTATION FOR NREL EMPLOYEES

A large portion of the NREL staff lives in the Denver metropolitan area. Metro Denver is connected by light rail and bus services provided by the Regional Transportation District (RTD). In the cities of Golden and Lakewood surrounding NREL, the nearest light rail stations are more than two miles from the STM campus. To encourage alternative transportation, NREL operates shuttles to provide a "last-mile" connection to the light rail stations as well as some bus stations in the area. In February 2015, NREL updated shuttle services to offer a new shuttle route connecting STM campus commuters during morning and evening commuting hours to the Oak St. light rail station on RTD's W Light Rail Line, which provides service to Lakewood and downtown Denver's Union Station.

The development of the new route began with NREL's FY 2014 Commuter Survey. A number of the open-ended responses from employees included a suggestion for shuttle service to the Oak St. Station. To gather additional input, in FY 2015, NREL held focus groups with employees and worked with its shuttle service subcontractor, MV Transportation, and RTD to identify the best options for improving shuttle services. As a result, some adjustments were made to existing shuttle routes and the new Oak St. route was put in place—without



The Oak St. Shuttle waits to collect morning NREL commuters at the Oak St. light rail station.

additional resources. Shuttle ridership has steadily increased since the Oak St. shuttle route opened in February. Increasing the number of employees who use transit options to commute to work helps to reduce NREL's Scope 3 GHG emissions. NREL continues to seek new opportunities to make alternative commuting a viable option for all employees.

Success Story

WORKPLACE CHARGING CHALLENGE

In February 2015, NREL joined more than 150 employers nationwide to become a partner in DOE's [Workplace Charging Challenge](#). These employers provide workplace charging for their employees who drive plug-in electric vehicles (PEVs). Partners receive technical support from DOE to help them establish and expand workplace charging. The program launched in January 2013 with the goal of increasing the number of American employers offering workplace charging tenfold by 2018.

Since 2008, NREL's employee and contractor population has increased more than 70% to just over 2,300. To accommodate this and future growth, the laboratory constructed the 1,800 space, centrally located parking garage on the STM campus in 2012. The garage includes 36 electric vehicle charging stations (with infrastructure to support additional stations) which help NREL reduce Scope 3 GHG emissions from commuting, minimize the laboratory's environmental footprint, support its sustainable campus vision, and support the NREL mission to advance renewable energy and energy efficiency-related science through research.

The charging stations are equipped with sophisticated monitoring and charge control capabilities. This equipment allows NREL researchers to capture

detailed data (including time of use, charge time, and charging profile) at each individual station. This infrastructure allows NREL to test dynamic PEV charging and analyze detailed information on energy systems integration hardware-in-the-loop testing. Staff use of the charging stations allows higher utilization of the charging infrastructure and helps researchers accumulate more technical and behavioral data. Charging behaviors are an integral part of developing charge scheduling programs of interest to utilities, businesses, and agencies.

NREL is committed to the development of sustainable options for commuters and the campus as a whole. Electric vehicle charging stations fit within NREL's overall mission to create a more sustainable laboratory environment. Employee participation is essential to the success of sustainable programs that foster environmental and social responsibility across the laboratory. On the STM campus alone, NREL currently has 57 registered, employee-owned PEVs. NREL models sustainability by maximizing efficient use of all resources, minimizing waste, and serving as a positive force in economic, environmental, and community responsibility.



NREL employee Phil Pienkos charges his hybrid vehicle on one of the 36 electric vehicle charging stations in the NREL parking garage.

Business air travel accounts for 35% of all Scope 3 emissions, totaling 2,645 MTCO₂e. This is a 26% increase from the FY 2008 baseline year and a 5% decrease from FY 2014 levels. NREL has extensive teleconferencing and video conferencing capabilities in place to reduce the need for business air travel. Employee air travel is limited to mission-critical activities.

Business ground travel accounts for 3% of all Scope 3 emissions, totaling 241 MTCO₂e. This is a 21% increase from the FY 2008 baseline and a

291% increase from FY 2014 levels. FY 2015 was the first year in which NREL was able to pull a report of every trip to calculate privately owned vehicle reimbursements and other ground travel (including rental cars); past reporting was based on random samples and estimates. The increase in ground travel emissions in FY 2015 is due to underestimating past privately owned vehicle and rental car travel. No other changes to business ground travel have been made.

Employee commuting accounts for 39% of all Scope 3 emissions, totaling 2,963 MTCO₂e. Despite continued population growth, NREL continues to see decreases in commuting GHG emissions. This can be directly attributed to a decrease in overall NREL employee commuter miles, a new NREL shuttle route coordinated between RTD station and NREL to encourage alternative commuting by transit options, telecommuting and alternative work schedule programs, and employee commuter awareness campaigns. Approximately 19% of NREL staff

telecommutes at least one day per week, and approximately 25% of NREL staff work an alternative work schedule.

In FY 2015, NREL took part in Colorado Bike to Work Day, and for the ninth year in a row, held on to first place in the Jefferson County Class D Business Challenge, thanks to 238 NREL Bike to Work Day participants. NREL also had the highest Bike to Work Day effort index in all of Jefferson County.

In FY 2015, NREL conducted a commuter survey tailored specifically for the NWTC. NREL worked with the Denver Regional Council of Governments (DRCOG's) WaytoGo program to identify the best alternative commuting options for this campus. Employees received individualized emails about their commutes that helped to connect them with transit options, carpooling, and vanpooling.

Contracted wastewater treatment emissions accounted for less than 1% (0.1%) of all Scope 3 emissions, totaling 6 MTCO₂e. This is 40% higher than the FY 2008 baseline and 2% lower than FY 2014 levels. The values for wastewater treatment emissions are calculated based on population. NREL's population increased slightly and DOE-GO's population decreased. Overall, population decreased and emissions from contracted wastewater treatment decreased as well.

Contracted waste disposal emissions accounted for 3% of all solid waste (i.e., waste that goes to the landfill), totaling 211 MTCO₂e. This is a 38% decrease from the FY 2008 baseline and a 28% decrease from FY 2014 levels. NREL's solid waste reduction and waste diversion measures are resulting in less solid waste, and therefore, in fewer waste disposal emissions. In FY 2015, a waste audit was conducted on NREL's FTLB to determine the building's waste make-up

and to find other areas for further diversion that will continue to decrease solid waste totals.

PROJECTED PERFORMANCE GOALS AND STRATEGIES

Reducing Scope 1 emissions involves decreasing stationary, mobile, fugitive, and process emissions. NREL will continue to optimize the RFHP performance to reduce natural gas consumption for the STM campus. If appropriate to the laboratory's mission, NREL will purchase additional alternative fuel vehicles (AFVs) and zero emission vehicles to reduce emissions for the fleet vehicles, and will evaluate fleet reduction opportunities annually in light of changing mission requirements. NREL will also investigate new ways to reduce refrigerant emissions. In the short term, the laboratory will use a new tracking system that was recently implemented to more accurately report on refrigerants purchased, used, and recycled at NREL. In the long term, NREL will continue to explore opportunities to substitute current chemicals with alternative chemicals that are less harmful and emit fewer GHG emissions.

Reducing Scope 2 emissions involves reducing electricity load wherever possible through renewable energy and energy efficiency measures. In FY 2016, NREL will implement the SkySpark analytical software at four facilities, which will support efforts in energy management and continuous commissioning. It will also help to identify energy efficiency measures that can be implemented in each facility. The monitoring of plug loads in the ESIF in FY 2016 will also help to mitigate Scope 2 emissions by decreasing electricity consumption. The HPCDC in the ESIF, however, will continue to grow in capacity, doubling electricity consumption every two years. In FY 2016, demand is estimated to increase by 300 kW. The

addition of more renewable energy technologies will also help to mitigate this electrical load. NREL is in the process of planning for the installation of multiple new solar PV arrays with the collective capacity ranging between 1.2 to 1.6 MW on the STM campus. Construction of the solar PV arrays is expected to begin in FY 2017.

To reduce Scope 3 emissions, NREL will continue to work with WaytoGo to promote alternative commuting through the Go-Tober pilot event in October 2015. Employees will be asked to join the event and try some form of alternative commuting for at least four days throughout the month of October. The WaytoGo website will include connections to other carpoolers and vanpoolers and present information about transit options, biking, and walking to work. NREL will continue to explore other methods to effectively disseminate alternative commuting advice to NREL employees, and will continue to promote teleconferencing and video conference services to minimize business ground and air travel.

In FY 2016, NREL plans to conduct more waste audits to identify areas for improvement in waste diversion rates and solid waste reduction.

MEASUREABLE GOALS

In FY 2016, NREL will:

- Continue energy efficiency improvements to reduce Scope 1 and 2 emissions
- Implement improvements to the RFHP to reduce Scope 1 stationary emissions
- Continue to promote teleworking and alternative commuting practices to reduce Scope 3 emissions
- Reevaluate the *Scope 3 Greenhouse Gas Emission Reduction Plan* to identify other opportunities to reduce Scope 3 emissions.

Climate Change Resilience

FISCAL YEAR 2015 PERFORMANCE STATUS

As climate change becomes more apparent worldwide, NREL is proactively engaged in mitigation and adaptation strategies both inside its laboratories and on its campuses. NREL's ESIF is studying grid resilience and the state of the electric grid system, along with the grid's ability to meet clean energy needs in a changing climate. The NREL campuses are living laboratories that demonstrate long-term, whole-community solutions for a sustainable, energy-resilient infrastructure.

Planning for Climate Change: Regional and Local Coordination

NREL continues to support the White House Council on Environmental Quality's Climate Change Preparedness Pilot in cooperation with the State of Colorado. The intention of the pilot is to bring federal agencies and local communities together to assess and plan for region-specific vulnerabilities and interdependencies associated with climate change impacts. The goal of the pilot is to create a model for other communities and agencies to follow.

NREL also supports the Colorado Resiliency Working Group by providing technical assistance

and leadership as a federal liaison. Sustainable NREL staff participated in meetings and workshops, reviewed materials and furnished technical expertise during the development of the framework and the National Disaster Resilience Competition grant application. NREL specifically supported the infrastructure working group efforts focusing on transportation, water/wastewater, grid and renewable energy, and green infrastructure facilities.

Planning for Climate Change: The NREL Campuses

Preparing for the extent of future climate change impacts depends on what is done now to plan

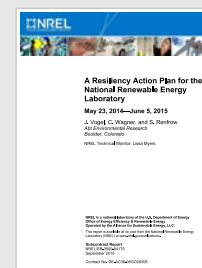
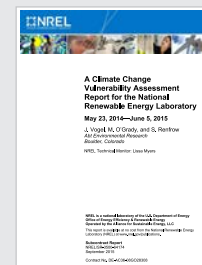
Success Story

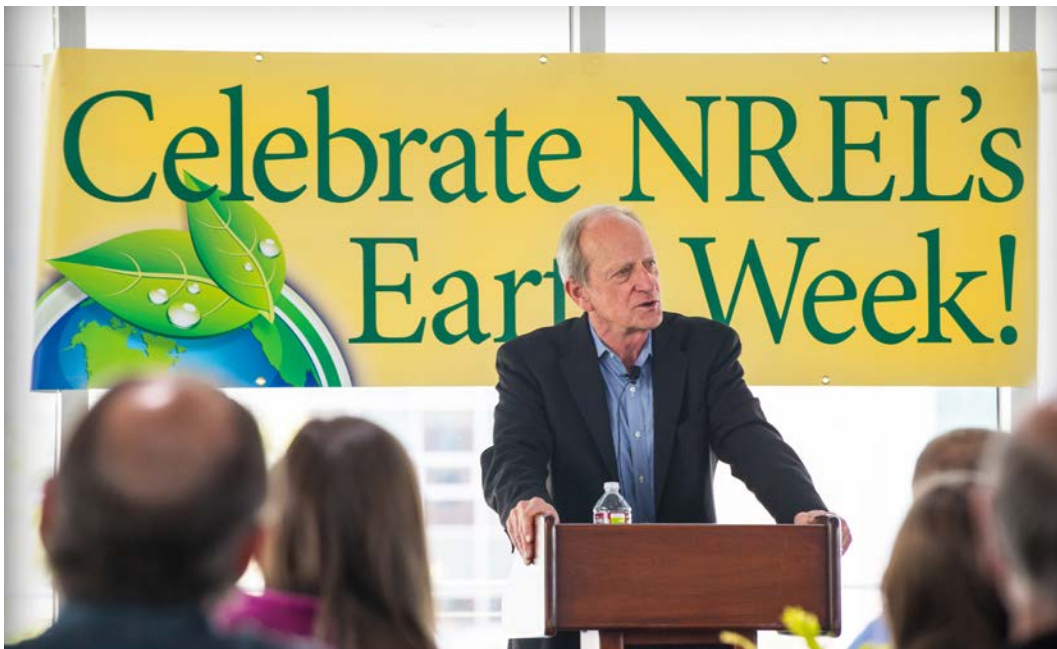
STAKEHOLDER-DRIVEN CLIMATE CHANGE VULNERABILITY ASSESSMENT

When beginning efforts to improve climate change resilience, NREL decided that resilience planning should be part of ongoing management and operations across the laboratory. Consequently, NREL selected an approach that built on the knowledge and capabilities of internal staff by engaging them at various levels in the vulnerability assessment and resilience planning process. A steering committee composed of 22 mid- and senior-level staff members from departments across the laboratory, including facility operations personnel, those with an interest in climate science, and other high-level staff had input throughout the vulnerability assessment. Steering committee members also included subject matter experts or managers who could provide strategic guidance, make decisions, and recommend additional staff representation from within the organization. Committee members provided periodic input and guidance about the vulnerability assessment and resilience action plan process. The committee focused on identifying specific departments and participants who had implementing roles or specific technical knowledge that would benefit the project and offer the opportunity for management-level review of project documents.

In addition, NREL solicited feedback through focus group sessions on both vulnerabilities and resilience planning efforts. These focus groups included some steering committee members and additional technical experts from across the laboratory. The participants gave input on specific systems and processes at NREL that could potentially be affected by climate change.

This participatory stakeholder-driven approach established ownership of the process for all those staff involved, maintaining transparency and ensuring staff support for the implementation of climate change resilience and adaptation measures. This approach emphasized NREL's unique organizational context in the effort to identify vulnerability and evaluate resilience actions to achieve maximum impact.





NREL's 2015 Earth Week kicked off with former NREL director Denis Hayes speaking at the Café. Hayes is an environmental activist and proponent of solar power. He rose to prominence in 1970 as the coordinator for the first Earth Day. Hayes founded the Earth Day Network and expanded it to more than 180 nations.

for dynamic occurrences. NREL increased its internal capacity specifically to address climate change planning on the campuses. In FY 2015, NREL:

- Completed and published a vulnerability assessment and resilience action plan
- Identified key climate-related risks to NREL's key resources
- Identified and prioritized adaptation options that will minimize climate change impacts to NREL.

With funding from the DOE Sustainability Performance Office and support from Abt Associates and Western Water Assessment, a consortium of climate scientists from the University of Colorado and the National Oceanic and Atmospheric Administration, NREL crafted a participatory, stakeholder-driven risk management process. This process enabled

NREL to integrate key organizational objectives with the latest climate science to identify and prioritize the laboratory's highest climate-related vulnerabilities and develop adaptation strategies to build resilience on NREL's campuses. This was done to ensure robust input and cultivate ownership across the laboratory and throughout the management structure. The assessment involved a core project management team consisting of sustainability program staff, several work groups comprising representatives from a range of technical subject matter experts, and a steering committee of NREL high-level managers.

Key to the project was the development of the impacts framework that facilitated the collection and organization of information about what is most important to NREL. This enabled NREL to examine the climate science information specifically as it related to the most critical aspects of the NREL organization,

resulting in the identification of vulnerabilities that had the greatest potential impact. Where possible, this effort maximizes mutual benefits by recommending strategies that complement or directly support other related environmental initiatives or mission areas, such as efforts to improve disaster preparedness, promote sustainable resource management, reduce GHG emissions, and demonstrate renewable energy and energy efficiency technologies.

Emergency Response Procedures

The emergency response procedure has not yet been updated to account for projected climate changes. One of the resilience options identified is to update existing plans and procedures to include climate change considerations. These include the emergency preparedness plans.

Workforce Protocols

Workforce protocols have also not yet been updated to reflect human health and safety from the impacts of climate change, but are one of the resilience options identified.

Internal Communications

NREL strives to maintain a high level of awareness in the laboratory around safety, health, and environmental responsibilities. As management approves resilience options and planning gets under way, internal communications will be a vital component of the implementation strategy.

Policy and Program Updates

Resilience planning is a risk-management strategy. NREL plans to continue to assess climate change vulnerabilities regularly. The goal of the participatory stakeholder-driven approach is to grow internal capabilities and decentralize climate change adaptation and resilience planning into everyday business practices.

PROJECTED PERFORMANCE GOALS AND STRATEGIES

Executive management is in the process of reviewing the recommendations and task teams are being assembled to evaluate resilience options and implementation strategies, and develop a process for ongoing review of climate

change resilience. Task teams will also help NREL staff develop baseline metrics to measure and monitor progress. NREL plans to revisit *A Climate Change Vulnerability Assessment Report for the National Renewable Energy Laboratory* and *A Resiliency Action Plan for the National Renewable Energy Laboratory* annually to determine whether conditions have changed or discover any new information to consider that would alter the resilience strategies.

Sustainable NREL staff is providing technical assistance to support DOE's Sustainability Performance Office in developing a Climate Change Vulnerability Assessment Practical Strategies Guide for DOE facilities. The guide will be based on NREL's experience, along with three other pilot projects from Idaho National Laboratory, Pacific Northwest National Laboratory, and the Thomas Jefferson National Accelerator Facility. The guide will also demonstrate DOE's commitment to meeting the requirements set forth by EOs for agencies to evaluate their climate change risks and vulnerabilities and manage the effects of climate change on agency missions.

NREL recognizes that climate change impacts and successful adaptation strategies that build resilience extend beyond the laboratory's organizational control and geographic

boundaries. As a result, coordination with surrounding communities is critical. NREL plans to engage external stakeholders in a regional symposium when the vulnerability assessment and resilience action plan development efforts conclude. The intent is to share what has been learned through the process, learn what community partners are doing to plan for climate change, and identify opportunities for local partnerships and cooperation. The goal of the symposium is to initiate a long-term dialogue to improve the collective understanding of climate change science, share best practices and data, and establish regional coordination in adaptation planning and policy.

MEASUREABLE GOALS

In FY 2016, NREL will:

- Convene the steering committee to review climate change conditions at the laboratory
- Develop task groups to address recommendations from the resilience action plan
- Coordinate a regional symposium to identify opportunities for local partnerships in climate change resilience planning.

Energy Management

Goals and Achievements

25% energy use intensity (Btu/GSF) reduction, achieving 2.5% reductions annually by FY 2025 from a FY 2015 baseline

- Energy use intensity reduced 48% from the baseline and increased 13% from FY 2014 to 133,395 Btu/GSF

EISA Section 432 energy and water evaluations

- Conducted EISA audits on three facilities that use 0.6% of total energy
- Evaluations are 81% complete; comprehensive evaluation due 6/30/2016

Data Center Efficiency: Establish a PUE target in the range of 1.2–1.4 for new data centers and of less than 1.5 for existing data centers

- The RSF data center had a PUE of 1.19
- The ESIF HPCDC had a PUE of 1.06.

Renewable electric energy account for no less than 10% of total electric consumption, working toward 30% of total agency electric consumption by FY 2025.

- Onsite renewable electric energy consumed at NREL accounted for 19% of total electric consumption.

Increase annual alternative fuel consumption by 10% increase by FY 2025 relative to a FY 2005 baseline and maintain a 10% increase thereafter. (FY 2015 target: 10%).

- Alternative fuel use increased a cumulative 127% from the baseline to 17,007 GGE. This is a 53% increase from FY 2014.

An air intake structure outside the west wing of the RSF—nicknamed the “football”—takes in chilly night air to cool the data center. Energy efficiency measures such as this are essential to lowering energy consumption in the facility.



Energy Management

FISCAL YEAR 2015 PERFORMANCE STATUS

The high-performance buildings at NREL incorporate a number of ultra-high-energy efficiency and renewable energy technologies, making them models for sustainability. NREL currently has 18 buildings larger than 5,000 GSF. As of FY 2015, seven of these facilities were designated LEED Platinum or Gold.

Energy Use Intensity

Energy use intensity at NREL is below DOE's goal for FY 2015 with a value of 133,395 Btu/GSF, which is 13% higher than FY 2014 and a 48% decrease from the FY 2003 baseline. NREL excludes fully serviced leases (Denver West Buildings and the Washington, D.C., office) from its energy use intensity calculation. The new baseline for achieving 2.5% reductions annually by FY 2025 is represented in the FY 2015 value at 133,395 Btu/GSF.

NREL's *Strategic Energy Management Plan*, which was completed in FY 2015, outlines the laboratory's energy management strategy to improve energy efficiency at both the STM and NWTC campuses. This document prescribes that NREL reduce its energy footprint by implementing energy efficiency measures in campus facilities, informing occupant behavior for energy conservation, and installing renewable energy systems to meet presidential EOs and DOE mandates. By applying tactical measures set forth in the laboratory's *Strategic Energy Management Plan*, NREL is working toward meeting these required targets.

NREL's S&TF is one of the older LEED Platinum high-performance laboratory buildings on the STM campus. It was chosen in FY 2014 as a pilot facility for automatic fault detection and diagnostics using the SkySpark analytic software. The software, which monitors energy systems within the facility, can notify personnel in real time about specific energy threshold and system failures or required maintenance. So far, NREL estimates a \$14K savings from better energy management through SkySpark. In FY 2015, energy managers and SITE Operations staff refined the tool and are currently incorporating the technology into facility operations. NREL was selected for a conditional award under the Sustainability Performance Office Funding Opportunity Announcement (SPOFOA) grant in early July 2015. By combining the award money with other funds, the laboratory will implement this software in four other facilities in FY 2016.

NREL is actively using the EPA's ENERGY STAR Portfolio Manager to benchmark metered building energy performance on a monthly basis. It has not yet incorporated the use of Green Button data from Xcel Energy, but the laboratory is currently exploring the possibility of gaining access to utility bills through this program and using it for monthly energy reporting purposes and data analytics.

NREL's Energy Management Team is composed of individuals who have demonstrated energy competency through their education, training, and experience. The Energy Management Team's role is to define, implement, and maintain NREL's Energy Management System (EnMS).

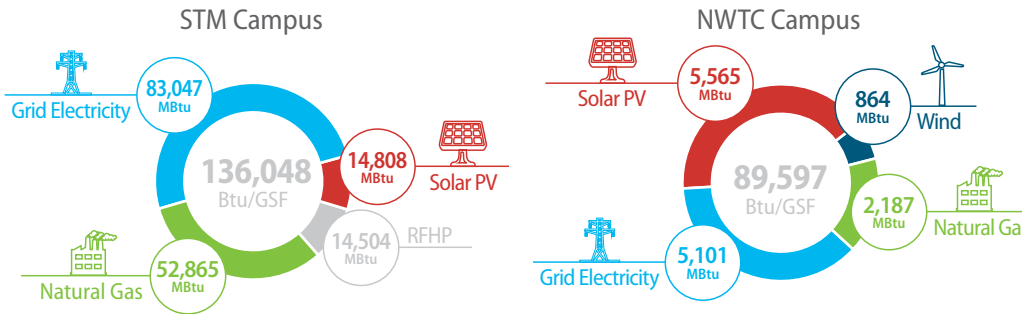
Strategic Intent

NREL's goal is to establish a living laboratory 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.

The EnMS is a combination of the EIC platform and the Sustainable NREL Team's SharePoint data collection and management reporting tool. This group seeks the resources required to monitor and deliver continuous improvement in campus energy performance. The Energy Management Team is responsible for performing energy management activities and developing criteria and methods to ensure effective operation and control of the EnMS. NREL ensures that campus energy professionals receive all training necessary to control significant energy uses and operation of the EnMS. In addition, NREL ensures these professionals participate in stakeholder workshops to inform activities and behavior that contribute to achieving energy objectives and targets, and to identify the potential consequences of departure from specified procedures. The Energy Management Team also works to disseminate campus energy performance information to all laboratory staff through NREL Now, the laboratory's internally published newsletter.

Energy Intensity: FY 2015

133,395 Btu/GSF
FY 2015 Total Energy Use Intensity



Two Energy Management Team members have obtained certified energy manager certifications and are licensed Professional Engineers in Colorado.

Energy Metering

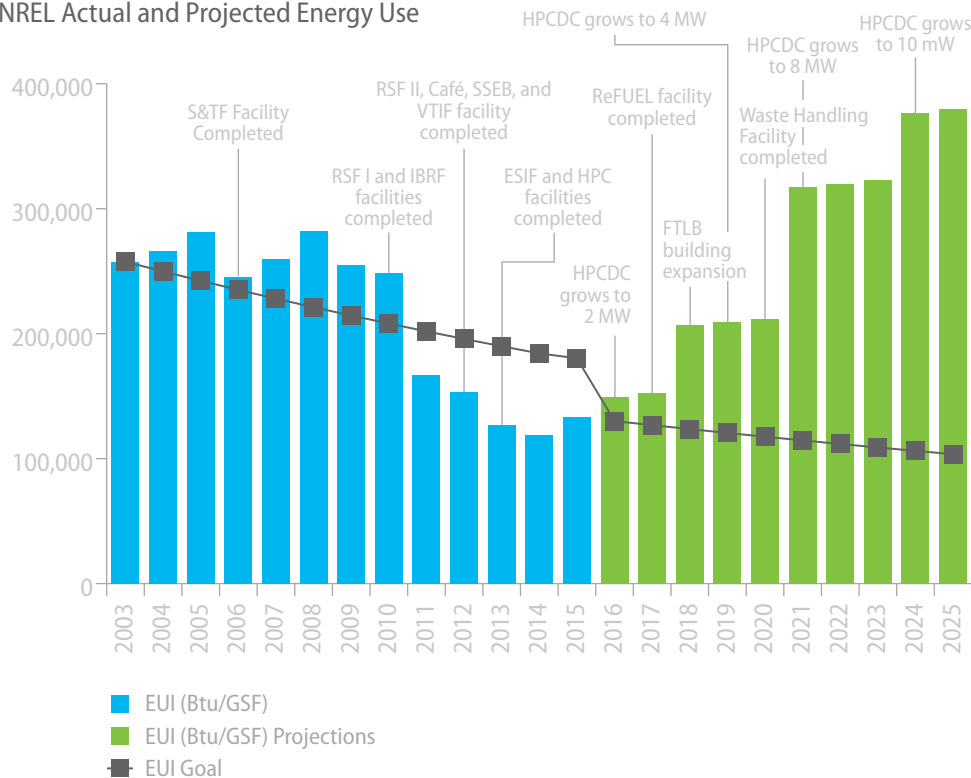
Energy meters, which are installed in all of NREL's buildings, track energy consumption and demand including electricity, gas, and water usage.

Electricity metering at the laboratory includes more than 297 advanced electricity meters in all major facilities and on major process loads. All facilities that require water on the STM site have dedicated utility water meters. Chilled water meters and hot water meters (NREL does not use steam) are installed in 100% of NREL's buildings. All NREL facilities that use natural gas have building-level gas meters.

To support DOE's metering requirements, NREL's design standards for new and renovated spaces require water sub-meters at make-up water systems that support mechanical HVAC equipment and laboratory processes. Design standards also require that meters be installed on chilled water and heated water systems for all new facilities that are tied into the main centralized district heating and cooling plants. An irrigation meter is also required for all newly constructed facilities that use water in the short term to establish new plants. NREL in-house maintenance staff members maintain the sub-meters and record the data they yield each month.

In early 2011, NREL began gathering data from the hundreds of electric, natural gas, and water meters throughout the campuses using the Energy Dashboard, which directly records 85% of the natural gas used and 95% of the electricity used. In FY 2015, NREL launched the EIC architectural platform. The goals of this platform are to integrate the rich data streams coming from the sensors and meters on NREL's campuses.

NREL Actual and Projected Energy Use



This platform is helping NREL create real time data resources and analytics that will both inform the Energy Systems Integration research agenda and support operational awareness and decision making with respect to energy use. It is also providing a more actionable and integrated view of energy management, demonstration, and replication—with a greater emphasis on operational, financial, and environmental accountability necessary for NREL’s campuses. The *NREL Metering Management Plan* (Appendix A) discusses metering management operating practices in further detail.

Energy Independence and Security Act Audits

NREL has conducted ASHRAE Level 2 audits for Energy Independence and Security Act (EISA) evaluations on nearly 97% of the NREL facilities covered by EISA Section 432. EISA Section 432-covered facilities are defined as major energy-consuming facilities with opportunities for energy efficiency improvements. FY 2016 is the last year of the current cycle with four NREL buildings to be audited by June 2016.

In FY 2015, energy and water audits were performed at the NWTC Administrative Building, the Structural Testing Laboratory, and the 2.5-MW Dynamometer Spin Test Facility. In-house experts performed the EISA audits, which evaluated lighting, mechanical, heating, cooling, water, and plug-load systems. Several energy conservation measures (ECMs) were identified during these audits. NREL is developing an in-house savings reinvestment procedure to help fund the implementation of these ECMs. The procedure will include criteria for prioritizing the measures based on economic and environmental impact.

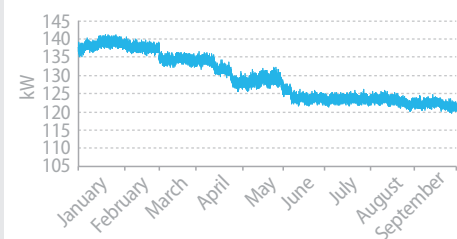
Success Story

DATA CENTER ENERGY SAVINGS IN THE RESEARCH SUPPORT FACILITY

The original design intent of the RSF when it opened in 2010 was to achieve a net zero energy status. One contributing factor to energy increases was the load growth of the RSF data center. Data centers typically operate 24 hours a day, seven days a week and, as a consequence, consume large amounts of energy each year. In the RSF, the data center accounts for 33% of annual energy consumption, making it a top target for energy reductions.

From 2012 to 2014, the IT load grew steadily from 114 kW to 141 kW. In 2015, NREL’s Systems Engineering staff phased out several pieces of legacy IT equipment, which significantly reduced the load of the data center from 141 kW to 122 kW. This was accomplished by migration to NetApp Storage and Cisco’s UCS servers

Data Center Load Reduction in 2015



during the decommissioning of the legacy equipment. Further power savings were achieved by consolidating Hewlett Packard (HP) Blade Centers, which enabled NREL to decommission three HP chassis. NREL decommissioned two chassis in one cabinet, fully eliminating the 4.3 kW load.

The systems engineering staff plans to turn off more legacy storage equipment in FY 2016 and estimates that these additional measures will reduce the data center load by up to 10 kW.

ISO 50001—Energy Management

DOE’s Federal Energy Management Program (FEMP) has recognized NREL’s leadership in energy management and aims to establish NREL as a center of excellence for ISO 50001 to assist other federal agencies with attaining certification. ISO 50001 specifies the requirements for establishing, implementing, maintaining, and improving an EnMS. The purpose of the system is to enable an organization to follow a systematic approach in achieving continuous improvement of energy performance, including energy efficiency, energy

use, and consumption. NREL currently has integrated these requirements into its oversight of energy management activities. Preparation to attain third-party certification for ISO 50001 in FY 2016 is under way.

Savings Reinvestment Fund

In FY 2015, NREL began creating an in-house savings reinvestment funding source to promote sustainability at all levels of the laboratory by funding projects that demonstrate sustainability leadership and economic benefit, and also decelerate utility costs. A draft procedure

Lessons Learned

LESSONS LEARNED IN DATA CENTER HEAT RECOVERY

The HPCDC design intent was for liquid cooling to remove 90% of computer rack heat directly from chips before it escaped into room air. Air coils with fan walls would provide space cooling for the remaining 10%. Recovered HPCDC heat would be used to warm the building, supplemented by 160°F campus district hot water in cold weather (if needed).

Careful attention must be paid to hydronic piping. In the ESIF, the rack cooling coils and air coils were originally piped in parallel, providing both with the coldest water. Once the system was operational, observers discovered that cooler return water from the air coils was diluting warmer water from the racks. This was caused by more computer rack heat being removed by air coils than expected. Air coil temperatures needed to be lower than intended to adequately cool computer equipment. In

addition, return air temperatures were lower than expected.

The result was that even though the computer racks were adequately cooled, the combined return water temperature was lower than anticipated because warm and cool streams were mixing. The HPCDC could heat the rest of the building only when the outside air temperature was above 48°F. Much more supplemental campus district heat has been necessary than planned.

In FY 2015, NREL re-piped the computer cooling hydronic system so that air cooling coils could be operated in series with rack cooling. The temperature of the water leaving the air coils is now low enough to send to the racks, where it will be warmed to 105°F. This will be sufficient to supply base-load heating for the building much

of the year with only minimal supplemental hot water from the district heat system.

An additional 300 kW of new computer racks is planned in the near term. The new liquid-cooled racks will be specified to emit less heat to room air. More heat at higher water temperature limited the need for supplemental campus hot water to only the coldest times of the year.

It is important to plan for low-temperature heat recovery systems to need fine tuning and ongoing commissioning. The waste heat recovery system in the ESIF is innovative and new, with the associated performance risks. But because the potential energy savings are significant, it was important for a national laboratory to demonstrate leadership in this first-of-its-kind low-temperature heat recovery technology.

describing the establishment of the funding source, guidelines for selecting projects for funding, and verifying savings was completed in FY 2015. Once the draft is finalized and the procedure implemented, seed funds will be used for a set of energy and water efficiency projects that will help replenish the funds for future sustainability projects.

Data Center Efficiency

The primary core data center supports staff business operations for NREL's campuses and is located in the RSF—a LEED Platinum and designed as net zero facility. The RSF data center's PUE is managed by metering the following loads: lighting, uninterrupted power supply, power distribution units, air-handling

units, and chilled water. The data center's meters are connected to the RSF energy monitor for real-time visualization of data center performance.

In FY 2015, NREL exceeded DOE's goal of 1.40 PUE as well as its internal goal of obtaining a PUE less than 1.20. The average PUE for the RSF data center was 1.19, slightly higher than the 1.18

PUE that NREL achieved in FY 2014. The average PUE for the HPCDC was 1.06, which was the same level of performance that the data center achieved in FY 2014.

The state-of-the-art HPCDC in the ESIF is a national resource for scientific computing. Its powerful processing capabilities, efficient design, and innovative waste heat capture for reuse make it the most energy-efficient data center in the world.

PROJECTED PERFORMANCE GOALS AND STRATEGIES

NREL's energy footprint continues to expand, primarily because of increased population and computational activities from both the HPCDC at the ESIF and the data center at the RSF.

The laboratory will continue to seek ways to reduce energy use intensity on campus through site design and building development that maximizes energy and water efficiency as well as renewable energy opportunities. NREL uses advanced metering data and energy and water audits to ensure the highest efficiency and best use of resources throughout its facilities.

Specifically in FY 2016, NREL seeks to increase solar PV on the STM campus through a PPA to install multiple new solar PV arrays with the collective capacity ranging between 1.2 to 1.6 MW. The project was selected for a conditional award under the SPOFOA in early July 2015. Implementing a large solar PPA agreement

can ensure net zero energy performance in the RSF, achieve the required annual 2.5% energy use intensity reduction, and assist the DOE complex in attaining 30% of its portfolio energy consumption derived from renewable resources.

The core of NREL's strategic energy management approach is to consistently incorporate energy management into central practices and decision making, such as strategic planning and budgeting processes. In FY 2016, NREL will make changes to energy-related business practices that will cover all applications of energy management, including major renovations, improvements in existing facility operations, upgrades, and the economic analysis and procurement practices underlying these changes.

NREL will refine the results of the EIC project based on pilot demonstration outcomes and proposes to begin deploying the architectural platform at the ESIF and the FTLB in FY 2016.

MEASURABLE GOALS

In FY 2016, NREL will:

- Turn off up to 10 kW of legacy equipment in the RSF
- Maintain a PUE of less than 1.20 in the RSF data center
- Attain third-party certification of ISO 50001
- Select the EIC architectural platform for deployment in the ESIF and the FTLB
- Perform EISA audits for four additional facilities
- Finalize the procedure for the savings reinvestment fund.

Clean and Renewable Energy

FISCAL YEAR 2015 PERFORMANCE STATUS

NREL serves as both a living model of sustainability and a place to develop new clean energy ideas, technologies, and practices. The laboratory strategically employs progressive energy-efficient technologies, renewable energy systems, and REC purchases to continuously improve campus sustainability and resilience.

In FY 2015, clean energy generated from onsite wind, solar, and NREL's RFHP accounted for 20% of total site energy use. Renewable electric energy generated onsite from wind and solar accounted for 19% of total electric consumption. Furthermore, NREL supplemented onsite renewables with RECs to attain Scope 2 carbon neutrality and support additionality in the renewables marketplace. With DOE's FY 2015 clean energy and renewable electric energy goals both at 10% and FY 2025 final target goals at 25% and 30%, respectively, NREL has met and exceeded FY 2015 requirements, and is well on its way to reaching future goals.

Solar Photovoltaics

In FY 2015, NREL conducted an assessment of the STM campus to evaluate the potential of new solar PV array installations. The assessment took into consideration site constraints and boundaries, contractual obligations, NREL's Ten-Year Site Plan, and the 2011 STM campus Master Plan guidelines. Nine parcels and five facilities were identified as candidates for further investigation. The potential sites were further aggregated into four possible options, and on April 17, 2015, NREL submitted a proposal to

receive funding under a SPOFOA to help reduce the price per kWh of a PPA for proposed multiple new solar PV arrays, with the collective capacity ranging between 1.2 MW to 1.6 MW. Furthermore, after rigorous analysis of potential locations, NREL narrowed the project down to the upper limit of power generation and is in the process of finalizing an agreement with DOE's Western Area Power Administration (Western) to support this increase and extend the term to 25 years. In July 2015, NREL was selected for a conditional award to receive funding under the SPOFOA and the laboratory is in the process of seeking a third-party vendor to deliver the system.

Wind

Three of the four utility-scale turbines installed at the NWTC are operated by various manufacturers under either a CRADA or a strategic partnership project agreement. Power generated from these turbines is transmitted directly to the grid and not consumed by NREL. The fourth utility-scale turbine is a DOE-installed 1.5-MW General Electric (GE) turbine that, together with other smaller and mid-size research turbines, generated 253 MWh of electricity in FY 2015.

The NWTC has an allowable interconnection cap of 10 MW with Xcel Energy. The utility-scale turbines were in operation a significant part of the year and the GE/DOE turbine had to be routinely curtailed to ensure that the 10-MW limit was not surpassed. This resulted in a lower number of MWh generated for the campus than were generated in FY 2014. A project is currently under way to upgrade from distribution transmission voltage and build a new substation.

Thermal

The RFHP, NREL's onsite thermal installation, is a sustainable and efficient source of heat for more than 945,000 ft² of laboratory and office space through NREL's district heating system. The RFHP is essentially a boiler that burns wood chips, displacing natural gas for heating throughout the cooler months of the year. Onsite thermal energy generated from the RFHP in FY 2015 offset 21% of NREL natural gas demands and 30% of the STM site's district heating demands. These percentages were down from last year, which were 28% and 37%, respectively. This can be attributed to the combustor and ash removal system, along with the weather. The combustor and ash removal system is currently undergoing an upgrade with the expectation of reaching a rated output of 9 million Btu/hr, which is expected to significantly reduce natural gas use. And although the 2014 to 2015 winter was a colder winter overall, there were a number of days that were too warm to run the RFHP. Because the start-up time for the RFHP is long, it is NREL's cost-effective practice to turn it on only when an extended period of cold temperatures is predicted. In FY 2015, a large fluctuation in temperatures kept the RFHP from running for approximately 42 days of the heating season. The impending "super El Niño" weather phenomenon may result in a longer runtime for the RFHP in FY 2016.

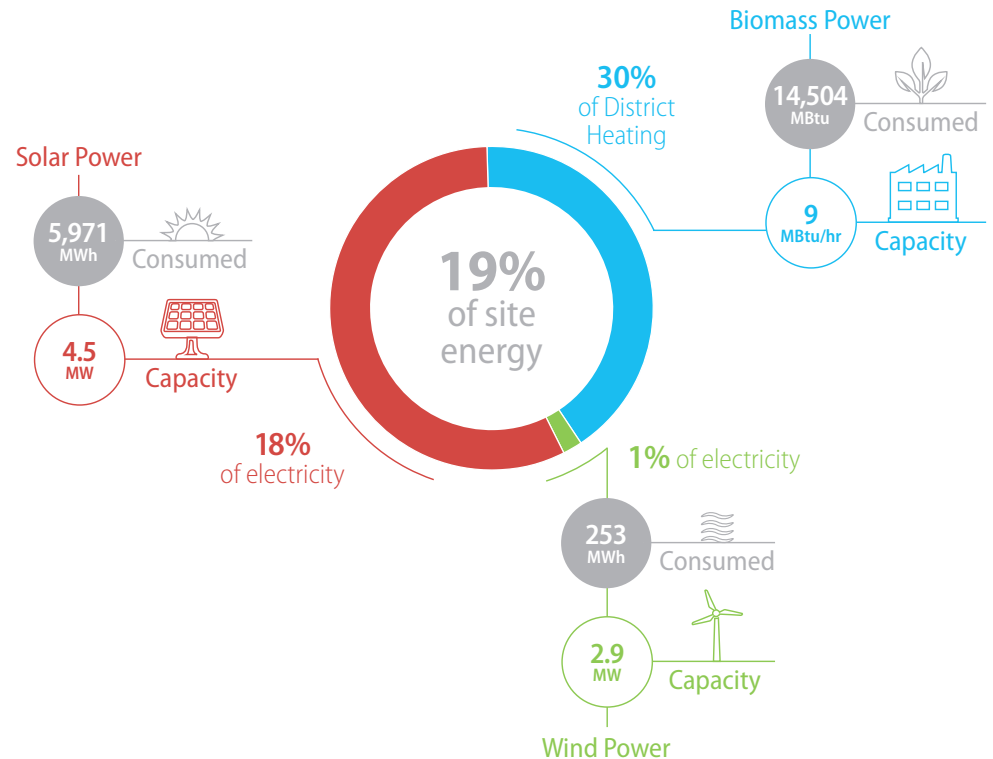
Renewable Energy Credits

NREL purchased RECs through an interagency agreement with Western to attain Scope 2 carbon neutrality and to support additionality in the renewables marketplace. The RECs purchased under this agreement are from renewable energy projects installed within the past ten years and from eGRID (Emissions and Generation Resource Integrated Database) regions with solar radiance values comparable or representative of NREL's regional area solar radiance attributes.

NREL also retains the RECs from several smaller and mid-size research wind turbines installed at the NWTC and the GE/DOE wind turbine. The laboratory also purchased replacement RECs from two of the utility-scale turbines under CRADAs. RECs from some of these turbines are sold to Xcel Energy to support the state of Colorado's renewable portfolio standard. NREL explored offsite wind and found that it could not wheel green power through the Xcel grid because Colorado is a regulated utility market. This also precludes NREL from buying grid power from sources other than Xcel Energy/Public Service Company of Colorado.

Currently, NREL does not purchase any electricity, energy products, and energy byproducts directly from Indian Tribes. NREL has explored purchasing renewable energy products from Indian Tribes in the past but found that the distance of the electric distribution systems made it physically impossible to transmit the electricity to NREL. In 2017 NREL's current REC contract will be renewed, at which time the laboratory will incorporate preference for energy byproducts produced by tribal majority-owned business organizations.

Onsite Renewable Energy Portfolio: FY 2015



PROJECTED PERFORMANCE GOALS AND STRATEGIES

A number of NREL's solar PV systems experienced significant downtime in 2015 contributing to a lower clean and renewable energy output than what was reported in FY 2014. NREL will explore improvements to the maintenance plan for these systems to avoid extended periods of nonproduction.

NREL will proceed with the installation of a solar PV system ranging in size from 1.2 MW to 1.6 MW on the STM campus through a PPA and use SPOFOA funds to reduce the price per kWh of the PPA. Construction is expected to be nearly complete in the first quarter of FY 2017.

The current electrical generation capacity at the NWTC is 10.2 MW, but turbine operations are being curtailed to stay below an existing 10-MW generation limit in accordance with the interconnection agreement with Xcel Energy. NREL plans to upgrade existing onsite electrical infrastructure and add an interconnection to the local utility, including a new higher-voltage electrical service (transmission) to accommodate a total of 50 MW of onsite electrical generation capacity. The updated electrical system will be built for 50 MW of capacity, but operated only as 20 MW to stay under the North American Electric Reliability Corporation reporting requirements. When required to operate the system at a higher capacity, the system can be increased to 50 MW by a paperwork process instead of construction. Plans in place to expand the electrical service infrastructure at NWTC could allow for greater production, but will not be fully operational before 2018.

NREL will continue to displace natural gas used for building heat by utilizing the RFHP to its fullest extent. Under its current ESPC, NREL is working with Ameresco, a global energy services provider, to upgrade the combustor and ash removal system of the RFHP and will continue to make improvements as necessary.

NREL's preferred method of offsetting GHG emissions is through onsite production of renewable energy. Contracts will continue to be in place, however, to purchase RECs for Scope 2 neutrality. NREL will also continue to work with Xcel Energy on a green electricity tariff to make it possible for organizations to purchase offsite renewables to offset their energy usage.

MEASUREABLE GOALS

In FY 2016, NREL will:

- Increase solar PV generation by greater than 1 MW with construction starting mid-2016
- Continue working with Xcel Energy to develop a green tariff to buy offsite wind
- Increase the thermal output of the RFHP by 50%
- Supplement onsite renewables with REC purchases, as necessary, to ensure that electricity is 100% carbon neutral.

Energy Performance Contracts

FISCAL YEAR 2015 PERFORMANCE STATUS

NREL's sustainable campus design serves as a replicable model of state-of-the-art energy efficiency and renewable energy technologies and practices. Realizing the value of energy performance contracting to support the installation of progressive technologies on campus, NREL pursues PPAs, ESPCs, and utility energy services contracts to the greatest extent possible.

To date, NREL has completed one energy savings performance contract (ESPC) project for the RFHP on the STM campus and eight PPAs throughout both the STM and NWTC sites that have led to the installation of 2.35 MW of solar PV and 8.18 MW of wind.

As opportunities arise to explore new ECMs, the deployment of additional onsite renewables, and the construction of new high-performance buildings, NREL will investigate appropriate mechanisms to finance these projects. NREL is targeting \$2 million in performance contracting by FY 2017.

Approach and Challenges

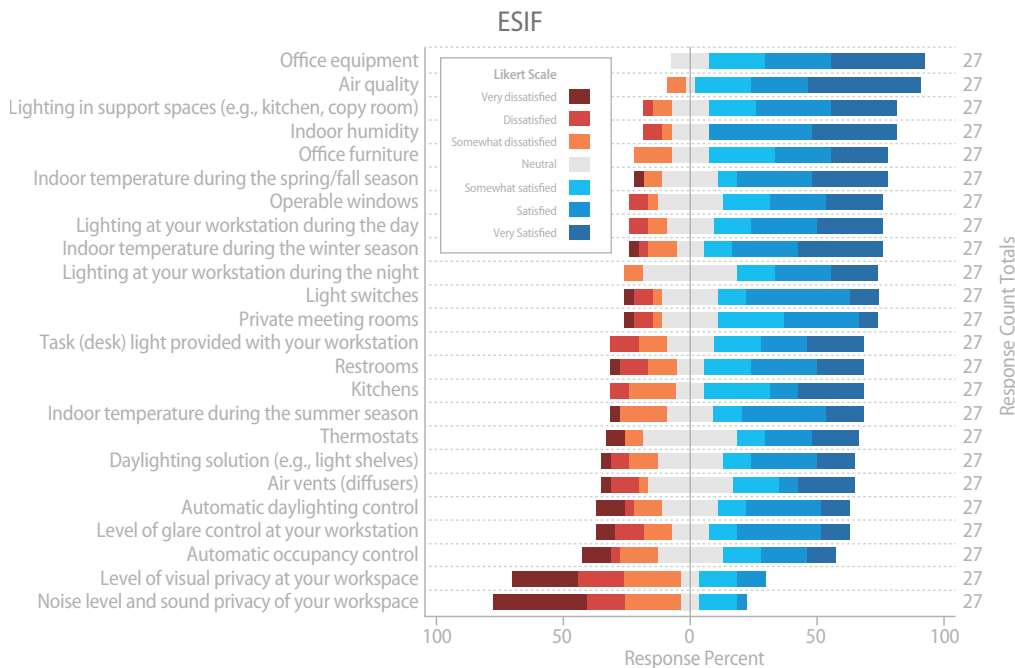
In FY 2015, NREL submitted a proposal to receive funding under a SPOFOA to reduce the price per kWh of a PPA for multiple new solar PV arrays with the collective capacity ranging between 1.2 to 1.6 MW. NREL was selected for a conditional award to receive the funding. NREL is currently working on finalizing its agreement with Western and drafting an RFP with hopes of completing the PPA project by late 2016 or early 2017.

NREL has a substantial list of unfunded opportunities for energy and water reduction that could be bundled into an ESPC. The laboratory has determined, however, that bundling current unfunded ECMs is not necessarily economically viable; therefore, the cost savings from bundling ECMs may not support an ESPC.

PROJECTED PERFORMANCE GOALS AND STRATEGIES

In FY 2016 and beyond, NREL will explore the economic feasibility of using ESPCs, along with other alternative financing mechanisms. In addition, NREL will continue to utilize other funding options such as REC sales, utility rebates, and in-house savings reinvestment funds.

Comfort Surveys: FY 2015



FISCAL YEAR 2015 PERFORMANCE STATUS

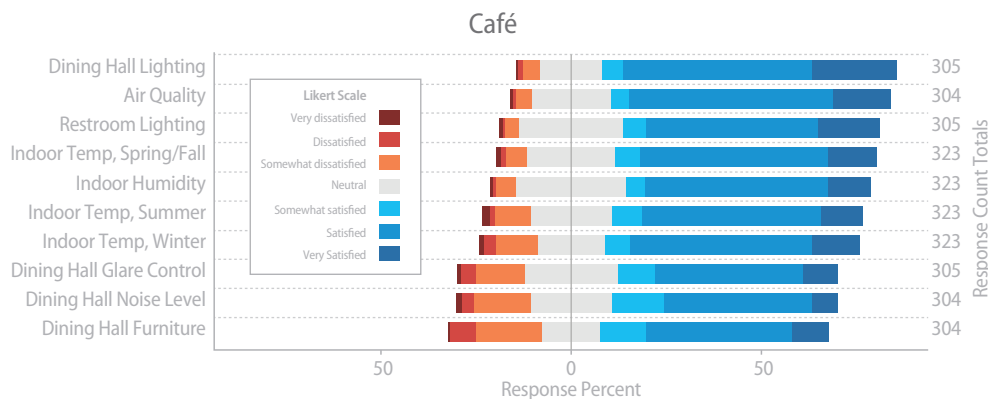
NREL is committed to the design, operation, and maintenance of high performance sustainable buildings (HPSB) on its campus by employing building design and operation strategies that promote optimal performance and maximize life-cycle asset value.

NREL currently has 18 buildings larger than 5,000 GSF that make up the candidate pool for the Guiding Principles for HPSB. As of FY 2015, six of these buildings meet 100% of the Guiding Principles for HPSB: the S&TF, the RSF I and II, the Integrated Biorefinery Research Facility, the Café, and the ESIF. With these six buildings, NREL is currently 33% compliant and exceeding the requirements of this goal.

Guiding Principles

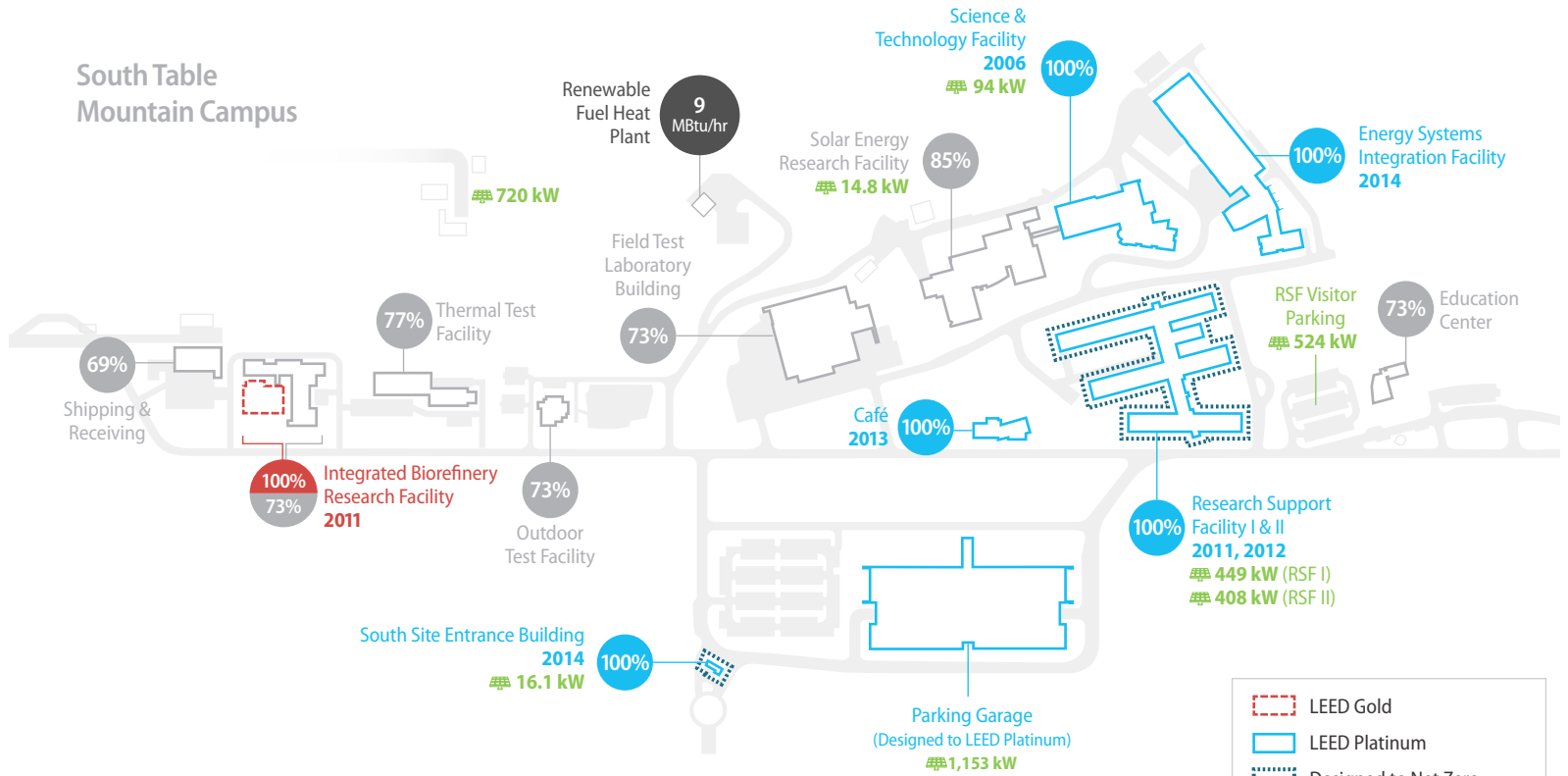
NREL uses the EPA's ENERGY STAR Portfolio Manager to assess and manage Guiding Principles for HPSB compliance. All checklists, with supporting documentation, are maintained in this tool and are used to ensure that the Facilities Information Management System sustainability fields are accurate.

In FY 2015, NREL completed building comfort surveys on the ESIF and the Café to identify possible improvements in energy efficiency and building occupant education and comfort. The biggest concerns with the ESIF were about visual privacy and noise in the workstation cubicles. Because the building was designed with open office spaces to optimize daylighting, exterior views, and collaboration, these issues have been voiced regularly. There were some glare



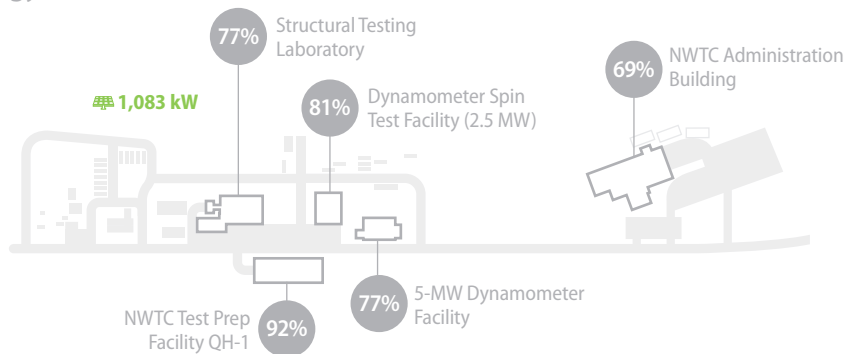
High Performance Sustainable Buildings: FY 2015

South Table Mountain Campus



National Wind Technology Center Campus

- † 1.4 MW (Research Turbines)
- † 1.5 MW (GE/DOE Turbine)
- † 2.3 MW (Siemens Turbine)
- † 3.0 MW (Alstom Turbine)
- † 2.0 MW (Gamesa Turbine)



- LEED Gold
- LEED Platinum
- Designed to Net Zero
- % Guiding Principles for HPSB
- ☀️ Solar PV capacity
- 🌬️ Wind capacity

(especially from the south-facing windows) and noise issues with the Café and some ongoing temperature issues in the kitchen. NREL is discussing options to address these concerns. The survey indicated that employees were interested in learning more about the energy use of the Café. NREL needs to train employees who work in the Café on some specific equipment such as the grill hood, the temperature controls, and the freezer strips. Some of the temperature issues in the kitchen (too warm in the summer) are an ongoing project. This year NREL adjusted some of the exhaust fan speeds to increase airflow and continues to evaluate installing an additional air-conditioning unit. Meetings have been held to discuss next steps on these issues and these will continue into FY 2016.

The completion of these surveys brought both buildings into full compliance with Guiding Principles for HPSB. Currently, 100% of NREL's eligible buildings have been assessed and 33% are in full compliance with the Guiding Principles for HPSB.

Leadership in Energy and Environmental Design Certification

NREL is committed to pursuing LEED Gold or higher certification to the extent possible for all new construction on the STM and NWTC campuses as well as ensuring that all new construction at NREL will be fully compliant with the Guiding Principles for HPSB.

As part of this pursuit, NREL incorporates energy efficiency features in the building design,

resulting in performance that far exceeds ASHRAE standards. NREL ensures that all new construction is designed at 30% more energy-efficient than the baseline established by ANSI/ASHRAE/IESNA Standard 90.1 2010. NREL also incorporates onsite renewable energy generation to support the operation of net zero energy buildings. In an effort to uphold EO 13693, NREL is working toward the goal of net zero energy performance for all new buildings.

New Facilities

The NWTC Administrative Building is an old facility and the costs to maintain it to office-level standards continue to increase annually. In addition, using temporary office trailers at the NWTC is neither cost-effective nor sustainable.

Success Story

THE SOUTH SITE ENTRANCE BUILDING (SSEB) RETURNS TO NET ZERO

The SSEB was designed to be a net zero energy facility. After the building was completed, security and facility managers needed to improve the security equipment connected to the facility. This significantly increased the building's overall energy use intensity and made it impossible to maintain net zero energy performance. In FY 2015, 11 solar PV panels and microinverters were installed on the roof of the SSEB. These new solar PV panels will provide an estimated 4,368 kWh of renewable electricity to the SSEB each year, compensating for the energy-intensive security equipment that was retroactively added to the building.

The SSEB now has 66 panels on its roof for a total capacity of 16.1 kW. The SSEB's solar PV array is anticipated to restore the building's net zero energy performance—producing as much energy as it consumes each year. In FY 2016, NREL will be able to confirm the SSEB's status as a net zero energy facility with 12 months of metered energy data.



The SSEB at NREL had eleven new solar PV panels installed to bring the building back to a net zero energy status.

The lack of adequate infrastructure at the NWTC is contributing to an inadequate safety and environmental situation as well as increased long-term operations and maintenance costs. Based on the level of need to support the wind program at the NWTC, DOE-GO requested a mission need statement for a new facility. NREL is working on a proposal to replace the offices at the NWTC with a modern, environmentally sustainable facility fabricated with sustainable building materials. The building is targeted to be net zero and will be designed to accommodate 150 to 250 office spaces.

Net Zero Buildings

Two buildings on the NREL campus were designed to be net zero facilities: the RSF and the SSEB. The RSF building showcases numerous high-performance design features, passive energy strategies, and renewable energy technologies. Solar panels on the parking garage and the visitor's parking lot add to the solar PV installed on the RSF rooftop to offset RSF grid electricity consumption. The panels also help offset the energy used by the parking garage's 36 electric vehicle charging stations. NREL's SSEB is a high efficient and small facility (under 1,700 ft²). It has the same types of daylighting and occupancy sensors as the RSF, a wind catch tower for natural ventilation, and geothermal heating and cooling.

NREL demonstrates leadership in the net zero arena by publishing building sector definitions for the concept of a net zero energy building and by constructing and operating such facilities. This requirement is included in the scope of work and construction specifications for all new facilities.

PROJECTED PERFORMANCE GOALS AND STRATEGIES

NREL will continue to take steps to bring all 100% of its facilities into full compliance with the Guiding Principles for HPSB. The laboratory will address building concerns about open office spaces, noise, and visual privacy by educating employees and holding further discussions about mitigation of these factors. In FY 2016, NREL will assemble a team to disseminate information to employees on how to adjust to and stay productive in an open office working environment. In addition, ways to decrease noise in the open office areas will be discussed.

In FY 2016, NREL will begin to better educate Café workers on specific energy-efficient equipment such as the Café grill hoods and freezer alarms. In addition, there will be a discussion about ways in which Café staff can help reduce energy and improve sustainability throughout the facility. Discussions about installing an energy use display in the Café are also planned.

As NREL expands the campus footprint, the laboratory is committed to building high-performance sustainable facilities that are net zero energy and, if feasible, net zero waste or water.

MEASUREABLE GOALS

In FY 2016 NREL will:

- Pursue opportunities to integrate ECMs within existing facilities for expanded building portfolio compliance with the Guiding Principles for HPSB
- Install a solar PV array on the parking garage to retain net zero energy performance for the RSF complex if funding becomes available
- Continue monitoring for the HPSBs to ensure energy optimization.

Fleet Management

FISCAL YEAR 2015 PERFORMANCE STATUS

NREL is consistently meeting or exceeding DOE's annual light-duty AFV acquisition goal and currently meeting the alternative fuel consumption increase goal. Reducing annual petroleum consumption continues to present a challenge for NREL.

The laboratory continues to look for additional options to reduce GHG impacts, to promote alternative fuel use and AFVs, and to establish new policies and programs. The NREL *Fleet Management Plan* (Appendix B) discusses fleet management operating practices in further detail.

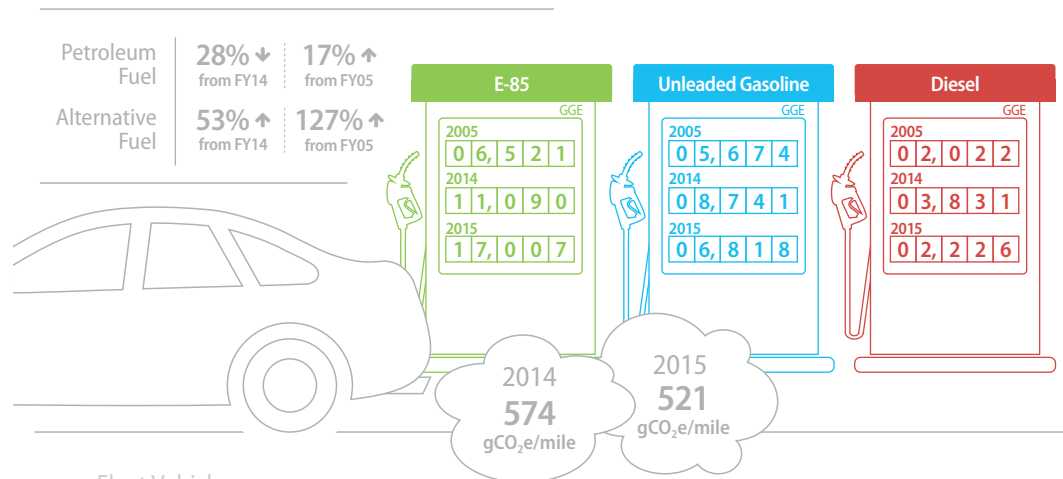
Petroleum Consumption Reduction

In FY 2015, NREL's petroleum consumption was 17% higher than the FY 2005 baseline and 28% lower than in FY 2014. Total consumption was 9,044 GGE (2,226 GGE of diesel and 6,818 GGE of unleaded gasoline). The decrease from FY 2014 resulted from replacing unleaded hybrid gasoline and unleaded gasoline vehicles with E-85 vehicles. NREL's petroleum use has increased from the FY 2005 baseline because diesel buses were added to the fleet to accommodate campus and population growth. In addition, the selection of AFVs available from GSA when older vehicles were up for replacement resulted in the acquisition of gasoline hybrid vehicles. For example, E-85 and compressed natural gas vehicles were replaced with unleaded hybrid vehicles, which are considered AFVs and meet the Energy Policy Act of 1992 requirement but consume petroleum.

NREL continues to work on overcoming the challenges of reducing petroleum consumption on the campuses through methods such as fleet reduction, alternative fuel consumption,

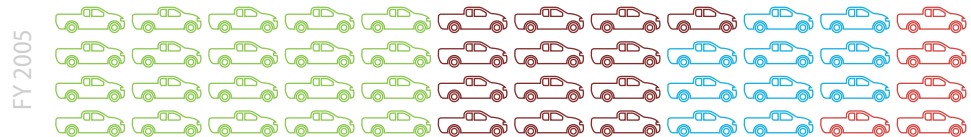
alternative transportation, and a no-idling policy. Referred to as the "30 Second Rule," NREL's no-idling guidance instructs fleet vehicle drivers to turn off their vehicle engines when

Fleet Performance: FY 2015



Fleet Vehicles

20 E-85 | 13 CNG | 0 PEV | 0 Gas Hybrid | 10 Gasoline | 5 Diesel



33 E-85 | 0 CNG | 0 PEV | 1 Gas Hybrid | 2 Gasoline | 7 Diesel



Success Story

GREENING THE FLEET

In FY 2014, NREL finished installing an E-85 fueling tank on the STM campus. Installing this alternative fuel asset has supported the additional growth of AFVs within the NREL fleet. In FY 2015, NREL was able to focus on replacing petroleum vehicles with AFVs, adding an additional seven E-85 vehicles to the fleet. These vehicles replaced four gasoline hybrid vehicles and two unleaded gas vehicles, and added an additional E-85 vehicle to the fleet.

Because the E-85 fueling tank is located on the STM, all E-85 fleet vehicles are required to be fueled with E-85 unless approved by a fleet vehicle manager. In FY 2016, NREL will continue to explore ways in which to increase AFVs in the fleet, particularly zero-emissions vehicles.



Of NREL's 43 fleet vehicles, 33 are fueled with E-85 fuel. Five of those E-85 vehicles are pictured here, parked on the STM campus.

parked for more than 30 seconds. Exceptions apply for operating a vehicle in extremely cold or warm weather and for special circumstances like emergency vehicles, vehicles engaged in traffic operations or waiting at a traffic signal, and when a vehicle is being serviced. No-idling training and educational materials are available to all fleet operators through NREL's Intranet. No-idling signs are posted at key locations near loading docks and passenger pick-up/drop-off locations.

NREL's fleet manager regularly monitors miles traveled, utilization rates (trips), and fuel consumption for all fleet vehicles. Monthly monitoring and reporting allows NREL to assess fleet performance and identify opportunities for improvement.

Alternative Fuel Consumption

Alternative fuel consumption increased by 127% from the FY 2005 baseline and increased 53% from FY 2014. This year the NREL fleet used

17,007 GGE of E-85. This increase is due to the seven additional E-85 vehicles added to the fleet, the majority of which replaced unleaded gasoline or unleaded-hybrid vehicles. In addition, the E-85 tank on NREL's STM campus performed better this year than in years past with much less downtime, enabling staff to fuel with E-85 as opposed to unleaded gasoline.

NREL has 36 electric vehicle charging stations on the STM campus that support research and fleet electric and plug-in hybrid electric vehicles. NREL staff and visitors are permitted to use the charging stations through a mission-critical research project—Expanding NREL's Energy Systems Integration Capabilities: Plug-in Electric Vehicle Load Control and Management—being conducted at the STM campus. NREL does not currently have any electric or plug-in hybrid electric vehicles in the fleet. The charging stations will support electric and plug-in hybrid electric vehicles added to the fleet in the future.

Greenhouse Gas Emissions Reduction

NREL's fleet-wide per-mile GHG emissions baseline for FY 2014 is 574 gCO₂e/mile. NREL's fleet-wide per-mile GHG emissions differ from the baseline calculated by the Federal Automotive Statistical Tool in that it does not include both fuel usage and vehicle miles traveled for law enforcement or emergency vehicles in the fleet. These vehicles are exempt from this goal. NREL tracks fuel usage and miles driven by vehicles and has calculated its baseline based on this information. In FY 2015, the fleet-wide per-mile GHG emissions increased to 521 gCO₂e/mile, a 9% increase from the FY 2014 baseline year. This decrease is due to the simultaneous decrease in both miles driven and GHG emissions from fuel usage in FY 2015. In FY 2015, NREL emitted a total of 95 MTCO₂e from fleet fuel usage and drove 182,447 miles. In FY 2014, NREL emitted 123 MTCO₂e and drove 214,593 miles.

Alternative Fuel and Zero Emission Vehicle Purchases

NREL makes every effort to right-size its vehicle fleet, which currently consists of 43 vehicles—40 GSA-leased vehicles and three DOE-owned vehicles.

All vehicle acquisitions in FY 2015 were E-85 vehicles. One hundred percent of light duty vehicle acquisitions were AFVs. NREL made efforts to look for zero emissions vehicles to add to the fleet; however, no zero emission vehicles were available through GSA in FY 2015.

The NREL fleet now consists of 77% AFVs:

- 33 E-85 vehicles
- 1 hybrid-gasoline vehicle
- 2 unleaded gasoline vehicles
- 7 diesel vehicles.

PROJECTED PERFORMANCE GOALS AND STRATEGIES

NREL recently installed a 700-bar hydrogen fueling station at the ESIF. It is designed to be a retail-style station in a research setting—enabling demonstration of real-world hydrogen fueling and infrastructure technologies with no disruption to customer service. NREL's SITE Operations is exploring the possibility of using this station if NREL acquires a hydrogen-fueled vehicle. Currently, GSA is offering hydrogen fuel cell vehicles only in California.

Diesel shuttles at NREL are scheduled for replacement in FY 2018. NREL is exploring the opportunity to replace these vehicles with AFVs.

Using telematics in fleet management has proven to be an effective way of accurately managing fleet performance. In accordance with EO 13693, NREL plans to investigate and install telematics on all fleet vehicles. These data will be valuable in increasing productivity, controlling fuel, reducing operating expenses, and conducting a fleet reduction analysis to ensure that NREL has a right-sized fleet.

In FY 2015, NREL explored the opportunity to enter into a pilot project with GSA to acquire electric or hydrogen fuel cell AFVs. NREL was not selected for the FY 2015 pilot; however, NREL will continue to explore opportunities to participate in future GSA pilot programs to acquire AFVs. NREL is particularly interested in pilot programs that would involve zero emission vehicles such as hydrogen or plug-in electric vehicles (PEVs).

MEASUREABLE GOALS

In FY 2016, NREL will:

- Explore the possibility of replacing diesel campus shuttles with AFVs
- Conduct a fleet reduction analysis to ensure NREL has a right-sized fleet
- Investigate the use of fleet telematics in accordance with EO 13693
- Continue to increase AFVs in an effort to decrease the fleet-wide per-mile GHG emissions.

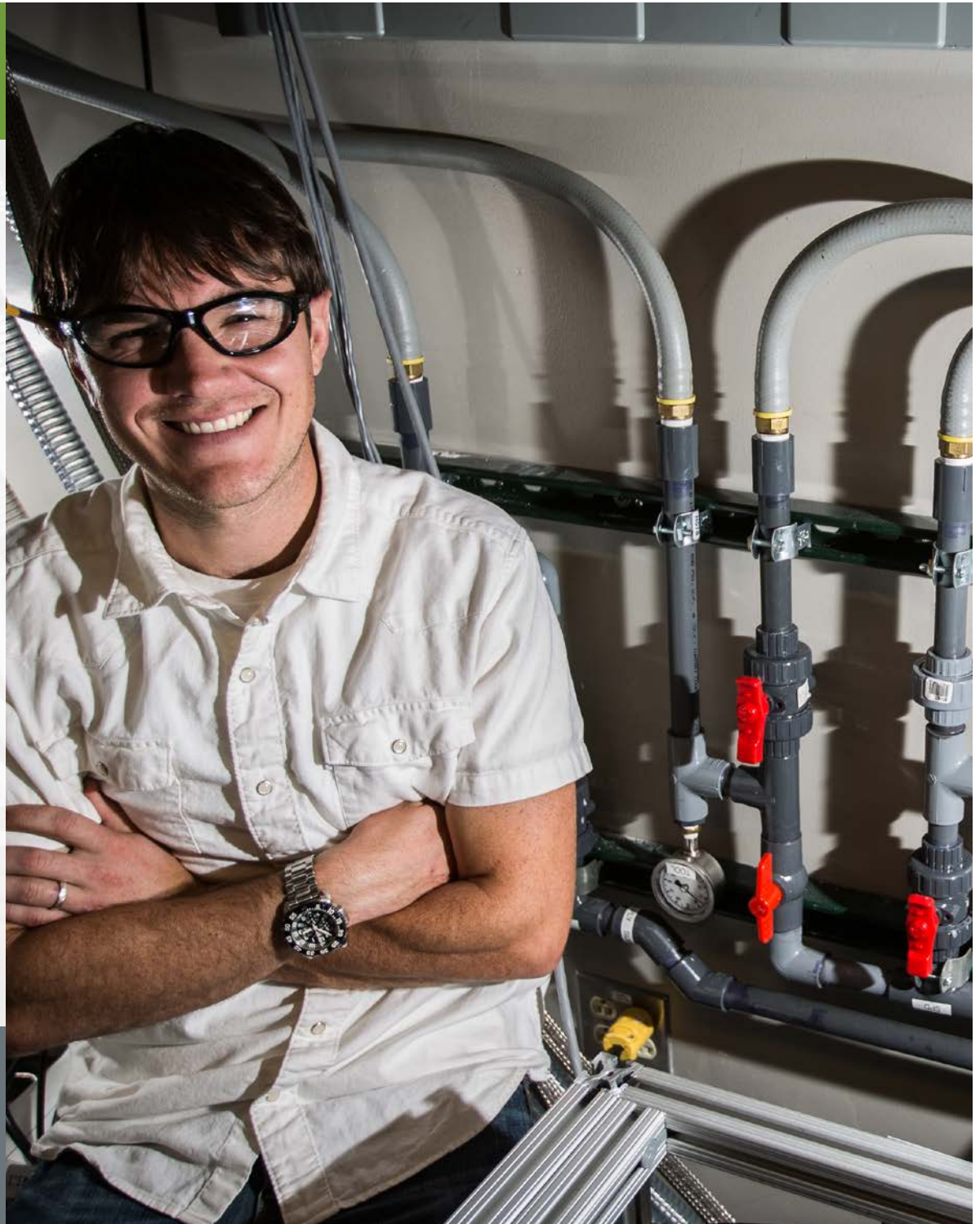
Water Management

Goals and Achievements

36% potable water use intensity (gal/ GSF) reduction by FY 2025 from a FY 2007 baseline. (FY 2015 target: 16%)

- Potable water use intensity reduced 42% from the baseline to 16 gal/GSF

Graham Colegrove spearheaded the implementation of a new type of connection for water lines used in NREL's laboratories and equipment. Thanks to his efforts, modifications have been made to various types of equipment to prevent failures and leaks.



FISCAL YEAR 2015 PERFORMANCE STATUS

Given the many connections between energy and water, NREL fully understands how critical water use efficiency and management is to the resilience of the laboratory's energy system.

Aggressive water efficiency and conservation measures at NREL have consistently resulted in lower water use intensity than DOE's goal target since 2010. In FY 2015, NREL's water use intensity measured at 16 gal/GSF, which is 42% lower than the FY 2007 baseline and lower than the goal target of a 36% reduction. NREL does not use industrial, landscaping, and agricultural (ILA) water.

Water at NREL's STM site is supplied by Consolidated Mutual Water Company. All facilities on the STM campus have water meters with sub-meters on high-intensity water devices such as evaporative coolers, deionized water, closed loop make-up water, irrigation, and autoclaves.

The NWTC site is remote and has no wells or municipal water supply. Water is delivered to the NWTC weekly, stored onsite in a 15,000 gal underground storage tank, and pumped on demand to a 2,000 gal aboveground storage tank. The 2,000 gal tank is used as the source to distribute water as needed to NWTC facilities.

Current Colorado state water laws limit the onsite collection of rainwater and reuse of storm water and gray water sources, and there are no municipal reuse water lines located near either campus.

Major water-consuming end use consists of cooling, laboratory equipment, domestic use for sinks and sanitation, and irrigation. End-use water consumption at NREL in FY 2015 was as follows:

- Cooling towers: 32%
- Direct evaporative coolers: 6%
- Laboratory deionized water: 3%
- Other inside use: 57%
- Irrigation: 2%.

Water Use Efficiency

In FY 2015, NREL reduced cooling water consumption by increasing waste heat utilization in the HPCDC. The HPCDC piping is now delivering warmer, more useful water temperatures to energy recovery systems. This will allow more heat to be put to beneficial use for space temperature control and avoid rejecting cooling tower water into the atmosphere.

NREL also met its FY 2015 goal of developing recommendations for future funding needs and building retrofit projects targeted at reducing campus potable water use. Recommendations have been made to replace the 30-year-old air handlers in the FTLB with more high-efficiency units. These units will reduce simultaneous heating and cooling, which will in turn reduce cooling tower water use during the heating season.

Water Management

NREL is working to conserve and optimize water efficiency for campus irrigation by using the WeatherTRAK smart irrigation system

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.

to automatically adjust landscape watering based on plant needs and daily local weather conditions. Irrigation systems use moisture sensors and run only when necessary. After plants become established, irrigation systems are taken offline and the areas planted in native species adapt to local climate conditions.

In FY 2015, NREL conducted EISA water audits on three of NREL's buildings. These audits resulted in recommendations to install water meters on two of the buildings on the NWTC campus to better understand the water use within those facilities. The third building does not use any water.

PROJECTED PERFORMANCE GOALS AND STRATEGIES

Cooling towers typically bleed water to the sanitary sewer to control total dissolved solids. Cooling towers can operate much more efficiently with softened water. NREL is working on supplying 100% softened water to cooling towers to reduce water use. In



Melting snow from the roof of the RSF flows into containment structures and then into landscaping around the building. One of the sustainable features to the building's exterior is the catch basins. Water flows off the roof, into the down spout, and then into catch basins lined with crushed glass. The water running through those troughs waters the trees and plants as it goes, providing much-needed supplemental water to the RSF vegetation.

addition, the laboratory is considering applying lessons learned from a water treatment study performed at the Denver Federal Center to decrease bleed water and, as a result, potable water consumption.

The ESIF accounts for 20% of total NREL water consumption. Johnson Controls, Inc., donated a thermosyphon cooler for NREL to install in the HPCDC at the ESIF. This device will reject most of the HPCDC heat without evaporating water in cool weather. At 50°F outdoor air temperature it can reject 1,000 kW of heat. Because Denver's mean temperature is 48°F, the thermosyphon can conceivably all but eliminate HPCDC cooling tower water use for half the year. This is very important considering that the HPCDC, in its 600-kW configuration, used 12% of all STM water in FY 2015. The supercomputer is growing by 300 kW in FY 2016, which will significantly increase its water use. NREL will instrument the thermosyphon cooler to track performance.

NREL is renovating a previous laboratory space in the S&TF to create a clean room on the STM campus. One of the features of the clean room is an ultra-pure water system to reduce or eliminate dissolved and suspended solids and gases, biological organisms, and organic carbon. This system could use a substantial amount of water. Colorado water law restricts water reuse; however, using reverse osmosis backwash water for cooling tower make-up water is allowed. NREL is working with the water equipment vendor to possibly divert reverse osmosis backwash water to a holding tank for use as cooling tower make-up water. Although overall water use is expected to increase, this measure will mitigate the rise.

NREL installed HydroPoint WeatherTRAK in 2011 to manage water conservation for

landscape irrigation. Since then, campus facilities have expanded greatly and restoration of additional areas have begun. NREL will conduct a comprehensive review of the system coverage in FY 2016 to ensure that weather-sensing irrigation controls are strategically placed to reduce outdoor potable water use. In addition, this will align with NREL's *Sustainable Infrastructure Master Plan* by identifying new areas in which to extend the irrigation system, along with its operational requirements.

Consolidated Mutual Water Company is in the process of installing advanced meters that customers can read in real time. This will greatly improve understanding of water use patterns, which today can only be ascertained from bimonthly bills. When the water meters are installed, they will be networked to the forthcoming EIC system.

NREL's first water efficiency plan was developed in 2003 to meet EO 13123 implementation guidance, as well as DOE Order 430.2A. In FY 2015, NREL began updating the plan to account for new water provisions in EO 13693. NREL anticipates completing its updated *Water Management Plan* in FY 2016.

MEASUREABLE GOALS

In FY 2016, NREL will:

- Divert heat from cooling towers to minimize the impact of the HPCDC
- Improve usage of the WeatherTRAK system
- Complete the update of NREL's *Water Management Plan*.

Environment and Pollution Prevention

Goals and Achievements

Divert at least 50% of nonhazardous solid waste, excluding construction and demolition debris

- Diverted 81% of nonhazardous solid waste from the landfill.

Divert at least 50% of construction and demolition materials and debris

- Diverted 75% of construction and demolition materials and debris from the landfill.

95% of eligible acquisitions each year are EPEAT-registered products

- 98% of eligible electronic acquisitions met EPEAT standards.



NREL employees donated used bikes to Goodwill at the Earth Week Green Commuting Expo.

Environment and Pollution Prevention

FISCAL YEAR 2015 PERFORMANCE STATUS

NREL has initiated several campus-wide programs at the STM and the NWTC to meet DOE's performance targets for pollution prevention and waste reduction. NREL's 4R Philosophy—reduce, reuse, recycle, and re-buy—is guiding significant progress toward a near-zero-waste laboratory and reducing the need for new chemical purchases. At the same time, employee education, outreach, and information sharing is resulting in an “all hands” effort to reduce waste, materials, air emissions, and water and energy use.

In FY 2015, NREL diverted 81% of nonhazardous solid waste, up from 75% in FY 2014 and well above the performance target of 50%. Seventy five percent of construction waste, including demolition materials and debris, was diverted from small-scale campus projects.

With DOE's FY 2015 solid waste and construction waste diversion goals both staying flat at 50% from FY 2014, NREL continues to exceed the requirements, even with the added challenge of increased population and campus growth.

Waste Diversion

NREL's Near-Zero-Waste Committee held two meetings in FY 2015 to find new ways to increase diversion rates. The committee identified several initiatives that will be implemented in FY 2016. These initiatives are described in more detail in the Projected Performance Goals and Strategies section.

NREL performed an onsite waste audit at the FTLB on the STM campus in August 2015. The

building is currently diverting 44% of material from the landfill, removing contamination. The FTLB has the potential for a maximum diversion of 64% from the landfill with education and bin placement efforts. Positive findings include that 96% of mixed paper and 81% of cardboard/paperboard is being diverted from the landfill, and the compost stream has low levels of contamination, which is critical for the quality of the compost material.

Construction and Demolition Waste Diversion

NREL's statement of work requires all subcontractors to track their waste and how it was diverted from the landfill. Subcontractors are given a Waste Tracking Log, similar to what is used in LEED projects in the Material Resources credit category. Project managers collect the logs at year end to determine the percentage of materials that were recycled.

Pollution Prevention

A mandatory training session for all laboratory workers on chemical safety and hazardous waste management was held in FY 2015. NREL gives workers a formal hazard identification and control process, which serves as a tool to identify and substitute chemicals that may be less hazardous to workers and the environment.

NREL developed a pilot project that will identify potential sustainability improvements in the supply chain of laboratory chemicals acquired. Potential sustainability considerations are the GHG footprint of chemical acquisitions, the resource intensiveness of shipping materials, and the social impacts of chemical supply

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 laboratory research.

and distribution. The pilot project will be implemented in FY 2016.

When pest wildlife species need to be controlled, NREL uses an integrated approach to humanely eradicate pests and minimize other potential impacts. In FY 2015, six species of noxious weeds were treated at both the NWTC and the STM campus: knapweed, Canada thistle, musk thistle, Scotch thistle, myrtle spurge, and Russian olive.

Instead of herbicides, biocontrol agents were used against knapweed in a specific test area at the NWTC. Biological pest control helps decrease agriculture's reliance on chemical pest control. The Colorado Department of Agriculture provided NREL with knapweed-loving weevils as an alternative to chemical use.

NREL worked to eliminate myrtle spurge from the STM site. Myrtle spurge plants around the ammunition igloo behind NREL's Solar Energy Research Facility were hand-pulled and plants that reemerged in June 2015 were treated with herbicide. It is likely that roots of the myrtle spurge plants are still viable and growth may

Waste Management: FY 2015



Compost



Waste Diversion History

FY 2008



914,260 lbs



586,175 lbs

Recycling

Compost

Landfill

FY 2014



1,169,970 lbs



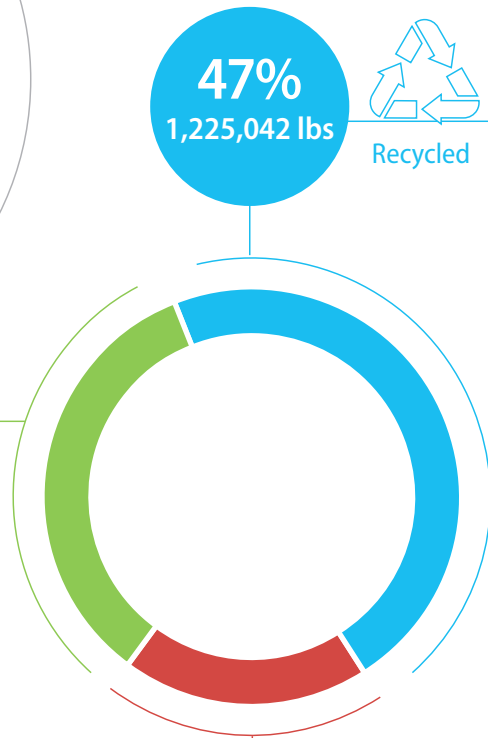
840,267 lbs

Compost

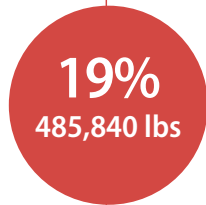
Landfill

Landfill











674,499 lbs



Recycled



Landfill

- 180,000 pounds  Wood and wood pallets
Mulch and wood chips are made from the recycled wood waste
- 178,760 pounds  Scrap Metal
- 33,441 pounds  E-waste
- 8,679 pounds  Batteries
- 2,636 pounds  MFD toner cartridges
- 1,305 pounds  Books from the NREL library donated to Goodwill
- 1,556 pounds  Styrofoam
- 826 pounds  Light bulbs (mercury and flourescent)
- 784 reams  Paper (12% decrease from 2014)
- 267 gallons  Cooking oil from the Café

appear in 2016. Alternating hand-pulling and herbicide use reduces the use of herbicide but still stresses the myrtle spurge root systems. NREL continues to work toward its goal to eliminate myrtle spurge; however, it may take a few more seasons to achieve. In addition, Russian olive trees at the STM campus were girdled and treated with herbicide. Physical disturbance (girdling) used with herbicide increases the effectiveness of the herbicide and may decrease the need to reuse herbicide on Russian olive trees in the future.

PROJECTED PERFORMANCE GOALS AND STRATEGIES

Employee participation is paramount in meeting DOE's Pollution Prevention and Waste reduction goals. Staff plays an important role in helping reduce the amount of solid waste reaching landfills as recycled and compostable materials increase. Staff members also submit new ideas through the Sustainable NREL website and emails. In FY 2015, NREL will continue to provide training to existing and new employees to promote sustainable and resilient campuses.

NREL is planning to initiate the following initiatives as recommended by the Near-Zero-Waste Committee in FY 2015:

- Increase communications on waste diversion, including producing a short video overview on recycling and composting
- Upload monthly recycling "Tips and Facts" to the Sustainable NREL website
- Test the effect of changing signs on waste bins that currently say "Trash Only" to "Landfill Only" (to deter items ending up in the trash that could be diverted through recycling or composting). In addition, add a stop sign graphic to lids with the message: "Is this

item Recyclable or Compostable?" NREL will evaluate diversion rate changes with the new signage and determine if all signage should be updated to increase diversion rates.

NREL will continue to analyze the findings of the FTLB waste audit conducted in FY 2015 to determine changes that could be made in the building to facilitate a higher diversion rate, specifically addressing compostable materials.

In an effort to increase construction waste diversion rates in FY 2016, NREL will make a conscientious effort to work closely with project managers and enforce subcontractor statement of work requirements for all construction projects, big or small.

NREL is committed to using alternative chemicals and processes and will continue to give preference to EPPs, including bio-based products, Electronic Procurement Environmental Assessment Tool (EPEAT), and low- or no-volatile-organic-compound paints. NREL will also continue to use a chemical management system to track chemical purchases, management, and disposal. Further, the laboratory will also continue to maintain an "excess chemical inventory" that allows users to exchange chemicals within NREL when unneeded chemicals are available. This reduces the need for acquiring new materials as well as the need to dispose of chemicals as regulated waste.

MEASUREABLE GOALS

In FY 2016, NREL will:

- Investigate additional measures with the Near-Zero-Waste Materials Committee to achieve higher diversion rates and reduce overall waste

- Work with project managers to collect data each month about construction projects in an effort to increase diversion rates
- Implement a sustainable supply chain pilot project
- Eliminate myrtle spurge from the STM campus, reduce the density and abundance of knapweed at the NWTC, and reduce Canada thistle at the STM site
- Develop and implement a uniform and enhanced landscape strategy to ensure restoration is efficiently and effectively completed after ground-disturbing activities.

Electronic Stewardship

FISCAL YEAR 2015 PERFORMANCE STATUS

NREL promotes electronic stewardship through life-cycle management of electronics from procurement to disposal. By using sustainable acquisitions, power monitoring, efficiency measures, and responsible disposal, NREL continues to improve performance in DOE's Electronic Stewardship goal year after year.

Purchases

NREL has long-established standards for computing equipment, which take into account sustainable acquisitions and operations best practices, business needs, and responsible disposal. NREL also directs purchases for eligible equipment through vendors who have knowledge of EPEAT and can offer equipment that can meet and exceed EPEAT's stringent standards. By establishing this standard and review process, NREL is able to direct the vast majority of its computing equipment purchasing toward EPEAT-compliant models and options.

In FY 2015, 98% of eligible computers and monitors and 98% of total eligible electronics purchases (including computers, monitors, tablets, imaging equipment, and televisions) met the EPEAT standards. Furthermore, 98% of eligible equipment purchases were ENERGY STAR-certified and 98% were FEMP-designated.

In FY 2015, the Green Electronics Council awarded NREL with a Three-Star EPEAT Purchaser Award, recognizing NREL's excellence in the green procurement of electronics. The combined efforts of the 2015 EPEAT Purchaser Award winners resulted in enough energy savings to power more than 6,500 U.S. households for one year, a reduction of more than 350,000 kg of hazardous waste, the elimination of enough mercury to fill more than 5,000 mercury fever thermometers, and carbon reductions equal to removing more than 11,000 passenger cars from the road for one year.

As a Federal Electronics Challenge partner from 2007 until the program retired in 2014, NREL continues to improve and monitor its electronic stewardship practices throughout the entire life-cycle of its IT equipment and infrastructure—acquisition and procurement, operations and maintenance, and end-of-life management.

Power Management

Power management settings are enabled on all eligible personal computers (PCs), laptops, and monitors before being deployed to employees or installed on any NREL site. Devices are set to turn off the display after 10 min of inactivity and set the hard drive into standby modes after 15 min of inactivity. In addition, all electronic devices in the RSF are plugged into a power management surge protector that cuts off power to inactive

devices when not in use. NREL also continuously monitors the power usage of plug loads at the workstation level in the ESIF. The ability to monitor this type of energy data has given NREL numerous opportunities for energy savings. In FY 2015, NREL conducted a study comparing power management settings on active devices after the initial setup by IT. The study found that more education is needed to encourage employees to maintain power management settings.

NREL enforces computer power management settings via group policy and monitors the settings using LANDesk management suite. In future years, NREL plans to audit computers including systems with power management exemptions. NREL is also developing specific training about power management and is working with the Office of the Chief Information Officer (OCIO) to enable additional power management capabilities through LANDesk or other commercially available software packages.

Automatic Duplexing

ENERGY STAR-certified multifunction devices (MFDs) continue to replace existing printers. Two new ENERGY STAR-certified Gold MFDs were purchased this year. NREL continues to replace computer printers, copiers, scanners, and fax machines with MFDs—effectively reducing the need for standalone imaging equipment. All new facilities are required to use MFDs.

Currently, 71 MFDs throughout the STM and NWTC campuses default to double-sided, black and white copies, which saves paper and toner ink.

Electronics: End of Life

NREL has a laboratory-wide sustainability practice that addresses recycling, reuse, composting, transportation, plug loads, and staff behaviors, among other programs. Electronics end-of-life management is no exception. All cartridges from MFDs are sent back to the manufacturer or a subcontractor for recycling. One hundred percent of electronics at the end of their useful lives in FY 2015 were recycled in an environmentally sound way, donated, or resold.

In FY 2015, NREL recycled 31,881 pounds of electronic waste and 1,560 pounds of computer monitors.

PROJECTED PERFORMANCE GOALS AND STRATEGIES

NREL's goal is to enable power management settings on 100% of eligible computers throughout the useful life of the equipment. For power management strategies to be successful, however, staff participation is essential. In FY 2016, NREL will continue to focus on educating staff about the importance of using power management settings through focused training sessions and competitions.

The IT Asset Management team will continue to work closely with OCIO to increase the percentage of purchases filtered through NREL's Basic Ordering Agreements purchasing contracts. Through this collaboration, OCIO will be able to monitor and recommend products based on EPEAT and ENERGY STAR guidelines, thereby continuing to increase NREL's commitment to electronic stewardship.

MEASUREABLE GOALS

In FY 2016, NREL will:

- Continue to uphold best practices for electronic stewardship
- Reduce overnight plug loads in the office wing of the ESIF by using state-of-the-art power strips
- Educate staff on the importance of using power management settings through focused training classes and competitions.

Sustainable Acquisition

FISCAL YEAR 2015 PERFORMANCE STATUS

NREL is committed to environmentally preferable and sustainable purchasing that promotes the natural environment and protects the health and well-being of its employees, subcontractors, and visitors.

One hundred percent of NREL's FY 2015 construction and custodial contracts include BioPreferred (a United States Department of Agriculture designation) and bio-based provisions and clauses, meeting and exceeding the requirements of DOE's Sustainable Acquisitions goal of 95% in FY 2015 and 100% by FY 2020.

Products and Services

In FY 2015, NREL received a GreenBuy Award from DOE for its sustainable acquisition purchases in FY 2014. This marks the fourth consecutive year that NREL has been a GreenBuy Program Gold winner. NREL's purchase card (PCard) program and purchase request procedures have significantly contributed to environmentally preferable and sustainable purchasing. Through the PCard program, employees are trained and given the tools to make informed choices on sustainable acquisitions for all laboratory purchases. Environmentally Preferable Products (EPPs) are defined for cardholders as products manufactured from recovered materials, energy-efficient products, bio-based products,

alternative fuels and fuel efficient vehicles, and non-ozone-depleting substances. PCard holders use this definition to identify their product purchases as "green" or "not green." Green purchases totaled 18% of NREL PCard purchases in FY 2015.

NREL uses EON as the primary procurement tool to encourage the purchase of sustainable products. EON is an authorized distributor with the Federal Strategic Sourcing Initiative and distributes a "green catalog" to NREL employees. They can then choose from more than 4,000 earth-friendly office supply products in the catalog. In FY 2015, 51% of the items purchased through EON were EPPs.

Construction

Subcontractor contracts and statements of work include language to promote the purchase of products with the following characteristics:

- Energy-efficient (ENERGY STAR- or FEMP-designated products)
- Water efficient (WaterSense)
- Bio-based
- Environmentally preferable (including those chosen via EPEAT)
- Non-ozone-depleting
- Recycled content
- Nontoxic or less toxic.

Supply Chain Greenhouse Gas Emissions Management

In FY 2015, NREL assembled a group of people to work on improving supply chain GHG emissions management, including reducing the distance traveled for products and reducing the number of deliveries for one type of product. This work will continue in FY 2016.

PROJECTED PERFORMANCE GOALS AND STRATEGIES

NREL will continue to implement new policies and programs and conduct training sessions to increase staff awareness of and accessibility to sustainable products. In addition, NREL will provide resources to make it easier for purchasers to find information about green products and services and engage in contracts with providers of goods and services that are consistent with EO 13693.

Exploring opportunities to update business systems reporting to improve green purchase accuracy will also proceed in FY 2016.

MEASUREABLE GOALS

In FY 2016, NREL will:

- Conduct PCard training classes with Q&A sessions to be held in October 2016
- Refine green purchase definitions with PCards
- Continue to require EPPs in contractor and custodial contracts
- Analyze supply chain improvement options.

Stakeholder Initiatives

Goals and Achievements

Efforts to increase regional and local planning coordination and involvement

- Continued to work with local governments to promote and encourage alternative transportation.
- Worked with the RTD and MV Transportation to develop a new shuttle route for NREL employees to encourage commuting by alternative transportation.
- Met with staff from the city of Golden and the Colorado School of Mines to discuss potential carshare and bikeshare opportunities.
- Worked with DOE and Jefferson County Open Space to improve the Cretaceous Trailhead accessing South Table Mountain Park.
- Coordinated efforts with the USFWS Rocky Flats Refuge officials to treat 102 acres for knapweed at the NWTC.

NREL cyclists from Boulder pull into the NREL Bike to Work Day breakfast station at the Education Center parking lot. Hundreds of NREL and DOE-GO employees opted out of their cars on June 24, 2015, and instead cycled to work for the event.



Stakeholder Initiatives

FISCAL YEAR 2015 PERFORMANCE STATUS

NREL is actively involved in strengthening the vitality and livability on its campuses as well as in the city of Golden and surrounding communities in Jefferson and Boulder counties. All campus projects work to integrate physical boundaries, connect to transportation and utility systems, and protect the ecosystem and open space. These initiatives nurture a sustainability culture and forge stronger community, neighbor, and user relationships.

Transportation Planning

NREL's transportation program helps to manage traffic, reduce GHG emissions, and improve air quality by employing an "avoid, shift, and improve" trip strategy. This program includes supporting alternative commuting options (ridesharing, bicycling, and public transit use), flexible work practices, teleworking, and incentive parking for green vehicles.

Cycling is popular in Colorado. With hundreds of miles of bike paths and more than 300 days of sunshine a year, NREL employees are turning to biking as a more cost-effective, environmentally friendly mode of transportation. In FY 2015, NREL:

- Coordinated and hosted a city of Golden Regional Bikeshare Feasibility Focus Group (of NREL staff) to support the city in its investigation and planning study for a new bikeshare system
- Participated in planning meetings for the *Metro Vision Regional Transportation Plan 2040-*

Regional Bicycle Network Vision Plan Update to help the region take inventory and prioritize new bicycle facilities

- Met with staff from the City of Golden and the Colorado School of Mines to discuss potential carshare and bikeshare opportunities
- Participated in DRCOG's Bike to Work Day and won the Business Challenge in the Class D category for Jefferson County.

Ridesharing and public transit options are also a big part of the sustainable culture at NREL and in the surrounding communities. In FY 2015, NREL used free tools from DRCOG's WayToGo program to facilitate a commuting survey for the NWTC site. The survey asked employees for feedback on their commuting practices and preferences. A specialist from WayToGo reviewed all the surveys and gathered information on individuals who were interested in learning more about alternative means of transportation to work. Emails were sent to the employees with tailored information related to their personal commutes. Interested carpoolers were connected and vanpooling and transit options were defined. DRCOG was an essential partner in getting this individualized information to NREL employees.

NREL is dynamically involved with regional transportation planning efforts, working with Jefferson County, the City of Lakewood, the City of Golden, Boulder County, and RTD to support transportation decision making in the west Denver metro area. In FY 2015, NREL:

- Conducted focus groups to solicit feedback on NREL-provided shuttles and make adjustments to NREL shuttle routes that connect with RTD services. Worked with RTD and MV Transportation to implement a new shuttle service that connects at the RTD Oak St. light rail station
- Provided technical support to the West Sustainability Team—composed of representatives from the General Services Administration (GSA), Federal Center, the City of Lakewood, NREL, and Red Rocks Community College—in its investigation of a potential regional sustainable transportation system
- Continued advocacy efforts and construction of bicycle and pedestrian-supportive infrastructure at NREL and throughout the community
- Participated in a focus group with other regional companies and advocates to brainstorm possibilities for a promotional "multimodal" month campaign in October 2015. This idea session was meant to create a pilot program to help promote alternative transportation, including walking, biking, carpooling, vanpooling, transit options, and telecommuting. NREL was chosen to participate in the Go-Tober event pilot scheduled for October 2015.

Environmental Management and Planning

The National Environmental Policy Act (NEPA) review is an environmental compliance evaluation required for proposed activities being conducted on federal lands or facilities or for projects leveraging the use of federal funds, such as for CRADA or interagency agreements. As a DOE-owned and-funded facility, all activities and projects proposed by NREL are required to undergo a NEPA review and decision before funding is expended or activities begin. The review, which includes an analysis of the proposed activities and their potential for environmental impacts, is a tool to assist the decision makers in making informed decisions. Several levels of reviews include determining if the activity fits under a DOE categorical exclusion (a class of actions determined to have no



Denver Mayor Michael B. Hancock welcomes entrepreneurs and investors to Colorado at the 27th Industry Growth Forum in Denver, Colorado, hosted by NREL.

significant impacts). If the activity does require a more rigorous analysis, an Environmental Assessment or an Environmental Impact Analysis is conducted. In order to streamline the NEPA review process, DOE-GO, assisted by NREL's Environment, Health, and Safety Office, developed two program-level Environmental Assessments that encompass many of the routine and planned projects for the STM and NWTC campuses.

NREL worked with DOE and Jefferson County Open Space to improve the trailhead and the first one-quarter mile of the Cretaceous Trail accessing South Table Mountain Park. A culvert was installed at the trailhead and crusher fines were placed in the improved trail tread, allowing for better drainage. Social trails were identified for removal to preserve native grasslands along the designated trail.

In FY 2014, 6,700 ft² of glass windows in the ESIF were retrofitted with a laminate to improve the visibility of the windows to birds, with the goal of reducing bird-window collisions, the leading cause of mortality for birds. Surveys to test the effectiveness of the ESIF window retrofit are currently being conducted. To date, no bird strikes have occurred on retrofitted windows. Surveys will continue through mid-November 2015.

NREL also coordinated weed control efforts at the NWTC with the USFWS Rocky Flats Refuge officials. The groups met to discuss efforts between their mutual boundaries of the NWTC. Knapweed was treated to the benefit of both groups. Noxious weed management continued with approximately 102 acres treated for knapweed at the NWTC. In addition, about 30 acres were treated in FY 2015 for Canada thistle, knapweed, and myrtle spurge at the STM site.

PROJECTED PERFORMANCE GOALS AND STRATEGIES

NREL will continue to participate in regional and local planning efforts in an effort to contribute to the social, environmental, and economic success of the region. NREL's culture plays a big role in sustainability, not only on campus but in the surrounding communities where employees live and play.

NREL will continue to provide and participate in outreach activities to communicate sustainable options and ideas to NREL employees, community groups, and regional partners.

MEASUREABLE GOALS

In FY 2016, NREL will:

- Continue efforts to advocate for and improve access to alternative commuting options through regional and local organizations
- Roll out a pilot program using revised NEPA criteria and changes made before rolling out the program across the laboratory. The laboratory-level procedure will be updated, as well as the NEPA Handbook
- Meet with USFWS to develop a 2016 strategy to work cooperatively to manage noxious weeds
- Continue participation in regional events promoting alternative transportation such as Go-Tober and Bike to Work Day.

NREL's Resiliency is Taking Many Forms



NREL Senior Scientists Ross Larsen and Travis Kemper examine a molecular model of Polymeric organic nitroxide radical (PTMA) film for battery applications using a 3D model at the Insight Collaboration Laboratory.

NREL'S RESILIENCY IS TAKING MANY FORMS

When Climate Changes, Adaptation is the Key

As the effects of climate change become more pronounced—with unprecedented storms and unpredictable weather patterns—NREL is drawing on its deep knowledge of renewable energy and energy efficiency to help mitigate or avoid climate change impacts.

NREL is conducting R&D to accelerate development of particular technologies to assist such adaptation. And in doing so, it seeks to influence change and adoption in the marketplace. Overall, NREL is advancing sustainability both on campus and across the

United States by finding innovative ways to make resiliency a part of energy systems, and therefore more sustainable.

It all starts at the lab. Associate Lab Director Robin Newmark said NREL's campus is becoming a working example of resilience. "We are doing a lot of clean energy piloting, and are able to demo the performance of new technologies, methodologies, and data analytics at NREL which can inform and make a more sustainable campus for us." Further, Newmark noted that tapping those capabilities are an element of what NREL can provide to other clients.

And while not everything the lab undertakes is a success, all initiatives contribute to a pool

of learning. "In our efforts to improve on our campus, our learnings translate directly into what we can bring to those seeking clean energy solutions," she said.

NREL's Vision Looking at the Grid

Even as NREL explores resiliency at the lab, it connects to the larger challenges of resiliency facing the U.S. electric grid. NREL's Director of Power Systems Engineering Ben Kroposki understands the value of such a holistic approach. "When energy systems as a whole—and the grid—can demonstrate the ability to withstand or adapt to some type of change, this is a resilient system," he said. The good news is that power companies and utilities already

regularly deal with disaster-related outages. “Storms take out major portions of the electrical grid, so utilities are used to having to go out and put things together again, and get the whole system up and running.”

Further, as grids become more hybridized—drawing not only on fossil fuels, but adding increasing amounts of natural gas and renewable energy power sources such as solar and wind power—supply and security of that supply is very important. “It’s great to have a natural gas supply—but if you can’t turn on the pump to move the gas because the pump is electric,” then the system fails, Kroposki explained, pointing to the tie between electric and natural gas infrastructures.”

As he noted, resiliency will become an increasingly key factor as grids modernize. Gone are the times when the electrical system could only focus on affordability. Moreover, future grids can’t just stop at providing reliable electricity most of the time; the stakes are higher today. Everyone has to be ready to respond in an emergency. “If a blackout happens, is the business system prepared? That’s where resiliency comes in, and that has been more in focus over the last 10 years,” Kroposki said, adding that the reason is fairly simple. “Everything is somehow connected to electricity now, so we have to make sure we can recover quickly from any kind of disturbance. Maintaining that power is key.”

This isn’t happening in a vacuum. The lessons learned from utilities are valuable, Kroposki said. For example, knowing how to isolate parts of a grid to create small, operable islands, allows utilities to bring up the infrastructure in pieces.

“The whole concept around microgrids is adding in the ability of localized power systems to keep running when there are extreme events. That’s a key to understanding resiliency in the context of the grid.”

Fortunately, NREL is well-equipped for this task. Kroposki noted that there are a number of things underway at the laboratory’s Energy Systems Integration Facility which involve setting up fully complete microgrids. For example, NREL has worked closely with the Department of Defense to plan a microgrid for Marine Corps Air Station Miramar near San Diego, California. For that project and others, NREL is able to run algorithms or test distributed generation power sources, and system concepts can be tried out before being deployed. “We can play with all sorts of scenarios, which makes it attractive for people to bring in all sorts of microgrid projects,” he said.

Such experimentation could also impact NREL, as researchers seek to see if a microgrid would be an option on the South Table Mesa campus. Such a measure could be part of the overall pursuit of resiliency.

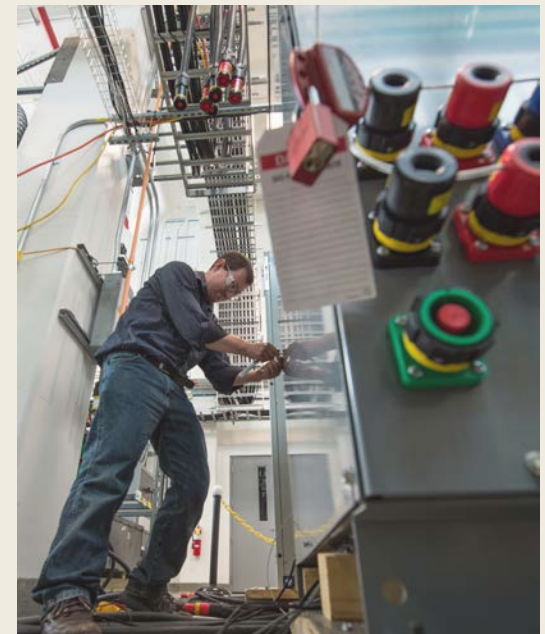
The Pursuit of Resiliency

This topic has become an integral part of the laboratory’s focus, according to Erfan Ibrahim, NREL’s director of Cyber Physical Systems Security and Resiliency, a group which was created in 2015 for NREL’s Energy Systems Integration. “Resiliency is the mitigation of failures scenarios,” he said, explaining that this process begins because there is a normal functioning of infrastructure that develops over time with technology, with people, and with processes. “When some adverse event occurs—and there could be multiple ones—such as a natural

disaster, advanced persistent threat, coordinated attack, a large-scale system error, or hackers (casual hackers do something that cascades into a much larger event)—these potential threats cause failures to occur.”

Those failures occur according to some method, which has to be analyzed to learn what a “failure scenario” is. “The mitigations for the failures additively build resiliency in your system to stop other systems, which may be connected to it, from failing,” Ibrahim said.

He said that once laboratory operators have a good idea on the various failure scenarios, they develop mitigations for them, and then introduce best practices for resiliency. A case



NREL engineer Nathan Ainsworth works in the Energy Storage Laboratory (ESL) at the ESIF, instrumenting a transformer for power hardware-in-the-loop (PHIL) testing.

in point is how distributed intelligence is used in computing by avoiding highly-centralized systems, because such central systems are susceptible to large-scale failure. “That’s where research is needed to break up systems into fractals—things that can operate autonomously for any period of time that they need to.”

The goal is to de-centralize by having the ability at a moment’s notice to move into this autonomous model. Other elements of a strengthened system include having backups that are not geographically co-located with primary assets; training people in the right way on how to deal with situations that are considered off-normal; and having proper business processes in place to handle emergencies.

As the lab develops, NREL is influencing cyber security and resiliency for the electric, water, and oil and gas sector. This is taking place even though the lab is not a traditional R&D institution for cyber security, the way some other national labs are. “We are the new kid on the block. There are pros and cons to that. Pro is that we don’t have any mental models based on our past work,” he said, which requires out-of-the-box thinking about how to secure assets. “One of the cons is that we have to prove ourselves in the industry first with small engagements before we will receive funding for large scale R&D projects in this field.”

He’s confident that NREL’s recent path, unlike standard resiliency models fashioned by many IT departments, is different. Instead of relying solely upon cyber security experts, his center is working to fold in team members with diverse backgrounds. That way, he said, “we can put ourselves in the place of the advanced persistent threat or hacker attacking distributed energy

resources—then figure out what to do to stop them.”

Avoiding Disruptions—and Expanding Renewable Energy

Chuck Kutscher, director of NREL’s Buildings and Thermal Systems Center, said he sees resiliency as being basic, meaning “no interruption of the workforce or the test facilities, and no impact on DOE or work-for-others milestones.”

But Kutscher said he views the topic as a way for NREL to develop particular renewable technologies—and as well as to accelerate the pace of development to meet climate change. “The key is to develop and deploy energy efficiency and renewable energy technologies to get at the root of the climate change problem by rapidly reducing greenhouse gas emissions.”

He noted that NREL’s work on demand response and transactional controls can allow the lab “to better handle grid disruptions, as can battery storage in vehicles and thermal storage in concentrating solar power plants. Rooftop photovoltaic (PV) systems with battery back-up will also make homes more robust and resilient.”

And NREL is about to influence change and adoption of these technologies and practices in the buildings marketplace.

Kutscher said that the lab develops and tests innovative components for both commercial and residential buildings. “Through our regional energy efficiency potential maps, we help state and local planners to determine the most cost-effective energy efficiency measures to deploy. Through OpenStudio and Energy Design Assistance Project Tracker, NREL helps utilities improve and administer their incentive programs thus allowing buildings to do better than code,” he said. “In our Systems Performance Lab we test

smart appliances and ways to control the utility load to better accommodate variable PV and Wind power on the grid.”

Resiliency at the Core of NREL’s Identity

Chris Gearhart, Director of the Hydrogen Technologies & Systems Center, said he sees resiliency and renewable energy technologies at the core of NREL’s identity. NREL was founded because the United States deemed resiliency to oil shocks of the 1970s as important. Over time, things evolved in the lab’s mission.

“I’ve thought about resiliency on two fronts: the resiliency of our transport sector to the energy supply, which then gets back to the history of the whole lab. We exist because of energy crisis. In some sense, everything we do on the transportation side is to diversify the transportation domain.” Currently, the U.S. transportation energy supply is monolithic as far as the energy source goes because it’s all petroleum. “By its very nature it’s not resilient,” he commented.

Gearhart explained that as the country moves towards tackling greenhouse gas abatement, it raises the issues of what resilience means in the face of climate change. “To get resilience with respect to petroleum supply, we’re going to move to biofuels. But these are extremely sensitive to climate change,” he said. If climate change becomes serious enough, it could affect biofuel crops.

One avenue that NREL is pursuing is to ensure diversity. “Our whole portfolio is dedicated to biofuels, hydrogen, or battery-electric vehicles,” he said. “As long as we don’t tie ourselves in to one infrastructure,” it provides better balance. Even if the lab and nation focus on biofuels, research can still focus on different sources, using feedstocks from sawgrass to corn and more.

NREL also works to help the Energy Department support resiliency. Gearhart said that an example would be how the Vehicle Technologies and Fuel Cell Technologies offices are exploring the benefits of using hydrogen benefit as an energy carrier. Hydrogen can be made in conjunction with a number of energy technologies.

Moreover, this type of research has other applications. Extreme weather—exemplified by Hurricane Sandy which devastated the East Coast in 2012, killing 285 people—is not only testing the grid—it’s providing opportunities to learn more about resiliency. For example, Gearhart said there’s been good data analysis by the National Fuel Cell Technology Center about backup power generators. Of those operating in the aftermath of Sandy, a number were stationary hydrogen backup generators. “All the hydrogen ones started up,” he said. “This technology provides really reliable backup power in part because the systems are simple. There are no moving parts, and they can sit for years”—unlike more standard diesel generators.

“Resiliency to storms and weather is now helping push the market for stationary fuel cells, which in turn helps push the market for electric vehicles,” he said. “EVs are potential generators that could be plugged in as long as they have bidirectional power flow—another area we are working on.” In the face of such change, NREL researchers are asking “what are the implications to not only being able to charge electric vehicles, but also off boarding electricity from either electric or hydrogen vehicles.” Gearhart noted that such versatility is a big selling point, which could be used to power a house—and is getting a lot of attention following the devastation of Hurricane Sandy.

Resiliency Comes Full Circle

Given that direction, resiliency is also one topic which NREL itself has considered. These days, resiliency of the lab’s operations is part of an on-going discussion.

Ideas abound on a campus which already has net-zero energy buildings. The concept of being able to unplug—and demonstrate resilience with a microgrid—greatly interests Gearhart and others. Taking a step in that direction, perhaps by providing a microgrid for the Data Center, is a thought that might be explored.

Another thrust could be transportation resiliency—and planning ways to secure alternative modes of transit if standard means are not available. “We have lots of transit options at the lab,” Gearhart said. For example, he can imagine autonomous vehicles, or supplement systems with connectivity to other modes around Denver area. Linking on-campus shuttles with an individual’s schedule might open up new routes, possibly plugging NREL’s system into on-demand channels such as Uber or Lyft.

“It’s about having more than one option,” he said—which is an approach that springs from NREL’s DNA.

As Newmark summed it up, “NREL has approached resiliency in a way that taps our expertise and is cross-cutting—with Operations, Security, Finance, and researchers together.” The lab works with entities such as utilities and other partners, exploring the options of an intelligent campus. “We learn from both our successes and our failures—that’s what research is about.” Such a vision involves NREL’s deployment arm, and has impact across the range of stakeholders and decision makers—sharing between academics and utilities. “We leverage our experience and impact more broadly,” she said.

Because NREL is a scientific lab, it uses scientific methods to explore resiliency—finding solutions in a process that comes full circle. “We have a theory, design something, test it, and have the metrics in mind,” Newmark said. As the lab goes forward, “we either learn something or realize we didn’t fully understand an issue.”

Unlike some commercial enterprises, NREL views each challenge in an unbiased way, making its findings more valuable. Using the applied science approach, she concluded, NREL not only tests new ideas—but assesses the results and communicates its knowledge to others. Overall, NREL is helping to accelerate development of technologies to assist adaptation and promote resiliency throughout not only the lab, but the United States and the world in the face of climate change.



NREL and Smart Grid Solutions (SGS) host members of their project advisory board to observe the Smart Campus use case demonstration at ESIF.

Global Reporting Initiative Key Performance Indicators



Energy-efficient vehicles and their owners in front of the RSF.

KEY PERFORMANCE INDICATORS

GRI Indicator	Indicator Title	Summary of Performance for FY 2015
CATEGORY: ECONOMIC		
ECONOMIC PERFORMANCE		
G4-EC1	Direct economic value generated and distributed	<ul style="list-style-type: none"> • Revenues: \$387.4M • Employee compensation: \$173.9M • Operating costs: \$207.6M • Payments to providers of capital/governments: \$0 • Donations: \$78k
G4-EC2	Financial implications and other risks and opportunities for the organization's activities due to climate change	<p>NREL completed a climate change vulnerability assessment and developed a resiliency plan for our campuses. NREL used current climate science projections for the region to develop appropriate methodologies that allow for comparative climate change risk analysis and a prioritizing of climate change resiliency actions for our campuses in support of EO 13653 released in November 2013 and EO 13693 released in March 2015</p> <p>The White House Council on Environmental Quality tasked NREL with leading the Climate Change Preparedness Pilot for the State of Colorado beginning in July 2014, which has progressed to NREL's involvement in a Rocky Mountain regional resiliency planning effort to support EPA and GSA Region 8 with resiliency planning requirements under EO 13693. Additionally, NREL supports various organizations across the country in different sectors (e.g., organizations in New York City, in the State of Colorado, the Department of Defense, the National Nuclear Security Site, tribal governments and others) to identify climate change related risks and vulnerabilities, as well as the strategies and technologies that can assist with becoming more resilient to the impacts of climate change. This topic is a cross-laboratory effort that spans many engineering and analysis centers at NREL</p> <p>NREL has several projects at the international, federal, and organizational level dealing with GHG emissions. Climate change and GHG activities continue to move to a broader, global focus with an emphasis on federal inventories, international accounting, private corporate responsibility, and the carbon reduction commitment. As such, discussions are being held to determine the best way provide technical support to other entities utilizing NREL's expertise in the area of sustainability, climate change, and GHGs</p>
G4-EC3	Coverage of the organization's defined benefit plan obligations	NREL meets all required funding obligations. NREL funding for the defined benefit retirement plan was over \$17M.
G4-EC4	Financial assistance received from government	NREL does not accept government grants
MARKET PRESENCE		
G4-EC5	Ratios of standard entry level wage by gender compared to local minimum wage at significant locations of operation	NREL pays well above the Federal and Colorado minimum wage requirements and pays a competitive salary for similar position in the area. Men and women earn a comparable wage throughout the laboratory in all positions
G4-EC6	Proportion of senior management hired from the local community at significant locations of operation	NREL recruits on a national level and hires from the local community when possible for all senior management positions.
INDIRECT ECONOMIC IMPACTS		
G4-EC7	Development and impact of infrastructure and services supported	NREL does not have investments or services primarily for public benefit.
G4-EC8	Significant indirect economic impacts, including the extent of impacts	<p>NREL continues to directly and indirectly encourage the renewable energy technology markets both on a national and international level. NREL had the following significant indirect economic impacts:</p> <ul style="list-style-type: none"> • In a 2015 study by the University of Colorado Boulder's Leeds School of Business, the economic impact of the laboratory was found to be \$872.3 million nationwide in FY 2014. The report includes case studies showing how innovations developed at NREL are moving from the laboratory into the marketplace. • In early 2015, NREL's Enhancing Capacity for Low Emission Development Strategies program was recognized by the U.S. Agency for International Development Global Climate Change and the U.S. State Department's Deputy Special Envoy for Climate Change for its success and global impact in the previous reporting year. The work lays the foundations for long-term, low-emissions development, promoting economic growth while slowing the growth of GHG emissions. It also furthers the United States' diplomatic relationships with these countries by helping to equip them to make robust and ambitious national contributions to an international climate change agreement in December 2015. • NREL used two material-handling equipment (MHE) fuel cell power packs from previous DOE/U.S. Department of Defense projects to successfully demonstrate shaving of several simulated building peak profiles and prove out the concepts studied in the MHE2B analysis. The MHE2B concept, studied at ESIF, could be a way to improve overall economic value of on-site hydrogen infrastructure and fuel cell MHEs in warehouse applications. (Cont.)

KEY PERFORMANCE INDICATORS

GRI Indicator	Indicator Title	Summary of Performance for FY 2015
G4-EC8	Significant indirect economic impacts, including the extent of impacts	<ul style="list-style-type: none"> NREL released the Jobs and Economic Development Impact model for hydrocarbon production via fast pyrolysis. This is the first publicly available model that can be used to estimate jobs and other economic impacts resulting from the deployment of hydrocarbon biofuel facilities. Working extensively with DOE in support of the EPA/Clean Power Plan (CPP) initiative, NREL provided the foundational analysis to inform national policy and regulatory considerations in developing the CPP. NREL provided extensive renewable resource information and analysis to inform the technical potential for the plan, and this analysis was referenced repeatedly in the final CPP rule (specifically, references included the technical potential work, the Annual Technology Baseline and Standard Scenarios, the economic potential study, integration and ramping cost studies, and interstate renewable energy flows). The Office of Energy Efficiency and Renewable Energy recognized NREL's robust analytic capability by awarding the Center for Energy Manufacturing Analysis (CEMAC) to be managed within the Joint Institute for Strategic Energy Analysis. The CEMAC provides objective analysis and up-to-date data on global clean energy manufacturing. Policymakers and industry leaders seek CEMAC insights to inform choices to promote economic growth and the transition to a clean energy economy. NREL created a software toolkit and hands-on training for utility engineers at Arizona Public Service (APS). In this project-funded by the SunShot High Pen PV FOA—researchers at NREL developed software toolkits and provided training to APS engineers to better predict, plan for, and mitigate the effects of high-penetration PV on their distribution feeders. In addition, NREL researchers coupled other analyses to APS economic information (e.g., cost for system upgrades or new equipment) to determine the most economical solution for safely deploying large amounts of PV. NREL worked with the DOE Wind and Water Power Technologies Office and Sandia National Laboratories to initiate a Structured Innovation Project, which will define a framework to assess and guide wave energy technologies. The effort will help determine a path to meet key functional and economic requirements and facilitate the advancement of innovative technologies with commercial potential.

CATEGORY: ENVIRONMENTAL

ENERGY

G4-EN3	Energy consumption within the organization	
	Non-renewable consumption	<ul style="list-style-type: none"> Natural Gas – 63,413 MBtu Propane – 509 Gal (49 MBtu) Gasoline – 7,901 Gal (987 MBtu) Diesel – 5,066 Gal (703 MBtu) E-85 – 23,625 Gal (1,930 MBtu)
	Renewable consumption	<ul style="list-style-type: none"> Solar PV – 5,971 MWh (20,373 MBtu) Wind – 253 MWh (864 MBtu) RFHP – 14,504 MBtu
	Electricity consumption	26,815 MWh (91,493 MBtu)
	Total energy consumption	194,316 MBtu

ENERGY CONT.

G4-EN4	Energy consumption outside the organization	
	Air Travel	<ul style="list-style-type: none"> Long Haul (≥ 700 miles) – 13,578,329 Passenger miles Medium Haul ($300 \text{ mile} \leq x < 700 \text{ mile}$) – 149,528 Passenger miles Short Haul (< 300 miles) – 7,605 Passenger miles
	Ground Travel	<ul style="list-style-type: none"> Rental vehicles – 312,345 miles POV vehicles – 315,405 miles Cabs and Shuttles – 177,746 miles Mass Transit – 1,572 miles

KEY PERFORMANCE INDICATORS

GRI Indicator	Indicator Title	Summary of Performance for FY 2015																																				
	Commuting	<ul style="list-style-type: none"> POV – 26,163 miles with gasoline and 966 miles with diesel Carpool/Vanpool – 2,675 miles with gasoline Mass Transit – 4,038 miles 																																				
G4-EN5	Energy intensity	133,395 kBtu/ft ²																																				
G4-EN6	Reduction of energy consumption	Based on ECMs employed NREL saved: <ul style="list-style-type: none"> 0 MWh of electricity 2,500,000 cf of natural gas 																																				
WATER																																						
G4-EN8	Total water withdrawal by source	NREL uses municipal water supplies for all facilities at the STM and NWTC campuses. All municipal water in this area is drawn from surface water.																																				
BIODIVERSITY																																						
G4-EN11	Operational sites owned, leased, managed in, or adjacent to, protected areas and areas of high biodiversity value outside protected areas	<p>STM: There is a 71.63 hectares Conservation Easement within the DOE- owned land at the STM Campus. This area contains a large expanse of native grasslands and shrublands.</p> <p>The Central Arroyo Detention Pond exhibits high biodiversity value, given its design and subsequent establishment of wildlife habitat. Due to the increased water availability, the detention pond provides hydric and mesic habitat that is generally lacking across the STM Campus. These hydric areas provide habitat for boreal chorus frogs, tiger salamanders, waterfowl, and shorebirds. Mesic areas provide habitat for songbirds and small mammals. In addition, NREL has placed several nest boxes for bats and birds to further enrich the area surrounding the detention pond.</p> <p>Adjacent properties include Jefferson County Open Space with similar characteristics of the Conservation Easement.</p> <p>NWTC: There are on-site areas that are managed for conservation and adjacent areas including Boulder County/City Open Space and the Rocky Flats National Wildlife Refuge that are of high biodiversity value. There has been no development on-site that has affected these areas.</p>																																				
G4-EN12	Description of significant impacts of activities, products, and services on biodiversity in protected areas and areas of high biodiversity value outside protected areas	<p>STM: None. Although the STM Campus has experienced rapid growth since 2009, the development of the site has not affected the biodiversity of habitats found in the Conservation Easement on top of South Table Mountain.</p> <p>NWTC: There are on-site areas that are managed for conservation and adjacent areas including Boulder County/City Open Space and the Rocky Flats National Wildlife Refuge that are of high biodiversity value. There has been no development on-site that has affected these areas.</p>																																				
G4-EN13	Habitats protected or restored	<ul style="list-style-type: none"> STM Conservation Easement: 71.6 hectares NWTC conservation management areas: 63.4 hectares No new protected or reclaimed areas. 																																				
G4-EN14	Total number of International Union of Conservation and Nature Red List species and national conservation list species with habitats in areas affected by operations, by level of extinction risk	<ul style="list-style-type: none"> Wildlife surveys of the STM campus in 2010/2011 documented a total of 102 species and included 86 bird species, 11 mammals, and 5 amphibians and reptiles. Wildlife surveys of the NWTC campus in 2010/2011 documented a total of 81 species and included 62 bird species, 16 mammals, and 3 amphibians and reptiles. <table border="1"> <thead> <tr> <th>2014</th> <th>Total # Avian Species</th> <th>Avian Species In Affected Habitats</th> <th>FWS Conservation Listing</th> <th>Total # Avian Species</th> <th>Avian Species In Affected Habitats</th> </tr> </thead> <tbody> <tr> <td>Least Concern</td> <td>95</td> <td>33</td> <td>Species of Concern</td> <td>15</td> <td>4</td> </tr> <tr> <td>Vulnerable</td> <td>0</td> <td>0</td> <td>Endangered</td> <td>0</td> <td>0</td> </tr> <tr> <td>Near Threatened</td> <td>1</td> <td>0</td> <td>Threatened</td> <td>0</td> <td>0</td> </tr> <tr> <td>Endangered</td> <td>0</td> <td>0</td> <td>Delisted</td> <td>2</td> <td>0</td> </tr> <tr> <td>Critically Endangered</td> <td>0</td> <td>0</td> <td>Candidate</td> <td>0</td> <td>0</td> </tr> </tbody> </table>	2014	Total # Avian Species	Avian Species In Affected Habitats	FWS Conservation Listing	Total # Avian Species	Avian Species In Affected Habitats	Least Concern	95	33	Species of Concern	15	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
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KEY PERFORMANCE INDICATORS

GRI Indicator	Indicator Title	Summary of Performance for FY 2015
EMISSIONS		
G4-EN15	Direct GHG emissions (Scope 1)	3,516 MTCO ₂ e
G4-EN16	Energy indirect GHG emissions (Scope 2)	23,183 MTCO ₂ e
G4-EN17	Other indirect GHG emissions (Scope 3)	7,593 MTCO ₂ e
G4-EN18	GHG emissions intensity	17.5 MTCO ₂ e/person (includes DOE and contractors)
G4-EN19	Reduction of GHG emissions	See the <i>Material Assessment: GHG Emissions Reduction</i> section for a detailed discussion about NREL's progress in reducing GHGs.
G4-EN20	Emissions of ozone-depleting substances	No ODS emissions
G4-EN21	Nitrogen oxides, sulfur oxides, and other significant air emissions	<ul style="list-style-type: none"> • Nitrogen oxide emissions—15.49 MT • Sulfur dioxide emissions—0.45 MT • Carbon monoxide emissions—6.42 MT • VOC emissions—0.54 MT • Particulate matter (smaller than 10 microns) emissions—3.95 MT
EFFLUENTS AND WASTE		
G4-EN23	Total weight of waste by type and disposal method	<ul style="list-style-type: none"> • Recycled Waste (no C&D) – 556 MT <ul style="list-style-type: none"> – Recycled oil – 1 MT • Recycled C&D – 36 MT • Composted Waste – 408 MT • Landfilled Waste – 220 MT
G4-EN24	Total number and volume of significant spills	NREL had no significant spills or spills which affected the environment.
G4-EN25	Weight of transported, imported, exported, or treated waste deemed hazardous under the terms of the Basel Convention Annex I, II, III, and VIII, and percentage of transported waste shipped internationally	NREL shipped 15,999 lbs. of hazardous waste, 0% was shipped internationally.
G4-EN26	Identity, size, protected status, and biodiversity value of water bodies and related habitats significantly affected by the organization's discharges of water and runoff	<p>STM: None. The Central Arroyo Detention Pond is designed to handle runoff from the STM site. The pond functioned well during recent flood events (Fall 2014) and is maintained to limit sediment accumulation. The STM Campus drains to Lena Gulch (which flows to Clear Creek), and does not have special protected status or any significant biodiversity value.</p> <p>NWTC: Campus drains to Rock Creek or Coal Creek. Rock Creek, which is a tributary of Coal Creek, is Critical Habitat for the Preble's meadow jumping mouse downstream of NWTC. Coal Creek also has critical habitat for the Preble's meadow jumping mouse and nesting habitat for Bald Eagles in lands adjacent to NWTC.</p>
COMPLIANCE		
G4-EN29	Monetary value of significant and total number of non-monetary sanctions for non-compliance with environmental laws and regulations	NREL received no sanctions for noncompliance with environmental laws and regulations significant, nonmonetary, or otherwise.

KEY PERFORMANCE INDICATORS

GRI Indicator	Indicator Title	Summary of Performance for FY 2015
TRANSPORT		
G4-EN30	Significant environmental impacts of transporting products and other goods and materials for the organization's operations, and transporting members of the workforce	<p>NREL makes every effort to right-size its vehicle fleet, which currently consists of 43 vehicles: 40 GSA-leased vehicles and three DOE-owned vehicles. NREL fleet now includes 77% AFVs:</p> <ul style="list-style-type: none"> • 33 E-85 vehicles • 1 hybrid-gas vehicles • 2 unleaded gas vehicles • 7 diesel vehicles. <p>NREL's fleet consumed the following amount of fuel, emitting 123.12 MTCO₂e:</p> <ul style="list-style-type: none"> • 16,762 GGE of E-85 • 2,226 GGE of diesel • 7,406 GGE of gasoline. <p>NREL also used a variety of motor equipment for work across the laboratory. In total this equipment consumed the following amount of fuel, emitting 146.93 MTCO₂e :</p> <ul style="list-style-type: none"> • 509 gal of LPG • 3,124 gal of diesel • 494 gal of gasoline • 0 gal of E-85.
OVERALL		
G4-EN31	Total environmental protection expenditures and investments by type	NREL is committed to environmental stewardship, pollution prevention, compliance with requirements, and continuous improvement in environmental protection and sustainability performance. A framework of policies, procedures, and programs that integrates environmental protection into daily work practices has been developed and implemented, and is registered to the ISO 14001:2004 standard. This includes processes to identify environmental needs, allocate funding and resources, and meet requirements.
ENVIRONMENTAL GRIEVANCE MECHANISMS		
G4-EN34	Number of grievances about environmental impacts filed, addressed, and resolved through formal grievance mechanisms	NREL did not file, address, or resolve any grievances about environmental impacts.
CATEGORY: SOCIAL - LABOR PRACTICES		
EMPLOYMENT		
G4-LA1	Total number and rates of new employee hires and employee turnover by age group, gender, and region	New hires: 157 employees and 8.3% turnover. NREL does not track this information by age group or gender.
G4-LA2	Benefits provided to full-time employees that are not provided to temporary or part-time employees, by significant locations of operation	Full-time and part-time employees are eligible for the following benefits that are not provided to temporary employees: <ul style="list-style-type: none"> • Long Term Disability, • Tuition Reimbursement, and • Interest Free-Payroll Deducted Computer Loan Program.
OCCUPATIONAL HEALTH AND SAFETY		
G4-LA5	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	Zero—NREL has instituted an alternative structure to address worker safety and health. 100% of the total workforce is represented, but not by a formal joint committee.
G4-LA6	Type of injury and rates of injury, occupational diseases, lost days, absenteeism, and total number of work-related fatalities, by region and by gender	This information encompasses all NREL sites. <ul style="list-style-type: none"> • Total Reportable Case rate: 0.60 cases per 100 employees • Days Away, Restricted, or Transferred rate : 0.20 per 100 employees • Fatalities: Zero. <p>NREL does not track this information by gender.</p>

KEY PERFORMANCE INDICATORS

GRI Indicator	Indicator Title	Summary of Performance for FY 2015
TRAINING AND EDUCATION		
G4-LA9	Average hours of training per year per employee by gender and by employee category	NREL has a robust training program but does not currently have the capacity to track training by gender, employee category, or total hours.
G4-LA10	Programs for skills management and lifelong learning that support the continued employability of employees and assist them in managing career endings	<p>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 include:</p> <ul style="list-style-type: none"> • Managing Conflict (primarily for managers) • Executive Forum Leadership Series (for managers only) • Technical Writing • 7 Habits for Managers • Crucial Conversations • Speed of Trust, Influence • Pillars of NREL Leadership • Interviewing Today's Workforce • 7 Habits of Highly Effective People®, and • BizLibrary – a collection of more than 5,000 online courses. <p>Individual NREL centers have overhead funding that can be used to pay for training to advance employee skill sets and learning objectives.</p>
G4-LA11	Percentage of employees receiving regular performance and career development reviews by gender and by employee category	100% of all NREL employees receive regular performance and career development reviews.
CATEGORY: SOCIAL - HUMAN RIGHTS		
INVESTMENT		
G4-HR2	Total hours of employee training on human rights policies or 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		
G4-HR7	Percentage of security personnel trained in the organization's human rights policies or procedures that are relevant to operations	100% of security personnel are trained in NREL's human rights policies and procedures.
CATEGORY: SOCIAL - SOCIETY		
LOCAL COMMUNITIES		
G4-S01	Percentage of operations with implemented local community engagement, impact assessments, and development programs	<p>To implement executive orders and expand SNREL initiatives, campus projects integrate physical boundaries, connect to transportation and utility systems, and protect ecosystems and open space. All 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 in the community. This past year NREL:</p> <ul style="list-style-type: none"> • Provided shuttles that connected staff to RTD public transit services • Participated on the West Metro Sustainability Team (consisting of DOE-GO, NREL, GSA, City of Lakewood, and Red Rocks Community College) • Supported the Sustainable Buildings Council of Colorado • Worked closely with the Battelle Sustainability Group <p>(Cont.)</p>

KEY PERFORMANCE INDICATORS

GRI Indicator	Indicator Title	Summary of Performance for FY 2015
G4-S01	Percentage of operations with implemented local community engagement, impact assessments, and development programs	<ul style="list-style-type: none"> Partnered with the US Green Building Council Worked closely with the Jefferson County Sustainability Board Acted as a liaison to the Colorado Resiliency Working Group (stakeholders include the Federal Emergency Management Program and Colorado Recovery Office) Held three Community Open House informational meetings discussing environmental and sustainability stewardship, and community opportunities Expanded the NREL Community Portal to include local hiking and biking trails Held regular student and adult programs through the Education Center including topics on clean energy innovation, sustainability, NREL's mission, and Sustainability Campus Tours (the Education Center is open weekdays to the community) Public Affairs has a board representative on the Golden Chamber of Commerce and the Jefferson County Economic Development Corporation as well as participant engagement with the West Chamber of Commerce Held multiple VIP Tours with numerous community representatives including Jefferson County administration and commissioners
G4-S02	Operations with significant actual and potential negative impacts on local communities	NREL operations had no significant actual or potential negative impacts on local communities.
ANTI-CORRUPTION		
G4-S03	Total number and percentage of operations assessed for risks related to corruption and the significant risks identified	<p>The risk of all forms of fraud, including corruption is evaluated across the laboratory as follows:</p> <ul style="list-style-type: none"> The Enterprise Risk Management committee includes discussion of the potential for fraud, the probable impact if experienced, and the likelihood that it could occur, at least three times each year. The Enterprise Risk Management committee covers all NREL operations. NREL's Deputy Laboratory Director/chief operating officer, Alliance Secretary/NREL General Counsel, and Alliance/NREL chief financial officer brief the Alliance Finance and Audit Committee on all forms of risk during each of the Alliance Finance and Audit Committee meetings, which occur three times each year. The Finance and Audit Committee Chair, supported by the Alliance Secretary/NREL General Counsel and Alliance/NREL chief financial officer, brief the Alliance Board on all forms of risk during each of the three yearly Alliance Board meetings.
G4-S04	Communication and training on anti-corruption 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 ensure timely completion.
G4-S05	Confirmed incidents of corruption and actions taken	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 this fiscal year no reports of incidents of corruption were received, so no action was necessary.
PUBLIC POLICY		
G4-S06	Total value of political contributions by country and recipient/beneficiary	NREL had \$0 of political contributions.
ANTI-COMPETITIVE BEHAVIOR		
G4-S07	Total number of legal actions for anti-competitive behavior, anti-trust, and monopoly practices and their outcomes	<p>NREL did not experience any legal actions for anti-competitive behavior, anti-trust, or monopoly practices.</p> <p>Note: As a Federally Funded Research and Development Center, NREL has one primary business client, DOE. DOE provides comprehensive oversight of NREL operations. NREL and DOE policies maximize compliance with laws and regulations plus sound business practices.</p>
COMPLIANCE		
G4-S08	Monetary value of significant fines and total number of nonmonetary sanctions for noncompliance with laws and regulations	<p>NREL was not fined, nor did NREL experience any significant nonmonetary sanctions for non-compliance with laws and regulations.</p> <p>Note: As a Federally Funded Research and Development Center, NREL has one primary business client, DOE. DOE provides comprehensive oversight of NREL operations. NREL and DOE policies maximize compliance with laws and regulations plus sound business practices.</p>



Dan Getman and Jordan Macknick were recognized by the Geothermal Energy Association (GEA) during its National Geothermal Summit on June 3, 2015, in Reno, Nevada. GEA selects companies and individuals who have advanced technology, spurred economic development.

Awards and Honors FY 2015

In FY 2015 NREL garnered more than 25 honors and awards. The awards here celebrate a diverse group of achievements across the laboratory including researchers, scientists, staff, inventions, leadership, publishing, and process improvements. These awards from FY 2015 illuminate a brief snapshot of the brilliant dedication and continual innovation across the NREL campuses every year.

LEADERSHIP AWARDS AND HONORS

Dr. Dan E. Arvizu was honored at the [16th annual Wirth Chair Sustainability Awards Luncheon](#) in Denver for his longtime leadership at NREL. The longest-serving director and chief executive in the research organization's history, Arvizu retired after 10 years at its helm. The Wirth Chair in Sustainable Development, part of the University of Colorado Denver's School of Public Affairs, annually honors someone who has made an impact on environmental, economic and social sustainability issues. The Wirth Chair is named for Tim Wirth, who represented Colorado first in the U.S. House of Representatives and then in the U.S. Senate.

Bob Garrett, Deputy Laboratory Director for Strategic Programs and Partnerships, was recognized by the [Denver Business Journal](#) as one of the [region's top female executives in the energy industry](#). Garrett was featured in the Business Journal's second annual Women in Energy special publication and honored at an event in July 2015. The newspaper recognized the accomplishments of 40 women working across all areas of

Awards and Honors FY 2015

the energy sector. Garrett's work at NREL combines broad experience in energy research management, energy analysis, and strategic planning, along with a deep understanding of the Energy Department's renewable energy and energy efficiency programs.

Judith Gomez, a materials engineer at NREL, was selected as a **Luminary Honoree for 2015** by the **Hispanic Engineer National Achievement Awards Corporation (HENAAC) Great Minds in STEM (science, technology, engineering, and math)**. Luminary Honorees represent professionals in STEM areas that initiate, collaborate, and lead key programs and research within their organizations, and make significant contributions to the Hispanic technical community as leaders and role models.

Andrew Hudgins, with NREL's Transportation and Hydrogen Systems Center, was among the recipients of the **National Park Service's 2015 Director's Partnership Awards** for his work on DOE's Clean Cities National Parks Initiative, a partnership to reduce petroleum use and greenhouse gas emissions.

In FY 2015, NREL named **Richard DeBlasio, Sarah Kurtz** and **Suhuai Wei** to its **Research Fellows Council**, the laboratory's top advisory council, comprised of internationally recognized NREL scientists and engineers.

Three NREL hydrogen and fuel cell researchers, **Huyen Dinh, Mike Ulsh**, and **Guido Bender** were among seven outstanding mentors from NREL's **Science Undergraduate Laboratory Internships (SULI)** program in Spring 2015. The **Outstanding Mentor Award** recognizes researchers and scientists who have been exceptional mentors for interns in the DOE Office of Science's SULI program.

The **SunShot Catalyst Team** won the **2015 Grand Prize at the International Society for Professional Innovation Management (ISPIM)**. The SunShot Catalyst is an open innovation program that allows the public, through a series of prize challenges, to rapidly create and develop products and solutions that address near-term challenges in the U.S. solar marketplace.

In 2015, ESIF was nominated as one of three international finalists for the **Project Management Institute (PMI) Project of the Year Award**. According to sources at the event, it was a "close call" between ESIF and the winner, a \$1.3 billion Canadian aluminum plant that was completed ahead of schedule and showcased how to scale a new technology while improving safety standards. Although ESIF didn't take home the award this year, being a top three finalist is a huge honor, and NRELIans can be proud of the lab's accomplishment in bringing one of the most innovative new laboratories in the country from the drawing board to fruition.

SCIENCE AND RESEARCH AWARDS AND HONORS

Four NREL publications were honored with Best Conference Paper awards at an Institute of Electrical and Electronics Engineers Power & Energy Society meeting in Denver in FY 2015.

- **Sudipta Chakraborty, Andy Hoke**, and **Blake Lundstrom** were awarded in the category of Grid Operation and Management for their paper "Evaluation of Multiple Inverter VoltVAR Control Interactions with Realistic Grid Impedances."
- Also in the category of Grid Operation and Management, **Blake Lundstrom, Peter Gotseff, Julieta Giraldez**, and **Michael Coddington** won for "A HighSpeed, RealTime Visualization and State Estimation Platform for Monitoring and Control of Electric Distribution Systems: Implementation and Field Results."
- In the Power System Modeling and Simulation category, **Hongyu Wu, Ibrahim Krad, Anthony Florita, Bri-Mathias Hodge**, and **Eduardo Ibanez** won for "An Assessment of the Impact of Stochastic DayAhead SCUC on Economic and Reliability Metrics at Multiple Timescales."
- **Bryan Palmintier** and **Tim Hansen** won in the same category for "A GridLABD Communication Interface for Smart Distribution Grid Simulations."

Dan Getman and **Jordan Macknick** received **Geothermal Energy Association (GEA) honors** during GEA 2015 National Geothermal

Awards and Honors FY 2015

Summit. Getman developed, in collaboration with the DOE Geothermal Technologies Office, the Geothermal Prospector, a mapping tool that provides a data resource for visual exploration of geothermal resources. Macknick received the award for his work improving the understanding of geothermal water usage in a water-constrained region such as the West. His analysis helped improve the industry's knowledge on geothermal power's role in the future and how the industry can fit into different environments.

During the [2015 Annual Innovation and Technology Transfer Awards](#) ceremony, NREL recognized the professionals behind the lab's greatest innovations and also celebrated the 43 U.S. patents issued in FY 2014, which is the largest number in lab history-nearly three times more than the previous year. The annual event acknowledges NREL's **Distinguished Innovator Min Zhang**. During her 25 years at NREL, Zhang has worked to support the Energy Department's Bioenergy Technology Program by engineering advanced microbes to further the adoption of cellulosic biofuels. Zhang has contributed 80 peer-reviewed papers, numerous meeting abstracts, and 21 issued patents. She helped transfer foundational biotechnologies to companies with three commercial licenses incorporating her innovations, including DuPont's cellulosic ethanol facility in Nevada, Iowa, which plans to produce 30 million gallons of clean energy per year from the non-food parts of plants. In addition, NREL recognized **Rising Stars Chuck Booten and John Simon**. Rising Star awards recognize employees who have fewer than six years of service at NREL and who have demonstrated increasing engagement with the laboratory's commercialization and technology transfer process. Since coming to NREL in 2010, Booten has focused his research on heat transfer modeling and the study of home energy management system performance. He has submitted 11 Records of Invention. Simon, who joined NREL in 2011, studies novel crystalline substrates for growth of III-V Nitride semiconductors for solid-state lighting applications and the development of low-cost III-V solar cells, high-efficiency multi-junction solar cells, III-V semiconductor epitaxy, and novel semiconductor devices. He has submitted nine Records of Invention.

Brian Gregg, a lead researcher for the development of photoelectrochromic window technology, was named a Fellow of the [American Association for the Advancement of Science \(AAAS\)](#). AAAS cited Gregg for "distinguished contributions to the field of solar photoconversion, particularly for developing a unified understanding of the photoconversion mechanism in the various cell types." The photoelectrochromic window technology uses sunlight to power changes in the coloration of the windows, automatically darkening when the sunlight is strong, lightening when the interior needs more sun.

John Turner, a research fellow at NREL, was selected as the [2015 Electrochemical Society Fellow](#). The Fellow of the Electrochemical Society was established in 1989 for advanced individual technological contributions in the field of electrochemical and solid-state science and technology; and active membership and involvement in the affairs of The Electrochemical Society. Matt Dabney was awarded the [2015 Teamwork Award from the Energy Facilities Contractors Group](#) for exceptional performance.

Kara Clark was awarded the [2015 Achievement Award from the Utility Variable-Generation Integration Group](#) for leadership in improving the understanding of power system dynamics in WECC under high variable generation conditions.

Debbie Brodt-Giles shared in an international grand prize given by the [International Society for Professional Innovation Management \(ISPIM\)](#). Attendees of the ISPIM meeting in Budapest chose the Energy Department's Office of Energy Efficiency and Renewable Energy's (EERE) SunShot Catalyst program as the winner from among three finalists. SunShot Catalyst was a virtual hackathon that encouraged participants to come up with innovative approaches for the solar industry. Brodt-Giles supplied those participating in the collaboration with NREL data and tools.

Awards and Honors FY 2015

DOE AWARDS AND HONORS

Jon Weers and Debbie Brodt-Giles, with the Strategic Energy Analysis Center, were two of sixteen recipients of the [2015 Energy Innovation Award](#) at the first-ever Energy Open Data Roundtable cosponsored with DOE and the Center for Open Data Enterprise.

NREL Small Business Program Lead Rexann Dunn recently received the prestigious [Facility Management Contractor Small Business Program Manager of the Year award](#) from the DOE Office of Small and Disadvantaged Business Utilization for her outstanding work in FY 2014. Rexann was nominated for bringing NREL's involvement with small business to a level that significantly exceeded the laboratory's expectations.

[DOE's Hydrogen and Fuel Cells Program](#) presented awards for contributions to the overall efforts of the program and to recognize achievements in specific areas. This year, the Hydrogen and Fuel Cells Program honored four NREL staff for their outstanding achievements. Pin-Ching Maness received the [2015 Merit Award](#) for her outstanding achievements in biological hydrogen production. **Brian Bush, Marc Melaina, and Michael Penev** (with Amgad Elgowainy of Argonne National Laboratory) received the [2015 Team Merit Award](#) for their outstanding achievements in the development of hydrogen station techno-economic and financial tools in support of DOE's efforts and the H2USA public-private partnership.

SUSTAINABILITY AWARDS

In 2015, for the fifth year in a row, NREL was the recipient of the [GreenBuy Gold Award](#). NREL reported achieving the Leadership Goal for 11 products in 6 different categories, achieving excellence in Sustainable Acquisition.

NREL was a [2015 Federal Green Challenge Transportation](#) award winner. The EPA recognizes facilities for their outstanding efforts to advance sustainability efforts and for their leadership in reducing the environmental footprint of federal government activities.

In 2015, NREL was one of only seven workplaces in Colorado to be added to the list of [Best Workplace for Commuters \(BWC\)](#). Only employers that meet the National Standard of Excellence in commuter benefits—a standard created by the [National Center for Transit Research](#) and the EPA—are eligible for a spot on this list. This designation demonstrates NREL's commitment, not only to providing solutions to its employees, but also to reducing greenhouse gas emissions by encouraging employees to take advantage of alternative transportation options.

NREL was awarded the [2015 Three-Star EPEAT Purchaser Award](#) for excellence in green procurement of electronics. One star is awarded to an organization for each product category in which all of the eligibility requirements have been met including PCs/Displays, imaging equipment, and televisions.

In 2015, NREL joined more than 150 other employers nationwide to become a partner in [DOE's Workplace Charging Challenge](#). These employers provide workplace charging for their employees who drive PEVs. Partners receive technical support from DOE to help them establish and expand workplace charging.

Under [Xcel's Self-Direct Achievement Award](#) category of 2014, ESIF was recognized for a number of energy efficiency measures. This category is for efficiency measures developed by the organization that do not fit into standard efficiency categories like lighting, heating, and cooling. ESIF achieved an energy savings of 2,299,892 kWh in 2014, as well as a carbon dioxide reduction of 1,307 tons.



“NREL stands poised as the leader to provide strategies—and a testbed—for resiliency.”

Message From the Sustainability Program Director

When NREL produced its first Sustainability Annual Report in 2002, it merited attention, as it was one of the first in federal government. Climate change was becoming part of our vernacular but still wasn't front-page news. During the past 13 years, however, we have worked hard to broaden our efforts in response to increasing evidence about the effects of global climate change.

Topics we now talk about in terms of the technologies and processes included in NREL's mission in the renewable energy sector have been magnified by climate change impact. The majority of climate scientists are in agreement that greenhouse gas—from human intervention—is a primary driver of climate change.

Here in Colorado, scientists project it is likely that we will experience rising temperatures changes in precipitation, and increasingly severe weather events. Faced with such increased risk, the discussion is moving from “mitigation” to include the terms of “adaptation” and “resiliency.” But what's the difference—and what would be the best strategy for NREL?

According to the U.S. Global Climate Change Research Program, “adaptation” is adjustment in natural or human systems to a new or changing environment that exploits beneficial opportunities or moderates negative effects. While important in biology, where gene mutations lead to survival, it can be seen as a sort of passive approach.

A more proactive way to approach this challenge is “resiliency,” a term the Climate Change Research Program define as “a capability to anticipate, prepare for, respond to, and recover from significant multi-hazard threats with minimum damage to social well-being, the economy, and the environment.” To that, I'd add “NREL's ability to complete its mission”—a mission which is at the heart of sustainability.

The Brundtland Commission's report for the United Nations asserted sustainable development is “development that meets the needs of the present without compromising the ability of future generations to meet their own needs.”

NREL stands poised as the leader to provide strategies—and a testbed—for resiliency. We have developed a Resiliency Action Plan in 2015, which starts with a risk-based vulnerability assessment. That vulnerability assessment is the first part of a two phase project collectively called NREL's Climate Change Resiliency and Preparedness Project.

Those plans are seen as groundbreaking. And because of them, NREL took a lead for the U.S. Department of Energy, Sustainability Performance Office developing a report summarizing NREL's action plan along with three other pilot plans at national labs. The resulting "Practical Strategies for Climate Change Vulnerability Assessments" informs other DOE facilities on ways they can build their resiliency and will help all the laboratories fulfill their missions.

Leadership is natural to us. And if we as a nation are serious about curbing greenhouse gas emissions, we must move beyond the behaviors which have caused the problem—especially regarding fuel use, electricity generation, building efficiency, and travel. Our research into renewable energy and energy efficiency is a way of mitigating the effects, and providing resiliency.

Further, we are planning on more. As we ready our living laboratory here to function as a microgrid, we are increasing our abilities to withstand disaster or the predicted climate impacts. We are boosting physical cyber security to ensure systems can withstand disasters or attacks. And we are envisioning new methods and smarter systems for the grid which can integrate renewable energy at great levels of penetration, making us all more flexible.

Through it all, we will evaluate the resiliency options according to a set of criteria that make sense: effectiveness, feasibility, and cost. We are adopting practices that will move us forward—with more resiliency. And by doing so, we will be making not only NREL more resilient, but serving as a model for others across the country as they take action.

*Frank Rukavina, Sustainability Program Director
Chief Sustainability Officer*

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