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FY 2021 Site Sustainability Plan

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List of Abbreviations and Acronyms

ARIES	Advanced Research for Integrated Energy Systems
ASHRAE	American Society of Heating, Refrigerating, and Air Conditioning Engineers
BAS	building automation system
CART	Controls Advanced Research Turbine
CCF	Control Center Facility
CCHRC	Cold Climate Housing Research Center
CD	construction and demolition
CDOT	Colorado Department of Transportation
CO_2e	carbon dioxide equivalent
CHW	chilled water
DOE	United States Department of Energy
ECM	energy conservation measure
EISA	Energy Independence and Security Act
EMAPS	Energy Materials and Processing at Scale
EMIS	energy management information system
EPA	Environmental Protection Agency
EPEAT	Electronic Product Environmental Assessment Tool
ESCO	energy services company
ESH&Q	Environment, Safety, Health & Quality
ESIF	Energy Systems Integration Facility
ESPC	energy-savings performance contract
EUI	energy-use intensity
EV	electric vehicle
FEMP	Federal Energy Management Program
FTLB	Field Test Laboratory Building
FY	fiscal year (October 1 – September 30)
GFO	DOE Golden Field Office
GHG	greenhouse gas
GSA	General Services Administration
GSF	gross square foot
HEMSF	high-energy mission-specific facility
HPCDC	High-Performance Computing Data Center
HW	hot water
IBRF	Integrated Biorefinery Facility
ILA	Industrial, landscaping, and agriculture
IS2L	International Institute of Sustainable Labs
ISO	International Organization for Standardization
ITS	information technology services
kBtu	kilo British thermal units
kGal	kilo gallon
KPI	key performance indicator
kWh	kilowatt-hour
LEED	Leadership in Energy and Environmental Design
Mbtu	million British thermal units

MFD	multi-function device
MT	metric ton
MW	megawatt
MWh	megawatt-hour
M&V	measurement and verification
NOO	notice of opportunity
NREL	National Renewable Energy Laboratory
OCx	ongoing commissioning
PPA	power purchase agreement
PUE	power-usage effectiveness
PV	photovoltaic
RAIL	Research and Innovation Laboratory
RCx	retrocommissioning
REC	renewable energy credit
RFHP	Renewable Fuel Heat Plant
RSF	Research Support Facility
RTD	Regional Transportation District
SERF	Solar Energy Research Facility
SOV	single-occupancy vehicle
SPP	simple payback period
SSEB	South Site Entrance Building
STM	South Table Mountain
TRN	technical resilience navigator
TTF	Thermal Test Facility
WUI	water-use intensity
YOY	year over year

Executive Summary

The United States Department of Energy's (DOE's) National Renewable Energy Laboratory (NREL) is a recognized leader in sustainability, as evidenced by its ongoing optimization of resources in campus operations, including water, energy, waste, and purchasing, as well as continued commitment to meeting federal mandates and goals such as those listed in the table below. NREL's dedication to sustainability supports the laboratory's success by applying what is learned through research and development to campus facilities and infrastructure systems.

The Site Sustainability Plan provides a road map for all site planning and development. NREL drives the adoption of these initiatives to a global audience by conducting business operations that demonstrate the incorporation of clean energy practices. NREL will continue to develop a sustainable and resilient campus while growing greater technological capabilities to advance the national renewable energy marketplace.

DOE Goal	Current Performance Status	2-Year Performance & Plans	5-Year Performance & Plans	10-Year Performance & Plans
Energy Management				
30% energy intensity (Btu per gross square foot) reduction in goal-subject buildings by Fiscal Year (FY) 2015 from an FY 2003 baseline and 1.0% YOY thereafter	59% reduction from an FY 2003 baseline 11% decrease from FY 2019	Complete a comprehensive review of all processes supporting energy efficiency Complete the planning process for a Smart Labs program	Continue the Smart Labs program to improve laboratory energy efficiency Use metrics and dashboards to effect changes and actions within facilities	Develop advanced controls across the portfolio Offset additional new facility construction through a distributed energy configuration of new assets

DOE Goal	Current Performance Status	2-Year Performance & Plans	5-Year Performance & Plans	10-Year Performance & Plans
Energy Management, continued				
Energy Independence and Security Act (EISA) Section 432 continuous (4-year cycle) energy and water evaluations	Conducted energy and water audits at the Cafeteria (Café), Research Support Facility (RSF), Solar Energy Research Facility (SERF), and South Site Entrance Building (SSEB) Completed the third cycle of the EISA audits	Initiate the fourth cycle of the EISA audits Develop a process for evaluating savings from energy conservation measures	Continue to meet EISA S432 compliance Develop a measurement and verification (M&V) process using the Intelligent Campus platform Develop a retro-commissioning process for all facilities	Continue to meet EISA S432 compliance Transfer knowledge to other federal agencies

DOE Goal	Current Performance Status	2-Year Performance & Plans	5-Year Performance & Plans	10-Year Performance & Plans
Energy Management, continued				
Meter all individual buildings for electricity, natural gas, steam, and water, where cost effective and appropriate	91% of relevant buildings have electricity meters, all of which are advanced meters 75% of relevant buildings have chilled water (CHW) meters, all of which are advanced meters 75% of relevant buildings have hot water (HW) meters, all of which are advanced meters 94% of relevant buildings have natural gas meters 94% of relevant buildings have potable water meters; 28% of relevant buildings have advanced potable water meters NREL does not use steam for heating	Install digital water meters in all South Table Mountain (STM) Campus facilities Install central plant metering and develop power-usage effectiveness (PUE) measures for heating and cooling	Install natural gas metering to collect real-time data Expand metering to include environmental measures such as air quality and occupancy Update the metering management process	Implement the data library for advanced metering and controls Update hardware for aging facilities

DOE Goal	Current Performance Status	2-Year Performance & Plans	5-Year Performance & Plans	10-Year Performance & Plans
Water Management				
20% potable water intensity (gal per gross square foot) reduction by FY 2015 from an FY 2007 baseline and 0.5% year over year (YOY) thereafter	17% reduction from an FY 2007 baseline 19% reduction from FY 2019	Increased water consumption as the High-Performance Computing Data Center (HPCDC) expands will make meeting water savings goals difficult Complete a water balance analysis for the STM site Continue water conservation measures, irrigation improvements, and real-time metering	Explore opportunities for water reuse with changing state and local regulations	As part of upgrading the on-site waste treatment system at Flatirons Campus, NREL plans to build a pipeline to access raw water from a municipal source that would enhance the campus water system
Nonpotable freshwater consumption (gal) reduction of industrial, landscaping, and agricultural (ILA). YOY reduction; no set target.	NREL does not use industrial, landscaping, and agricultural water	N/A	N/A	N/A

DOE Goal	Current Performance Status	2-Year Performance & Plans	5-Year Performance & Plans	10-Year Performance & Plans
Waste Management				
Reduce at least 50% of nonhazardous solid waste, excluding construction and demolition debris, sent to treatment and disposal facilities	45% of waste diverted from the landfill	Investigate modifying Café permit agreement with the state of Colorado to include more compostable materials and eliminating plastics and polystyrene products Continue to explore including cameras or other technology in waste management recycling and refuse to reduce overall costs Investigate procurement activities to reduce waste earlier in the supply chain	Explore expansion of pilot programs in laboratory-specific recycling, such as nitrile gloves Develop pilot program to recycle hard-to-recycle high-use materials	Continue to take steps toward achieving a near-zero-waste campus to reach a 90% diversion rate by developing service standards, modifying contracts, and conducting awareness campaigns Explore feasibility of reducing plastic waste by implementing a program for plastic-eating bacteria by working with NREL researchers

DOE Goal	Current Performance Status	2-Year Performance & Plans	5-Year Performance & Plans	10-Year Performance & Plans
Waste Management, continued				
Reduce construction and demolition materials and debris sent to treatment and disposal facilities. YOY reduction; no set target.	96% of construction and demolition waste diverted No change in percentage of construction and demolition waste sent to landfill from FY 2019; however, actual metric tonnage of landfill waste and recycle waste increased dramatically (by a factor of nearly 21 for landfill and 20 for recycle) due to new business practices to improve data accuracy	Add a polystyrene recycling container to the construction and demolition waste program at Flatirons Campus Continue to collect data on the new construction and demolition centralized waste collection program at the STM and Flatirons campuses to assess outcomes	Continue to monitor outcomes of the new construction and demolition program, and update and improve as needed	Continue to monitor outcomes of the new construction and demolition program, and update and improve as needed

DOE Goal	Current Performance Status	2-Year Performance & Plans	5-Year Performance & Plans	10-Year Performance & Plans
Fleet Management				
20% reduction in annual petroleum consumption by FY 2015 relative to an FY 2005 baseline and 2.0% YOY thereafter		Complete testing with electric and plug-in hybrid shuttle options to support the conversion to zero-emissions vehicles from diesel shuttle buses Expand use of telematics and establish individualized vehicle usage targets	Expand electric vehicle options within the fleet	Develop a road map to a zero-emissions fleet
10% increase in annual alternative fuel consumption by FY 2015 relative to an FY 2005 baseline; maintain 10% increase thereafter		Continue to increase alternative fuel vehicles (AFVs) in the fleet Pursue replacement of Office of Security and Emergency Preparedness vehicles with hybrid-electric SUVs	Continue to increase AFVs in the fleet Explore hydrogen vehicle pilot projects in collaboration with NREL hydrogen researchers	Develop a road map to a zero-emissions fleet

DOE Goal	Current Performance Status	2-Year Performance & Plans	5-Year Performance & Plans	10-Year Performance & Plans
Fleet Management, continued				
75% of light-duty vehicle acquisitions must consist of alternative fuel vehicles (AFVs).		Continue to acquire General Services Administration (GSA)-leased replacement vehicles with AFVs, if available and as required	Continue to acquire GSA-leased replacement vehicles with AFVs, if available and as required	Continue to acquire GSA-leased replacement vehicles with AFVs, if available and as required
Clean and Renewable Energy				
"Renewable Electric Energy" requires that renewable electric energy account for not less than 7.5% of a total agency electric consumption by FY 2013 and each year thereafter	On-site clean electricity consumed at NREL accounted for approximately 17% of total electricity consumption On-site clean electricity (including renewable energy credits [RECs] and bonuses) accounted for approximately 40% of total electricity consumption	Upgrade electrical service at Flatirons Campus to reduce curtailment of the on-site wind turbines Install owner metering at new Flatirons substation to measure campus consumption and renewable generation Continue to purchase RECs to replace those sold from on-site renewable energy projects	Continue to pursue diverse renewable energy options, including electricity and thermal, where financially feasible	Continue to pursue diverse renewable energy options, including electricity and thermal, where financially feasible

DOE Goal	Current Performance Status	2-Year Performance & Plans	5-Year Performance & Plans	10-Year Performance & Plans
Clean and Renewable Energy, continued				
Continue to increase nonelectric thermal usage. YOY increase; no set target but an indicator in the Office of Management and Budget scorecard.	32% of energy is nonelectric thermal usage	Continue to optimize the Renewable Fuel Heat Plant operations	Continue to pursue diverse renewable energy options, including electricity and thermal, where financially feasible	Continue to pursue diverse renewable energy options, including electricity and thermal, where financially feasible
Green Buildings				
At least 15% (by count) of owned existing buildings to be compliant with the revised Guiding Principles for Sustainable Buildings by FY 2021, with annual progress thereafter	57% of GSF of facilities meet the Guiding Principles	Evaluate nine facilities for their compliance with the 2016 Guiding Principles, and determine the possibility and current estimated costs of bringing these facilities into compliance	For future facilities in the near and long term, NREL will continue to build facilities that meet Guiding Principles and will meet or exceed design standards at 30% more energy efficient than the baseline ANSI/ASHRAE/IESNA Standard 90.1 standard	For future facilities in the near and long term, NREL will continue to build facilities that meet Guiding Principles and will meet or exceed design standards at 30% more energy efficient than the baseline ANSI/ASHRAE/IESNA Standard 90.1 standard

DOE Goal	Current Performance Status	2-Year Performance & Plans	5-Year Performance & Plans	10-Year Performance & Plans
Acquisition and Procurement				
Promote sustainable acquisition and procurement to the maximum extent practicable, ensuring BioPreferred and biobased provisions and clauses are included in all applicable contracts	100% of contracts contain sustainability provisions Continue to implement Oracle cloud-based e-Procurement system, including beta testing the paperless system	Continue planned enhancements to Acquisition Services' systems and processes to improve sustainable purchasing Review of purchasing requirements, tracking, and reporting on sam.gov Establish new Policies, Programs & Compliance team in Acquisition Services to manage sustainable acquisitions	Build internal capacity to effect change in sustainable acquisition throughout the laboratory	Develop capacity to analyze supply chain and material choices to impact overall campus operations

DOE Goal	Current Performance Status	2-Year Performance & Plans	5-Year Performance & Plans	10-Year Performance & Plans
Measures, Funding, and Training				
Site set annual targets for sustainability investment with appropriated funds and/or financed contracts for implementation	Explored the use of economically feasible options to improve energy performance Assisted GFO in releasing a notice of opportunity (NOO) to engage an energy services company (ESCO) and award energy-savings performance contracts (ESPCs) for STM and Flatirons campuses	Continue to support the award of an ESPC to an ESCO to implement energy efficient measures on NREL campuses Explore the use of economically feasible options to improve energy performance	Investigate and implement an ESPC involving microgrids and resilience	Explore the use of economically feasible options to improve energy performance, including ESPCs and other alternative financing mechanisms
Electronic Stewardship				
End of Life: 100% of used electronics are reused or recycled using environmentally sound disposition options each year	100% of electronics are reused or recycled	Expand reutilization program and revamp how computers are purchased and provided to employees	Continue to recycle electronics at their end of life Evaluate policy changes for electronics reuse and recycling	Continue to recycle electronics at their end of life

DOE Goal	Current Performance Status	2-Year Performance & Plans	5-Year Performance & Plans	10-Year Performance & Plans
Electronic Stewardship, continued				
Data Center Efficiency: Establish a power usage effectiveness (PUE) target for new and existing data centers; discuss efforts to meet targets	RSF data center PUE of 1.20 Energy System Integration Facility HPCDC PUE of 1.03	Continue to pursue an average PUE below 1.20 in the RSF Data Center. Continue to pursue an average PUE below 1.05 in the HPCDC	With the required removal of the thermosyphon in future HPCDC expansions, explore opportunities for water savings	Continue to improve efficiency for the data centers as financially feasible

DOE Goal	Current Performance Status	2-Year Performance & Plans	5-Year Performance & Plans	10-Year Performance & Plans
Organizational Resilience				
Discuss overall integration of climate resilience in emergency response, workforce, and operations procedures and protocols	Conducted microgrid feasibility discussions within NREL research community	Identify funding and conduct microgrid feasibility demo at South Security Entrance Building Extend continuous monitoring to assess organizational assets, identify risks, and deploy security controls against cyber threats	Integrate ongoing resilience assessment in existing planning practices Implement an autonomous energy grid pilot with existing buildings and assets Reevaluate battery and thermal storage potential for operational cost savings and resilience Review the feasibility of a microgrid to improve resilience of data centers Build a robust/proactive incident detection and response program	Potential procurement of large-scale storage to improve the resilience of the main RSF data center

DOE Goal	Current Performance Status	2-Year Performance & Plans	5-Year Performance & Plans	10-Year Performance & Plans
Multiple Categories				
YOY scope 1 & 2 greenhouse gas (GHG) emissions reduction from an FY 2008 baseline	43.8% reduction from FY 2019 to FY 2020 27.5% reduction from an FY 2008 baseline *Scope 1 reductions do not include emissions from fleet*	Continue to explore opportunities to increase on-site renewable energy	Continue to explore opportunities to increase on-site renewable energy	Continue to explore opportunities to increase on-site renewable energy
YOY scope 3 GHG emissions reduction from an FY 2008 baseline.	21.1% reduction from FY 2019 to FY 2020 29.4% reduction from an FY 2008 baseline	Explore opportunities for space management to provide flexible options for staff Continue to promote teleworking and teleconferencing	Explore opportunities for space management to provide flexible options for staff Continue to promote teleworking and teleconferencing	Explore opportunities for space management to provide flexible options for staff Continue to promote teleworking and teleconferencing

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1 Mission Change

Research Strategy

Global energy use is expected to increase almost 30% in the next 20 years. While largely driven by population growth and increasing global living standards, this dramatic increase is taking place in the context of broader, interconnected trends, including urbanization, electrification, increasing digitization of our infrastructure (with associated cyberthreats), resource competition, and economic development. The National Renewable Energy Laboratory's (NREL's) vision is to provide foundational innovations that enable the nation to lead developments of next-generation renewable energy technologies, as well as developments of secure, resilient, and autonomous energy systems of the future. Over its history, NREL has been a global leader in this mission: to advance the science and engineering of energy efficiency, sustainable transportation, and renewable power technologies, and to provide the knowledge to integrate and optimize energy systems.

Within the U.S. Department of Energy (DOE) Office of Energy Efficiency and Renewable Energy (EERE) mission space and commensurate with its current priorities, NREL is focusing research efforts on three key research areas to realize its vision:

- Integrated Energy Pathways
- Electrons to Molecules
- Circular Economy for Energy Materials.

These "critical objectives" reflect the overarching themes that emphasize the focused initiatives of NREL's research portfolio over the next decade. In pursuing transformational innovations in these areas, NREL will contribute to the scientific and technical foundations, data analytics/tools, and scientific computing innovations needed to transform energy systems around the globe.

Consistent with NREL's research strategy, Alliance for Sustainable Energy® (Alliance®) has a comprehensive campus strategy that identifies key investments in facilities, infrastructure, and equipment that align with the three critical objectives in its 10-year vision. Of note is the Advanced Research on Integrated Energy Systems (ARIES) research platform, which will bring together capabilities at the Energy Systems Integration Facility (ESIF), the Flatirons Campus, and a new virtual emulation environment to address systems integration challenges. NREL has proposed the construction of the Energy Materials and Processing at Scale (EMAPS) Facility, which will foster a multidisciplinary research capability in process integration. In the nearer term, the construction of the new Research and Innovation Laboratory (RAIL) will provide critical wet laboratories for chemical, biological, and materials synthesis. Finally, the proposed establishment of the Global Clean Energy Center for the Rockies and NREL's third-party financed partnering facility will serve as a nucleus for partnerships and a clean energy ecosystem.

Site Sustainability

Site Sustainability is integral to the success of NREL's research strategy and is a major consideration during all stages of its planning and operations. NREL has been a world leader in

cost-effective, efficient, and sustainable operations for decades. Deploying advanced energy systems, where appropriate, on campus is a key strategy for advancing the lab's mission.

Current efforts by Alliance include expansion of campuswide energy analytics platform capabilities to collect performance data from available sensors and meters to manage on-site energy systems. The goal is to optimize energy performance and efficiency while improving resilience through advanced analytics and deployment of interactive dashboards. Future expansion for the platform will investigate enhancing communication and enacting information sharing across other systems, such as asset management, to inform decision-making activities.

Alliance continues to show leadership in sustainable electronic stewardship. IT Purchasing continues to win the Five-Star Electronic Product Environmental Assessment Tool (EPEAT) Purchaser Award for exceptional commitment in sustainable IT equipment purchasing with plans to continue to expand these practices to a growing list of EPEAT devices. Additionally, Alliance continues to lead sustainable computing with its world-renowned High-Performance Computing Data Center (HPCDC) that continues to achieve an average of 1.05 or below in power usage effectiveness (PUE), despite continued growth in computing capability. The Research Support Facility (RSF) Data Center continues to focus on optimization and implementation of best practices in sustainable data center management to reduce total energy while expanding computing capability for the laboratory.

Alliance manages a fleet of 50 vehicles at NREL, 78% of which are alternative fuel vehicles (AFVs; 70% E-85, 4% hybrids and 4% electric). The few petroleum vehicles that remain all perform unique functions for which there are currently no alternative fuel replacements available through the General Services Administration (GSA). However, Alliance is using its vehicle telematics system to improve its fleet vehicle management practices to reduce petroleum consumption. The laboratory is also implementing vehicle demonstration projects to test the viability of using hydrogen, all-electric, and hybrid electric vehicles in anticipation of more robust GSA alternative vehicle options.

Alliance's resilience action plan for NREL identifies actions to reduce operational risks through addressing site vulnerabilities associated with natural hazards. NREL staff will continue to investigate the implementation of select initiatives in FY 2021 with the goal of deployment within the next three years. Projects include the integration of battery storage, the development of advanced and secure controls, and the investigation of alternative fuels for diversified renewable generation.

COVID-19 Impacts

COVID-19 has introduced considerable uncertainties into planning and could potentially impact future implementation of plans in ways yet to be determined. NREL's response to the pandemic has prompted the NREL Leadership Team to begin to consider different, more efficient, and more effective ways to structure the NREL workplace in the future. Because this plan is under development during the pandemic, much of the office space, potential changes to infrastructure, and operational changes do not yet reflect what NREL has learned over the course of the outbreak.

Preparations to have personnel return to work on-site will extend into FY 2021 as the NREL Leadership Team continues to evaluate appropriate phases and timing. The Leadership Team is evaluating the percentage of people who need work at the lab to be more productive based on their job functions. The drivers for this policy, which is being developed by a cross-laboratory team, include accounting for what NREL has learned about remote working due to COVID-19 and establishing a more flexible, efficient, and effective workplace. NREL management is also rethinking space planning assumptions and considering how to enable laboratory growth and create work environments that foster better collaboration through thoughtful design of spaces on campus. Due to restrictions placed on travel, there has also been a steady increase in the use of virtual conferences, and this is a trend that is expected to continue into FY 2021.

COVID-19 also made it difficult to meet energy goals in FY 2020, resulting in operational repercussions that are expected to persist throughout FY 2021. While campus plug and process load electricity consumption fell significantly at the onset of the pandemic because of reduced staff on-site, the reduction was offset by safety-oriented ventilation changes that incurred an energy penalty. Overall photovoltaic (PV) energy production was also reduced due to the shutdown of the PV system located at the RSF Parking Lot, affecting NREL's ability to meet renewable energy goals and maintain the RSF at net zero.

2 Energy Management

Performance Status

Energy Usage and Intensity

Figure 1 shows NREL's annual energy-use intensity (EUI) history beginning in 2003. In FY 2019 NREL was close to, but did not meet, the EUI target. In FY 2019, the EUI increase was driven primarily by increased occupancy and research activities. In FY 2020, NREL recalculated the square footage of all South Table Mountain (STM) Campus and Flatirons Campus facilities. As a result, calculated EUI for goal-subject buildings decreased by 11% to 105 kBtu/GSF, which again meets the EUI goal. This reduction in EUI was driven primarily by an increase in goal-subject GSF in FY 2020 following the recalculation of facility area. (NREL continues to audit facilities for errors in calculated square footage and will adjust the goal-subject GSF again in FY 2021.) However, total energy also decreased slightly from 129,684 Mbtu in FY 2019 to 126,848 Mbtu in FY 2020, and corresponding greenhouse gas (GHG) emissions from facility energy consumption decreased by approximately 11%.

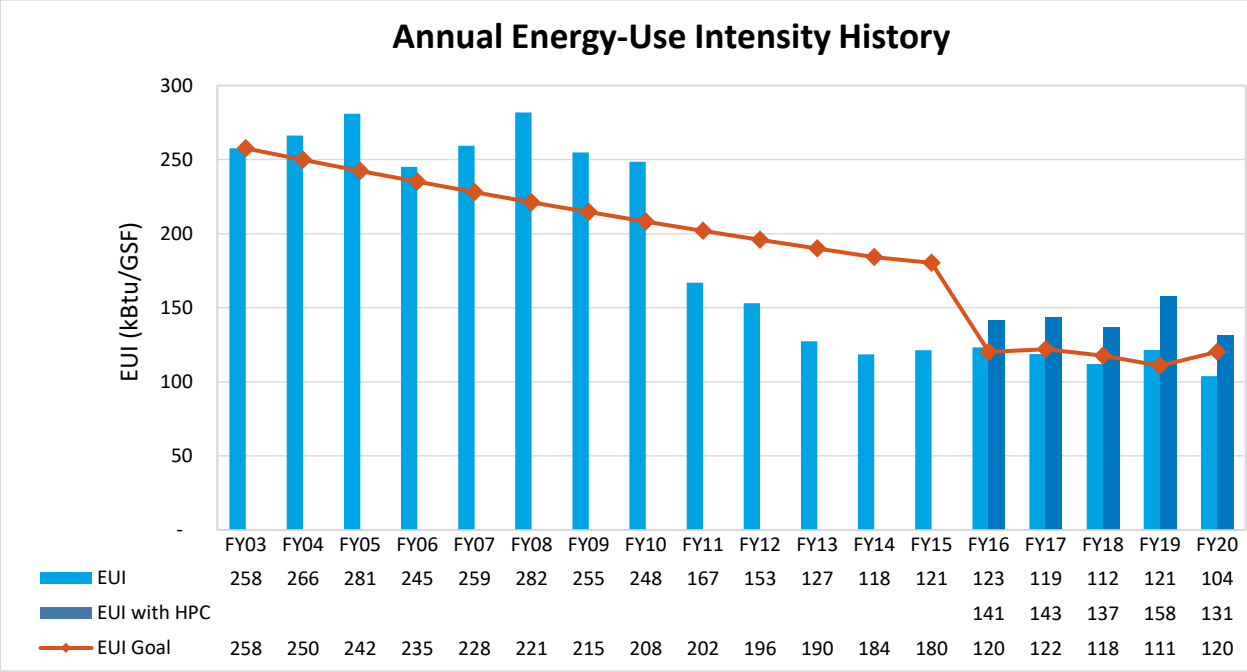


Figure 1. Annual EUI for NREL starting in the baseline fiscal year of 2003

EUI includes only goal-subject facilities; it excludes the HPCDC, partially and fully leased facilities, several small facilities that use no energy, and energy used to charge personal electric vehicles. EUI with HPCDC energy is also reported for reference.

The COVID-19 pandemic had several large but somewhat contradictory impacts on EUI. Initially, campus electricity consumption fell significantly as most NREL staff transitioned to working remotely. This reduction was due to a combination of reduced plug load energy and reduced laboratory activity. To enhance airflow within facilities and promote better air

circulation, operation of the ventilation units on campus was modified to mitigate potential COVID-19 virus transmission. Per American Society of Heating, Refrigerating, and Air Conditioning Engineers (ASHRAE) guidance for infectious aerosols, NREL overrode occupied/unoccupied schedules to 24/7, maximized outside air for all air handling units where possible, and shut down operations where air-to-air heat exchanger flywheels are used. These safety-oriented ventilation system changes imposed a significant energy penalty that largely offset the plug and process load reduction. NREL expects the COVID-19-related operation changes and the associated energy penalty to persist throughout FY 2021. Some facilities also saw a reduction in required cooling and an increase in required heating due to reduced occupancy; however, these effects were minor compared to the ventilation changes.

During the first quarter of FY 2020, NREL continued to implement the space optimization strategy begun in FY 2019. However, given the transition to remote work during the pandemic, further space optimization activities are currently on hold. NREL is committed to fully utilizing available office space prior to requesting resources to build new office facilities. Increasing occupancy density in existing buildings also typically increases EUI.

NREL continued to participate in the Better Buildings Smart Labs Accelerator, which ended in FY 2020. As a result of the accelerator, NREL has identified multiple potential monitoring and process improvements that may reduce laboratory energy consumption in the future. However, NREL also identified technical and process barriers that inhibit adoption of recommended Smart Labs practices; for example, the Smart Labs recommendations include using ventilation setbacks based on occupancy, but NREL's laboratories do not currently have adequate occupancy sensors. NREL continues to pursue process and laboratory equipment improvements that will enable adoption of the Smart Labs recommendations in the future.

In FY 2020, NREL celebrated the 10th anniversary of the construction of the RSF, NREL's flagship zero-energy facility. NREL remains committed to operating the RSF as a zero-energy facility and achieved Leadership in Energy and Environmental Design (LEED) Zero certification in FY 2020. NREL's Communications Office produced a video to highlight how the RSF influenced the national growth of zero-energy facilities.

EISA Section 432 Benchmarking and Evaluations

In FY 2020, NREL continued to use a subcontractor to conduct required Energy Independence and Security Act (EISA) energy and water audits. NREL audited four buildings in FY 2020, all on the STM Campus, including the Cafeteria (Café), RSF, Solar Energy Research Facility (SERF), and South Site Entrance Building (SSEB). Due to the COVID-19 pandemic, the audits were delayed relative to the normal cycle; walk-throughs were completed in the summer and audit reports finalized in the early fall.

NREL has one energy-savings performance contract (ESPC) with the Renewable Fuel Heat Plant (RFHP) project. An annual measurement and verification (M&V) report detailing performance is submitted to NREL by the energy services company (ESCO) that holds the ESPC. During the 2019–2020 heating season of Year 12 (2019–2020) per the ESCO performance contract, the RFHP performance continued to perform effectively despite having higher weather-related, Ameresco, and NREL shutdown days compared to last year. For Year 11, the warm shutdown days were 28, Ameresco shutdown days were 18, and NREL shutdown days were 0. For Year

12, the warm shutdown days were 70, Ameresco shutdown days were 16, and NREL shutdown days were 5. As a result, the RFHP delivered 21,180 Mbtu of heating energy in the FY 2020 heating season, an 8% reduction from the previous fiscal year.

All eligible facilities are benchmarked monthly in the ENERGY STAR® Portfolio Manager program for energy and water consumption.

Facility Metering

NREL uses meter data to benchmark facilities, energy, and water balances; analyze building energy and water use anomalies; identify maintenance issues; monitor demand response; perform cost allocation for ESIF; and project energy needs for utility budgeting and any new facilities. Most major NREL facilities have full metering of all energy consumption and renewable energy production; however, some of the meters used are utility-owned and not directly accessible for use by the NREL energy management information system (EMIS).

NREL recently conducted an audit of all known metering (including owner meters and utility-owned meters) for electricity, natural gas, heating water (HW), chilled water (CHW), and potable water consumption. The audit revealed that some smaller facilities did not have building-level meters. In addition, NREL identified issues with HW and CHW consumption in those facilities. As a result of this audit, NREL has revised the meter coverage percentages in the Executive Summary table.

NREL continues to expand metering infrastructure on both campuses. In FY 2020, NREL completed design for new electrical metering to monitor the STM Campus central plant and new pulse readers to provide local, real-time data from utility-owned renewable energy production meters. However, installation for these new systems was delayed in response to the COVID-19 pandemic. NREL is also investigating options to expand CHW and HW metering, provide real-time metering of natural gas consumption, and provide real-time metering of potable water consumption. For cases where only a utility-owned meter is available, NREL is investigating options to add a separate owner meter or obtain a real-time feed from the utility-owned meter.

NREL continues to develop new visualization, benchmarking, and fault-detection capabilities within its EMIS software, SkySpark. In FY 2020, NREL improved calculation methods for key performance indicators (KPIs) for all facilities and piloted a new building wellness report that provides facility managers with an accurate summary of each building's energy performance. NREL also improved its design guidelines to clearly specify metering requirements for future facilities. Finally, NREL's Intelligent Campus program is developing predictive machine-learning algorithms that analyze building energy consumption and flag deviations from expected energy consumption. This system will provide facility managers with early warning of energy-wasting faults or other large changes in energy consumption.

Nonfleet Vehicles and Equipment

In FY 2020, NREL used nonfleet vehicles and equipment that use gasoline, diesel, liquified petroleum gas, and electricity as fuel sources.

NREL utility vehicles and motor equipment were affected by COVID-19. Some equipment experienced lower usage than anticipated due to fewer staff being on campus. Other equipment

experienced higher usage due to NREL fleet vehicles being restricted to one person per vehicle and/or utility vehicles serving as an alternative transport option around campus. NREL continued to explore the replacement of petroleum fuel nonfleet vehicles with electric and other zero-emissions options.

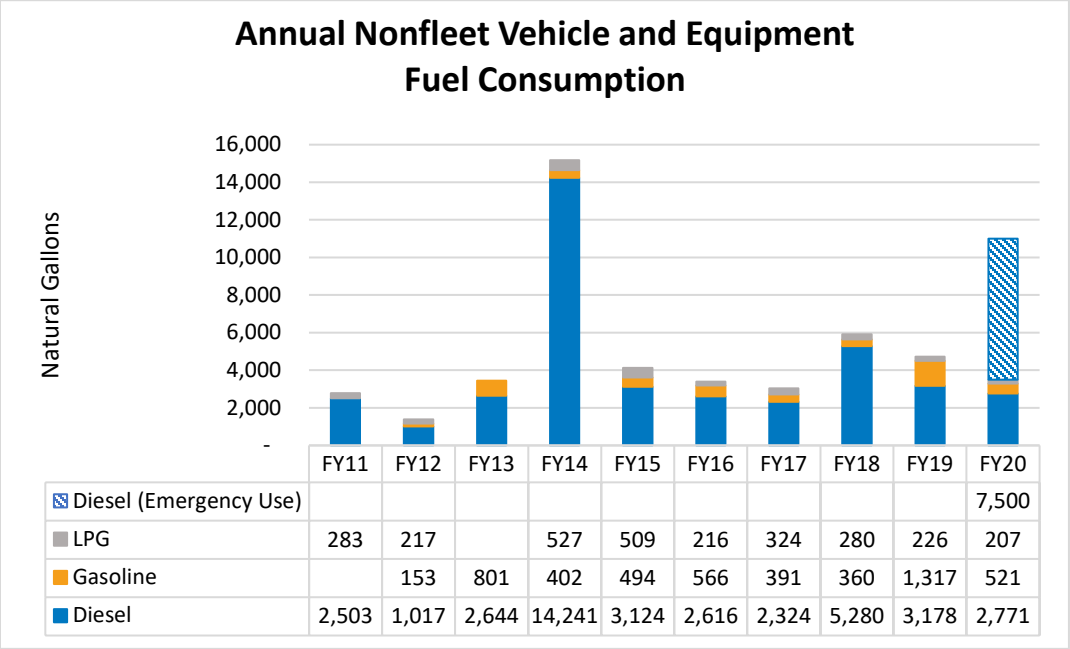


Figure 2. Annual nonfleet vehicle and equipment fuel consumption broken out by fuel type

On September 8, 2020, a substation failure at the Flatirons Campus caused a site-wide total electrical power outage. For nearly three weeks, emergency backup generators supplied electrical power to the site, resulting in an increase of approximately 7,500 gallons in diesel fuel consumed on-site.

In FY 2020, research fuel consumed by experimental vehicles tested at the ReFUEL facility was accounted for in the nonfleet vehicle and equipment fuel consumption. This data has not previously been captured or reported.

Overall, NREL increased nonfleet vehicle and equipment fuel consumption in FY 2020. Associated GHG emissions increased by approximately 145%. The increase is due to the diesel fuel consumed at the Flatirons Campus during the power outage in September 2020 and inclusion of the research fuel in the fiscal year reporting. Excluding the diesel generator and research fuel, the total diesel and gasoline consumption decreased by approximately 50%, and the associated GHG emissions decreased by approximately 29% from FY 2019.

Plans and Projected Performance

Energy Usage and Intensity

NREL anticipates continued staff and mission growth in FY 2021 and into the future. Growth in campus energy consumption may be partially mitigated by a long-term shift to remote work,

which is a possible outcome of the COVID-19 pandemic. However, laboratory research cannot be conducted remotely, and most anticipated load growth is driven by anticipated research needs.

Figure 3 and Figure 4 display historical and projected energy use on NREL's STM and Flatirons campuses categorized by facility (HEMSF, HPCDC, or other) and by fuel type, respectively. The projections assume the following:

- Energy use in existing facilities increases modestly (2% per year) due to population and mission growth
- Five new laboratory facilities are added:
    - In FY 2022, two new facilities totaling approximately 20,000 GSF
    - In FY 2025, two new facilities totaling approximately 219,000 GSF
    - In FY 2026, one new facility totaling approximately 85,000 GSF
- EUI for new laboratory facilities is based on existing laboratory buildings with similar mission profiles and ranges from 140 kBtu/GSF to 430 kBtu/GSF depending on the facility
- HPCDC computing capacity increases in future years according to anticipated upgrades, ultimately to a maximum of 8 MW peak usable capacity. HPCDC peak load varies by year according to anticipated upgrade. The load factor is 0.7. Use projections are higher in upgrade years because old and new systems are anticipated to run in parallel during the transition periods.

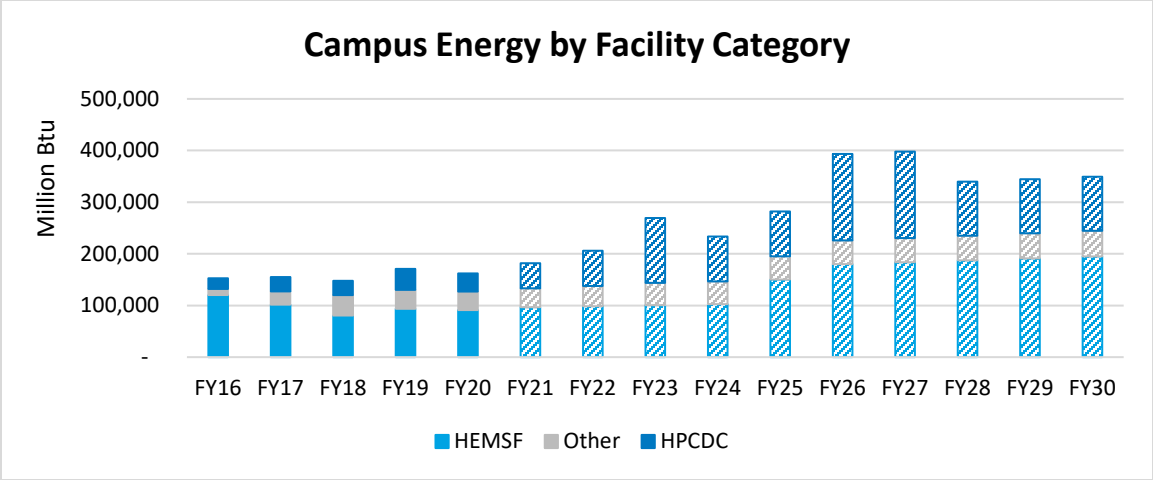


Figure 3. Annual energy use by facility category with projections to FY 2030

Includes only grid electricity and natural gas; self-consumed on-site clean energy is excluded.

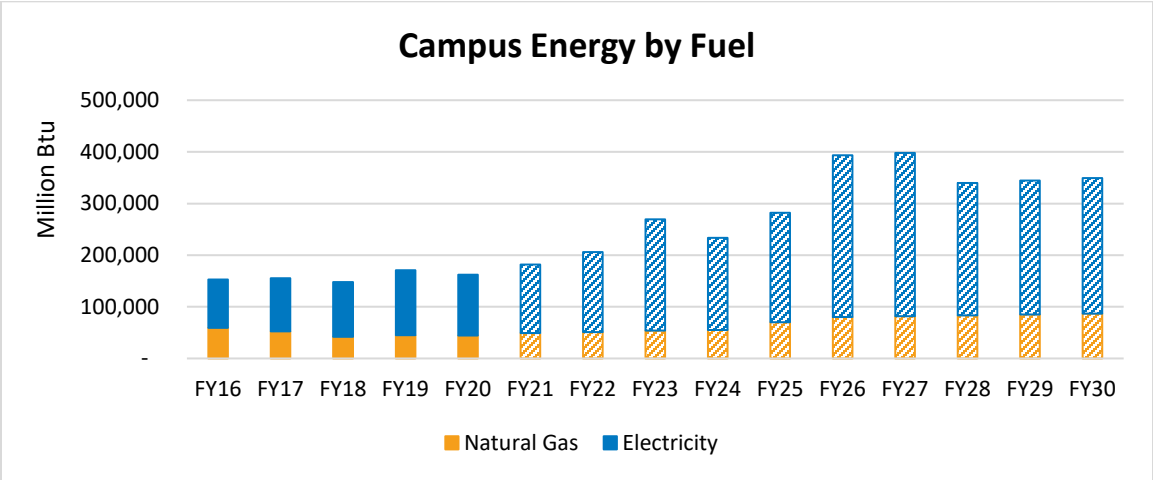


Figure 4. Annual energy use by fuel with projections to FY 2030

NREL's high-energy, mission-specific facilities (including the HPCDC) continue to drive overall energy consumption (Figure 5). The HPCDC alone is projected to consume more than 50% of campus energy by FY 2025.

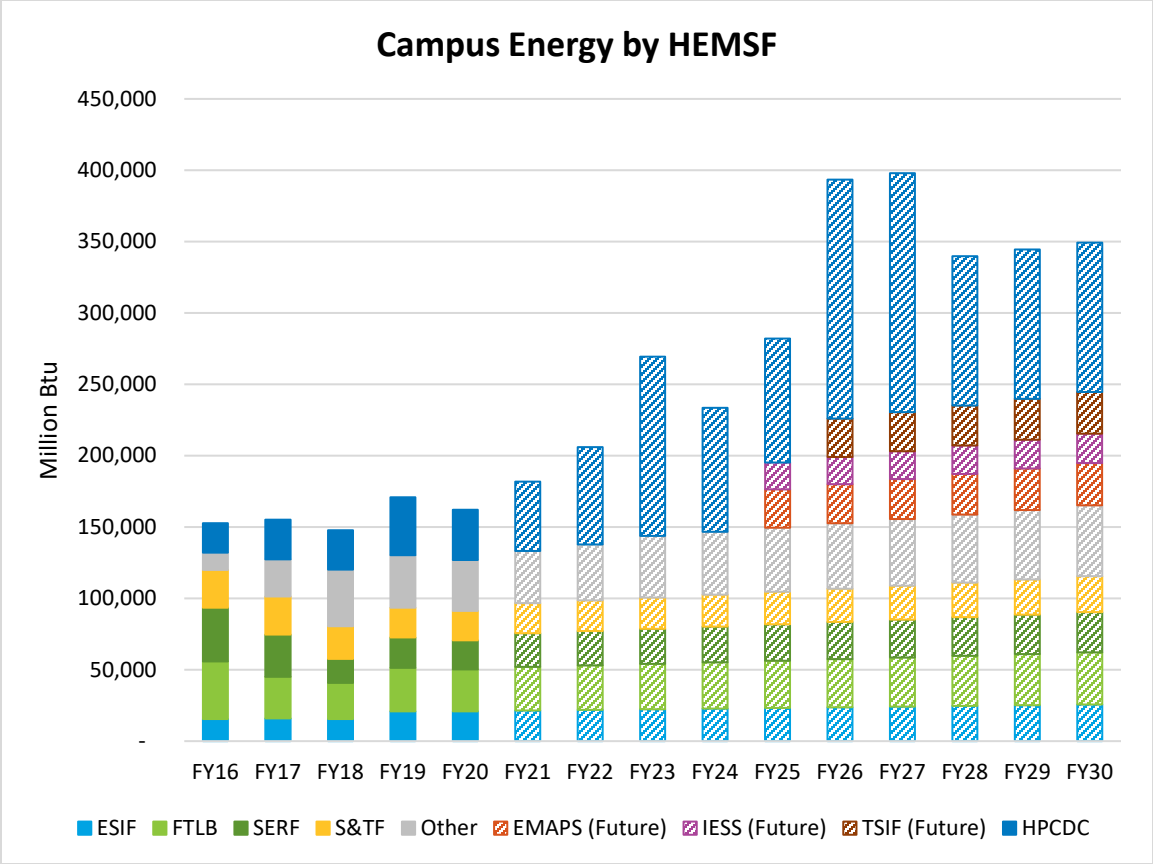
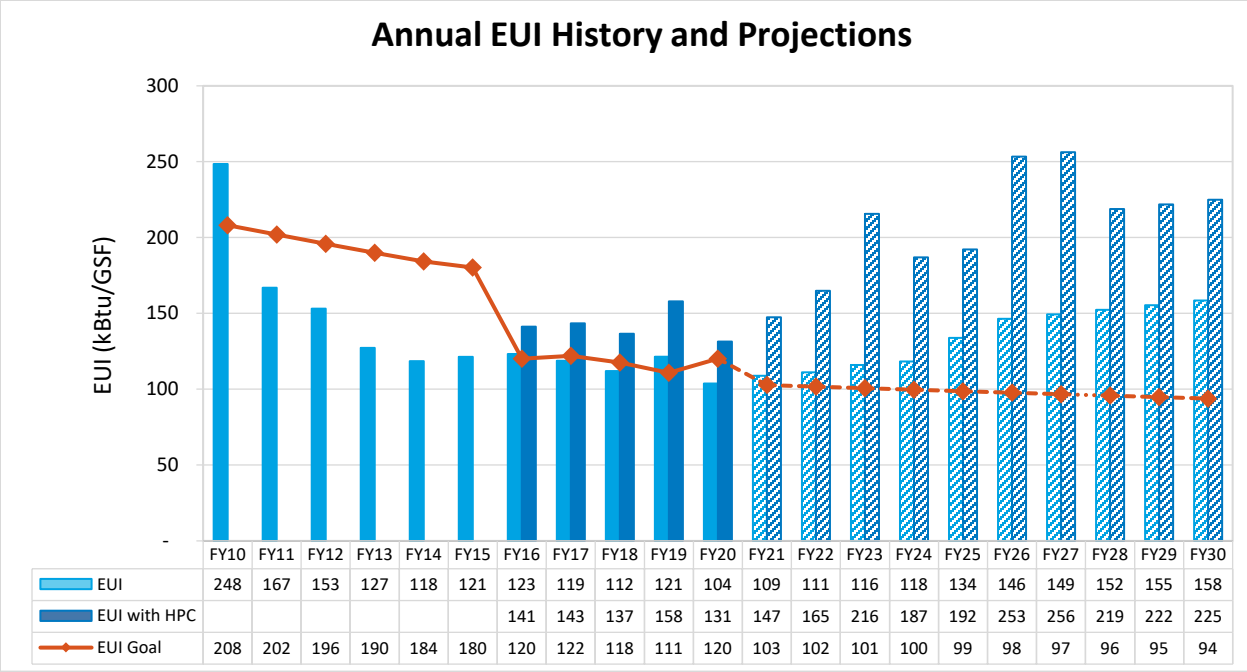


Figure 5. Annual energy use by high-energy mission-specific facility (HEMSF) with projections to FY 2030

Includes only grid electricity and natural gas; self-consumed on-site clean energy is excluded.



	FY10	FY11	FY12	FY13	FY14	FY15	FY16	FY17	FY18	FY19	FY20	FY21	FY22	FY23	FY24	FY25	FY26	FY27	FY28	FY29	FY30
EUI	248	167	153	127	118	121	123	119	112	121	104	109	111	116	118	134	146	149	152	155	158
EUI with HPC							141	143	137	158	131	147	165	216	187	192	253	256	219	222	225
EUI Goal	208	202	196	190	184	180	120	122	118	111	120	103	102	101	100	99	98	97	96	95	94

Figure 6. Annual EUI with history from FY 2010 and projections to FY 2030

EUI includes only goal-subject facilities; it excludes the HPCDC, partially and fully leased facilities, several small facilities that use no energy, and energy used to charge personal electric vehicles. EUI with HPCDC energy is also projected separately to demonstrate the large, expected increase in computing energy consumption over time.

Figure 6 displays historical and projected EUI for goal-subject buildings at NREL's STM and Flatirons campuses. Future EUI increases are driven primarily by the anticipated construction of new laboratory facilities, which consume significantly more energy than office facilities. Future year EUI goals are based on a compounding 1% YOY reduction starting from FY 2020; NREL does not anticipate being able to meet this reduction goal. NREL does not have plans for large-scale renovations, installation of new renewable energy systems, or other efficiency upgrades that will significantly impact the EUI trajectory, although NREL is investigating possible ESPCs to address outstanding energy conservation measures (ECMs) and future facility energy needs. NREL will also seek to include on-site renewable energy generation with any new facilities when it is cost-effective to do so.

NREL continues to leverage energy analytics to identify energy efficiency opportunities and promote energy-saving actions by building occupants. The following activities are planned for FY 2021 and FY 2022:

- Implement low-cost and no-cost ECMs identified in the FY 2020 EISA audit cycle
- Complete and deploy an updated Zero Energy Dashboard for the RSF
- Complete and deploy predictive analytics dashboards for facility energy consumption, enabling facility managers and occupants to better track and improve energy performance
- Integrate space information from NREL's Workspace system with NREL's EMIS, improving analytics capability

- Update NREL's master construction specification for building automation systems (BASs) to improve system integration and energy performance in future construction projects
- Assess laboratories and complete planning for a Smart Labs program (delayed from FY 2020 due to limited staff availability amid the COVID-19 pandemic)
- Upgrade campus networking infrastructure for the BAS
- Continue to maximize use of existing office and laboratory space to manage growth.

In the long term, NREL will continue to expand as a campus. NREL is investigating new options for high-efficiency district energy systems to support future facilities as part of the STM Campus east campus expansion. NREL will implement the Smart Labs recommendations in the design and construction of future laboratory facilities.

EISA Section 432 Benchmarking and Evaluations

In FY 2021, NREL will begin its fourth cycle of EISA audits. Audits are planned for the following facilities:

- ESIF
- Field Test Laboratory Building (FTLB)
- Integrated Biorefinery Research Facility (IBRF)
- Thermal Test Facility (TTF)
- Central Plant
- STM Campus irrigation systems.

NREL will continue benchmarking all facilities in Portfolio Manager and will be linking laboratory facilities to the Laboratory Benchmarking Tool to better assess laboratory performance.

Over the next 5 years, NREL plans to develop a process to address ECMs in all facilities more thoroughly. This will include addressing retrocommissioning (RCx) and ongoing commissioning (OCx) in feasible facilities, as well as measurement and verification (M&V) using the Intelligent Campus platform. (Limitations in the existing control system preclude effective RCx and OCx for some facilities.) Within 10 years, NREL plans to share this expertise with other federal agencies to expand resources for EISA audit resources.

Facility Metering

In FY 2020, NREL created an initial inventory of campus meters. In FY 2021, NREL will complete the meter inventory and perform quality assessment of its CHW and HW meters. NREL will incorporate meters into its master asset list and plans to develop an ongoing maintenance plan for all meter types, including electric, thermal, and water meters.

In FY 2021, NREL will continue to add systems to the EMIS, beginning with building automation points for remaining facilities (which are primarily small facilities). Future priorities for integration include new thermal meters, potable water meters, and natural gas pulse meters. NREL is developing an improved change management process for the BAS and meter points.

Meter installation projects planned for FY 2021 include central plant electrical metering for calculating accurate plant efficiency and new pulse readers for utility-owned PV generation meters at NREL's STM and Flatirons campuses. Design for these systems was completed in FY 2020, but funding and installation were delayed to FY 2021.

In FY 2021, NREL intends to implement a large metering project for water management. This project will include the purchase of water submeters to monitor large water consumers, including cooling systems, reverse osmosis, the HPCDC, and other water-intensive operations across the STM Campus.

Nonfleet Vehicles and Equipment

The STM Campus expects to see an increase in diesel use in FY 2021 due to five new diesel utility terrain vehicles added to the site in FY 2020.

At the end of FY 2020, 34 of the 38 utility vehicles on the NREL campus had telematic devices installed. These devices are primarily used to track vehicle usage and location. NREL plans to install these devices on the remaining utility vehicles as well as all drivable motor equipment, including forklifts and lifts that are on campus. Tracking this data will provide real-time usage data on the equipment and help reduce the reporting burden on equipment custodians.

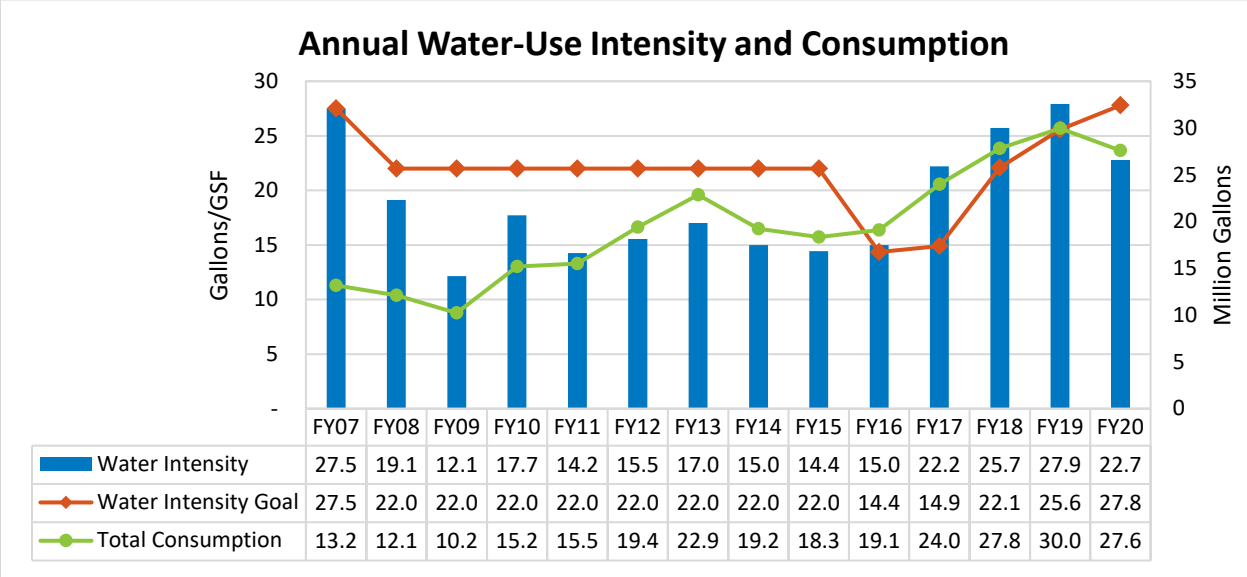
NREL will continue to explore the replacement of petroleum fuel nonfleet vehicles with electric and other zero-emissions options.

3 Water Management

Performance Status

Water Usage and Management

NREL purchases potable water from Consolidated Mutual Water Company. Cost varies by building and throughout the year; in FY 2020 it averaged $6.11/kGal. The major water end uses are cooling towers, laboratory equipment, irrigation, and the HPCDC. Due to COVID-19, NREL leadership limited access to campus facilities to essential staff for research and operations. Because of this limited site use, NREL did not conduct a water balance assessment in FY 2020; however, it plans to accomplish this in FY 2021. NREL has a water management plan that is updated on a regular basis.



	FY07	FY08	FY09	FY10	FY11	FY12	FY13	FY14	FY15	FY16	FY17	FY18	FY19	FY20
Water Intensity	27.5	19.1	12.1	17.7	14.2	15.5	17.0	15.0	14.4	15.0	22.2	25.7	27.9	22.7
Water Intensity Goal	27.5	22.0	22.0	22.0	22.0	22.0	22.0	22.0	22.0	14.4	14.9	22.1	25.6	27.8
Total Consumption	13.2	12.1	10.2	15.2	15.5	19.4	22.9	19.2	18.3	19.1	24.0	27.8	30.0	27.6

Figure 7. Total NREL water-use intensity (WUI) for the STM and Flatirons campuses

Figure 7 shows NREL's water-use intensity (WUI) and water consumption history. In recent years, the goal has been to achieve a 0.5% year-over-year (YOY) reduction in WUI, with each year's goal based on the previous year. NREL was not able to meet the WUI targets in FY 2017–2019; as a result, its WUI target increased to 27.8 gal/GSF by FY 2020. In FY 2020, NREL recalculated the square footage of all STM and Flatirons Campus facilities. As a result, calculated WUI decreased to 22.7 gal/GSF, which meets the FY 2020 target. This reduction in WUI was driven by an increase in facility GSF in FY 2020 following the recalculation of facility area in addition to a reduction in water consumption. (NREL continues to audit facilities for errors in calculated square footage and will adjust the GSF again in FY 2021.)

Limited by Colorado water law, NREL has been able to identify ways to reduce water consumption. Reverse-osmosis reject water used in creating deionized water is reused in a cooling tower for multiple NREL buildings. The thermosyphon installed at the HPCDC in FY 2016 continued to show significant reductions in the potential water consumption for the

HPCDC, while maintaining a highly efficient average power usage effectiveness (PUE). For future expansion of the HPCDC computing capability, additional cooling towers are necessary and will be added. Unfortunately, these cooling towers must occupy the area in which the present thermosyphon system is located. Upon installation of these cooling towers, the thermosyphon will be removed, which will cause water consumption to increase at least 50%.

NREL can view real-time hourly data for all the main water meters on the STM Campus through Consolidated Mutual Water Company's EyeOnWater program. NREL uses this data for benchmarking, leak detection, and identification of potential water savings in campus facilities.

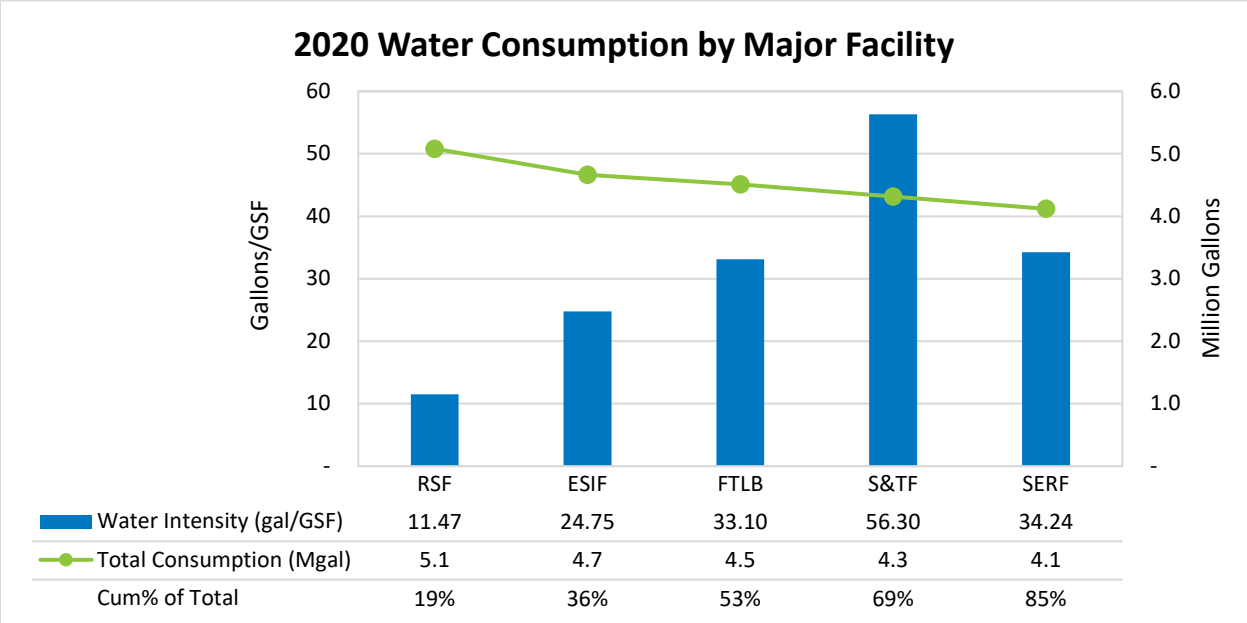


Figure 8. WUI and total water consumption for the facilities that account for 85% of NREL's total water consumption

As shown in Figure 8, NREL's facilities that accounted for 85% of total potable water consumption in FY 2020 are (in descending order of consumption):

1. **The Research Support Facility**, which uses water for irrigation, domestic uses (such as showers and toilets), and evaporative cooling (the use of which increased significantly due to COVID-related ventilation changes)
2. **The Energy Systems Integration Facility**, which houses the HPCDC and is water-cooled
3. **The Field Test Laboratory Building**, which is a wet laboratory facility and houses one-half of the STM Campus' central plant
4. **The Science and Technology Facility (S&TF)**, which is a wet laboratory facility and uses a significant amount of water in its cleanroom operations
5. **The Solar Energy Research Facility**, which is a wet laboratory facility and houses the second half of the STM Campus' central plant.

NREL also completed the installation of landscape improvements adjacent to the SERF and S&TF that will need potable water for the next three growing seasons to establish the vegetation community.

Plans and Projected Performance

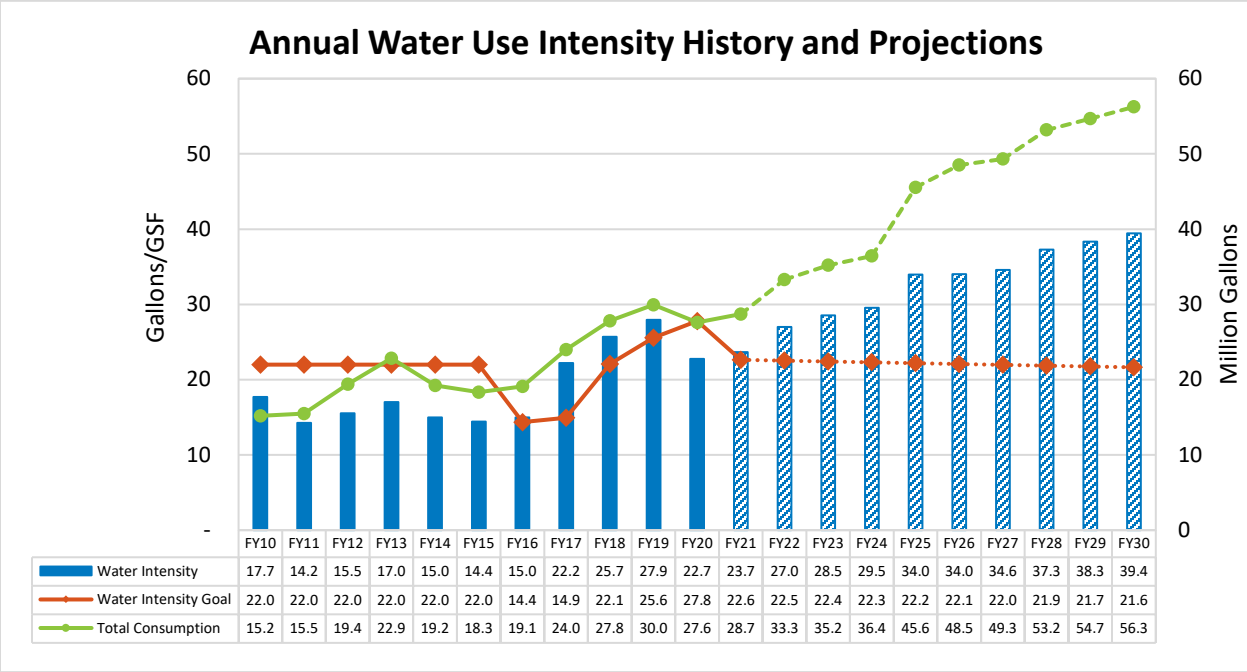
Water Usage and Management

To better understand the water consumption across the main STM Campus, NREL will perform a water balance assessment in FY 2021. The assessment will account for total water consumption for an entire year for all facilities. All available water data and information will be used to identify the main uses of water collectively across the STM Campus and within each facility. Areas of concern, possible leaks, possibilities for future water savings measures, and facilities where additional information is needed will also be identified. The water-balance assessment will also help NREL better understand the impact of the growing population and the possible addition of new facilities for the STM and Flatirons campuses.

Figure 9 displays historical and projected WUI for water-using buildings at NREL's STM and Flatirons campuses. The WUI projections assume the following:

- Water use in existing facilities increases at 4% per year due to population and mission growth
- Five new laboratory facilities are added:
    - In FY 2022, two new facilities totaling approximately 20,000 GSF
    - In FY 2025, two new facilities totaling approximately 108,000 GSF
    - In FY 2026, one new facility totaling approximately 85,000 GSF
- Baseline WUI for all new laboratory facilities is 35 gal/GSF; this usage is consistent with NREL's existing wet laboratory facilities.
- For facilities constructed in FY 2025 and later, water savings projects and/or grey-water reuse strategies are implemented to reduce facility water consumption 20% in the first year of operation, increasing to 40% reduction in each subsequent year of operation.
- HPCDC computing capacity increases in future years according to anticipated upgrades, ultimately to a maximum of 8 MW peak usable capacity. HPCDC peak load varies by year according to anticipated upgrade. The load factor is 0.7. Use projections are higher in upgrade years because old and new systems are anticipated to run in parallel during the transition periods.
- Beginning in FY 2022, HPC water use increases due to anticipated replacement of the thermosiphon system with conventional cooling towers. (As described below, this modification is needed to achieve adequate cooling within the available roof area.)

Out-year WUI goals follow a 0.5% YOY reduction progression starting from FY 2020.



	FY10	FY11	FY12	FY13	FY14	FY15	FY16	FY17	FY18	FY19	FY20	FY21	FY22	FY23	FY24	FY25	FY26	FY27	FY28	FY29	FY30
Water Intensity	17.7	14.2	15.5	17.0	15.0	14.4	15.0	22.2	25.7	27.9	22.7	23.7	27.0	28.5	29.5	34.0	34.0	34.6	37.3	38.3	39.4
Water Intensity Goal	22.0	22.0	22.0	22.0	22.0	22.0	14.4	14.9	22.1	25.6	27.8	22.6	22.5	22.4	22.3	22.2	22.1	22.0	21.9	21.7	21.6
Total Consumption	15.2	15.5	19.4	22.9	19.2	18.3	19.1	24.0	27.8	30.0	27.6	28.7	33.3	35.2	36.4	45.6	48.5	49.3	53.2	54.7	56.3

Figure 9. Total WUI for the STM and Flatirons campuses, including projections through FY 2030

The installation of real-time water meters at the STM Campus, continuing into FY 2021, will greatly improve access to water information. NREL is pursuing the acquisition of interval data and leak detection analytics for the STM Campus water meters. Using these meters, the expanded meter access from EyeOnWater, and the new Flatirons Campus water meters, NREL will review the laboratory water-metering strategy and water management plan. Additional buildings on the STM and Flatirons campuses will increase water consumption for NREL beginning around FY 2022.

In FY 2021, NREL will continue to develop its MS4 permit program for sustainable stormwater management. A training component addressing MS4-related concepts will be developed for all staff that have the potential to impact stormwater quality. This includes staff such as maintenance, some researchers, project managers, and subcontractors.

NREL does not anticipate being able to meet current water savings goals in future fiscal years. A large majority of this comes from increased water consumption as the HPCDC expands. In the next expansion, due to increased needs for cooling tower space, NREL anticipates the thermosyphon will need to be removed. This will significantly increase water consumption and is estimated in NREL's projected water consumption. NREL will discuss strategies to mitigate foreseen increases. Continued water conservation measures, irrigation improvements, water-balance analysis, and real-time metering will support efforts to identify water-savings opportunities.

Since its opening in the late 1970's, NREL's Flatirons Campus has never been served by municipal domestic water, fire water, or sanitary sewer services. Over the past four decades, the campus has used a mixture of well water, delivered and stored water, and on-site wastewater

treatment systems to meet the water utility needs of the NREL staff and research activities located on the campus. Over the past few years, the research mission of the Flatirons Campus has expanded to include multiple renewable energy technologies and energy systems integration. This additional research requires NREL to increase the number of research and operations staff located on the campus and expand the number, size, and type of facilities on-site. To provide code-compliant water systems for this expanded mission, and to address a vulnerability in NREL's resilience vulnerability assessment, the domestic water, fire suppression water, and wastewater systems on the Flatirons Campus must be expanded significantly.

The Flatirons Campus Water System project will provide and expand the domestic, fire suppression water, and wastewater facilities needed to support the planned growth of the research capabilities and a substantial increase in the number of NREL staff located at the Flatirons Campus. The scope of the project will be to design and construct a raw water line between the Flatirons Campus and Smart Reservoir, a domestic water treatment system, new fire suppression and domestic water tanks, code-required fire suppression system upgrades, and a new on-site wastewater treatment system. The project's budget is $12.4 million, and it is slated for completion in FY 2023.

4 Waste Management

Performance Status

Waste Management Strategies

In FY 2020, NREL continued its construction and demolition (CD) waste program. All new construction subcontracts were required to dispose of waste using centralized containers provided at the South Table Mountain (STM) Campus and Flatiron Campus. Most of the construction-generated wastes were expected to be captured at the centralized areas. The centralized NREL-provided waste containers were monitored and measured by Site Operations at the campus level. This effort looks to nearly eliminate the need for project-based waste reporting and will greatly improve the accuracy of CD waste diversion. For projects with waste streams too large to be handled centrally, CD waste tracking logs will still be used on a project-by-project basis. To better meet waste and recycling needs, NREL reallocated waste and recycling bins across the STM and Flatirons campuses.

In FY 2020, the NREL CD waste program recycled approximately 24,960 lbs in comingled items, 96,050 lbs in wood, and 2,201 lbs in polystyrene, as compared to 51,000 lbs generated in wood refuse and 80,740 lbs generated in comingled CD refuse. An additional approximately 3,304,373 lbs of CD waste (comprised mostly of asphalt and concrete) were diverted from landfill through construction subcontractors' off-site recycling efforts.

In FY 2020, NREL recycled approximately 33,960 lbs in shredded paper, 71,120 lbs in comingled items, and 99,174 lbs in composting material, as compared to 339,620 lbs generated in refuse. Additionally, employees recycled approximately 63,420 lbs in comingled recycling. In FY 2020, NREL also continued to recycle hard-to-recycle items, including approximately 141 lbs. in aerosol cans, 9,621 lbs in batteries, and a combined 2,687 lbs in fluorescent and mercury-containing lamps and light ballasts.

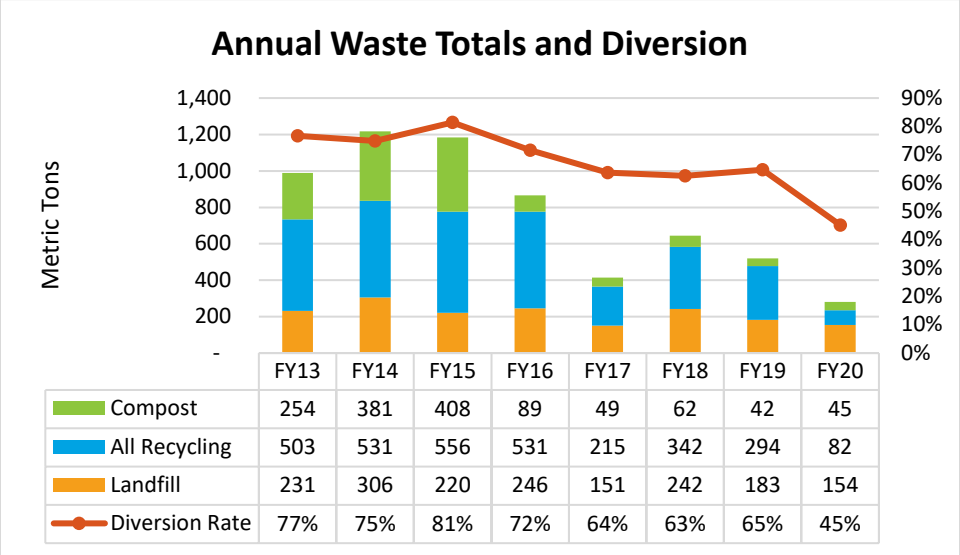
NREL continued its program of monitoring the wood recycling bin at the STM and Flatirons campuses in FY 2020. This allowed NREL to notify subcontractors in advance of dumping more wood if the bin was contaminated, saving time and money, and reducing the amount of wood materials sent to landfill. The wood recycling bin was contaminated seven times in FY 2020, leading to landfill disposal of container contents instead of recycling contents properly.

In FY 2020, NREL recompeted the recycling and refuse subcontract and ultimately awarded the subcontract to Waste Management. Waste Management used Smart Truck Technology, a proprietary technology designed to improve customer service. The Smart Truck can validate service to every customer by using GPS mapping and dedicated cameras to photograph or video every bin serviced, informing monthly reports to NREL. Using this technology, Waste Management can continually analyze container dumps and weights to right-size campus service and frequency.

NREL purchased new compost, recycle, and refuse containers for the Café in FY 2020. The Café recycled approximately 36 gallons of cooking oil in FY 2020. This quantity was considerably

less than in previous years due to closure of the Café during the coronavirus (COVID-19) outbreak.

COVID-19 greatly impacted NREL's waste management program in FY 2020. When the pandemic hit in March 2020, NREL's Leadership Team decided on a phased approach for employees to return to campuses. Because of this, NREL made some operational adjustments and scaled back waste management and refuse collection services at the STM and Flatirons campuses. NREL was not able to meet many performance goals due to the impact of COVID-19 and lack of budget. Goals not met in FY 2020 will be assigned to FY 2021 with hopes for a speedy resolution to the pandemic and the return of employees to campuses.



	FY13	FY14	FY15	FY16	FY17	FY18	FY19	FY20
Compost	254	381	408	89	49	62	42	45
All Recycling	503	531	556	531	215	342	294	82
Landfill	231	306	220	246	151	242	183	154
Diversion Rate	77%	75%	81%	72%	64%	63%	65%	45%

Figure 10. Annual waste totals broken out by disposition type

Landscape Management

In FY 2020, NREL continued its comprehensive landscape management program, including developing an annual noxious weed control plan that identifies target species and reduces the application of herbicides to the same area each year. Due to the success of past weed control management efforts, most broadcast treatments have been replaced by spot spraying.

Herbicides are reviewed for human and wildlife toxicity prior to use. Herbicides are acquired in the amount necessary for each application to eliminate the need for on-site storage and disposal of expired product. Site facilities are assessed semiannually, and vegetation removal and control strategies are developed to reduce wildland fire potential. Winter weed control efforts incorporate a half-strength concentration of herbicide in select areas to minimize impacts to desired vegetation and reduce potential chemical loading in soils.

Pest Management

NREL strives to provide an effective, efficient, and humane approach to pest control. The approach consists of the following (in order of preference):

- Engineering controls (design or retrofit facilities to minimize pests)
- Administrative controls (keep the area clean and food removed or in sealed containers)
- Relocation
- Mechanical extermination (no glue traps allowed)
- Poisoning.

The selection of the method of control varies depending on several factors, including building, location, time of year, degree of infestation, cost, and species. Pesticides are reviewed for human and wildlife toxicity prior to use.

In FY 2020, NREL's efforts to control pigeons included trapping and deploying various deterrents, such as screening, decoys, and predator calls.

Plans and Projected Performance

Waste Management Strategies

In FY 2021, NREL will add a polystyrene recycling container to the CD waste program at the Flatirons Campus. This will allow NREL to not only capture polystyrene waste in a centralized area but also measure and monitor it. In subsequent fiscal years, any updates to the program to improve diversion rate and accuracy will be ongoing.

In FY 2021, NREL plans to create and install better signage for the recycle stations at the STM and Flatirons campuses, making it clearer for employees and visitors to sort recyclables. In the Café, a redesign of the existing space is under consideration. The redesign may include a new waste station in addition to updated signage to educate employees and visitors and enhance awareness of proper recycling. The proposed design will also create better flow of traffic around waste and recycling containers and reduce bottlenecking, encouraging employees and visitors to properly manage waste and ensure effective recycling of eligible goods. Additionally, NREL will consider modifying the Café permit agreement with the state of Colorado to include more compostable service materials, reducing or eliminating plastics and polystyrene products where possible. The goal is to reduce overall plastic consumption and to strive to produce as little landfill waste as possible at the Café.

In FY 2021, NREL will consider adding cameras to wood recycling containers at the STM and Flatirons campuses. The addition of cameras will reduce costs by decreasing landfill haul amounts, detect for contamination and divert less trash to the landfill, reduce carbon footprint from hauling activities, assist with gathering more accurate weight measurements, and monitor bin fullness for bin servicing with 99% accuracy.

In the near term, NREL intends to develop a pilot program with Terra-Cycle to recycle hard-to-recycle materials sitewide to divert more waste from the landfills. As part of the pilot effort, NREL will choose a couple of hard-to-recycle items and provide targeted recycle stations across the laboratory for collection.

In the midterm, NREL intends to establish an expanded recycling program within the laboratories at the STM and Flatirons campuses. The goal is to implement a program like the Kimberly-Clark Nitrile Glove Recycling Program to promote laboratory sustainability and divert

less lab-specific waste to the landfills. To ensure success of such a program, it will be essential to work with facility managers, research operations managers, and research operations directors to make recycling accessible and to make it convenient for personnel to recycle properly. Through this effort, NREL will consider recycling miscellaneous lab items such as conical tubes, centrifuge and microcentrifuge tubes, and pipet tips to divert more waste from the landfills.

NREL will continue to work at achieving near-zero waste on its campuses, with a targeted goal of a 90% waste diversion rate in 10 years. NREL's solid waste plan will be successful in meeting this goal through the development of service standards, contract adoption, and deployment of waste management awareness campaigns. NREL will need employees, customers, visitors, and subcontractors alike to opt in to recycling properly and diverting more waste from the landfills.

Building on the success of NREL research efforts, in the 5- to 10-year time frame, NREL operations staff plan to partner with NREL researchers to develop a program for plastic-eating bacteria to help create more environmentally friendly recycling processes. The concept involves the breakdown of plastic into smaller, soluble chemical units, which then could be harvested and recycled to form new plastics in a closed-loop system. NREL researchers are currently seeking new ways to commodify plastic waste, using an integrative approach involving synthetic biology, polymer chemistry, and chemical engineering.

Landscape Management

Efforts in FY 2021 and beyond will be a continuation of FY 2020 activities and may include a reintroduction of biological controls such as insects, mites, and fungi to manage landscape pests.

Pest Management

Efforts in FY 2021 and beyond will be a continuation of FY 2020 activities.

5 Fleet Management

Performance Status

Fleet Management Strategies

NREL slowly continues to increase alternative fuel consumption for fleet vehicles and reduce petroleum consumption. Continuing to replace fleet vehicles with alternatively fueled vehicles, when available, will further reduce petroleum consumption.

NREL campus and fleet operations were impacted by COVID-19 in FY 2020 and will continue to be impacted until campus returns to normal operating conditions. In March 2020, NREL established a requirement that all fleet vehicles be restricted to one person per vehicle unless social distancing 6 feet minimum) could be maintained within the vehicle. This restriction led to an increase in demand for vehicles in some groups due to carpooling not being permitted. Fleet Management has been working with vehicle custodians and groups to identify vehicles that are not being used as frequently due to COVID-19 and to identify opportunities to share vehicles with groups that have immediate needs.

In FY 2020 NREL hired a Campus Mobility Specialist to support and coordinate with NREL fleet management for more efficient and comprehensive movement of people and vehicles on the campuses.

NREL held a Fleet Custodian and Operator Training in FY 2020. This biannual and new-hire training provides an overview of the current fleet policies, operator responsibilities for driving and maintaining fleet vehicles, a summary of what type of data is collected by the telematic devices, as well as information for what to do in case of a spill or accident to ensure greater consistency in practical application of fleet requirements.

In FY 2020, NREL used the telematic device data from the installations in FY 2019 to begin to optimize the fleet using real-time digital data. NREL primarily uses the telematic devices for required monthly reporting of miles and days of use, number of trips, and driver tracking. The on-demand data provided by the telematic devices have helped to improve the efficiency of fleet management data collection activities. The real-time locations make the vehicles quick and easy to locate on campus. The utilization information is used to identify opportunities for vehicles to be shared amongst groups to increase the per-vehicle utilization.

The telematic devices are also used to track safety measures, including seat belt use, speeding, and aggressive driving information, and to track idling information so Fleet Management can better work with vehicle groups to reduce idling and optimize fleet usage.

Several fleet demonstration projects continued in FY 2020. The demonstrations included the Zenith battery electric shuttle bus equipped with the Momentum Dynamics wireless charging system, a VIA Motors hybrid cargo van with bidirectional charging capabilities, and an electric autonomous shuttle. These demonstration projects are collaborations between NREL research programs and Site Operations staff who support research objectives, as well as opportunities to test fleet capabilities with zero-emissions vehicles and reduce overall petroleum consumption.

NREL finalized the procurement of an autonomous shuttle vehicle for a demonstration project that began operations at the end of FY 2019. The battery electric autonomous shuttle vehicle owned and operated by NREL's shuttle services subcontractor was used for NREL's STM Circulator (on-campus) shuttle route. Due to COVID-19 and NREL campus restrictions to maintain social distancing, this vehicle was taken out of service in March 2020 and returned to the shuttle services subcontractor in May 2020. NREL plans to continue to look for opportunities to bring an autonomous shuttle vehicle back to campus once the campus returns to normal operating conditions.

NREL continues to expand its electric vehicle (EV) charging infrastructure to meet the needs of its growing EV fleet. In September 2020, NREL added an off-grid solar-powered EV charging station at its RSF to support fleet EV charging. In addition, NREL worked with its workplace charging vendor to add a new option to charge fleet EVs at NREL's 123 workplace charging stations. This provides additional EV charging capabilities for fleet vehicles at both the STM and Flatirons campuses.

Plans and Projected Performance

Fleet Management Strategies

In FY 2021 and beyond, NREL plans to continue its electric and zero-emissions vehicle demonstrations when research opportunities arise. In addition, NREL plans to replace some of its existing petroleum-based fleet vehicles with EVs where possible. NREL will continue to pursue incorporating a hybrid electric SUV into the fleet of the Office of Security and Emergency Preparedness.

As part of a collaboration between DOE and Hyundai, in FY 2021, Hyundai will provide NREL with a Hyundai NEXO fuel cell vehicle to use for a campus demonstration project as well as outreach. The vehicle will primarily be used by NREL's security team to provide real-world operational data on hydrogen and fuel cell applications and help guide future DOE research and development.

NREL also plans to expand its use of telematics to streamline fleet reporting and provide better-quality data in the future. In FY 2021, NREL plans to create goals for vehicles/groups to improve operator safety, reduce idling, and improve utilization with vehicle telematics data. In the longer term, NREL will develop a comprehensive campus mobility program to better integrate disparate activities involving sustainable and zero-emissions fleet vehicles and mobility options.

NREL vehicles that use petroleum fuel will be replaced with AFVs when appropriate to increase alternative-fuel consumption and reduce petroleum-fuel consumption. All GSA-leased replacement vehicles acquired will be AFVs, if available. The total cost to replace the vehicles is unknown, considering that there are not many electric or other zero-emission options presently available through GSA. However, NREL does not anticipate costs to exceed planned funds.

6 Renewable Energy

Performance Status

Renewable Energy Strategies

NREL had no new renewable installations in FY 2020. Solar PV production in existing systems improved by approximately 5% to 6,226 MWh, due primarily to repairs on power purchase agreement (PPA) systems that experienced production issues in FY 2019. NREL's PPA systems continued to experience some issues in FY 2020, including several months of outage at the large Mesa Top 1-axis tracking system due to inverter failures. In addition, in April 2020, NREL disabled PV production for a DOE-owned system (the STM Campus Visitor Parking Structure) to prevent inadvertent export of electricity at the STM Campus main utility meter.[1] With most NREL staff working remotely because of COVID-19, the disablement of the system was necessary to eliminate the possibility of PV generation exceeding load capacity for short periods of time due to reduced campus loads. This was necessary since exporting energy beyond the campus meter is not permitted under our current interconnection agreement with Xcel Energy. NREL is investigating controls upgrades that would allow dynamic curtailment of PV systems to prevent electricity export rather than wholesale curtailment of entire PV systems. NREL continues to monitor PPA system performance to identify production issues quickly and work with PPA vendors to resolve them promptly.

Wind production reported as renewable generation includes the DOE-owned General Electric (GE) turbine and Controls Advanced Research Turbine (CART) turbines at the Flatirons Campus, for which NREL retains the renewable energy credits (RECs). (NREL does not retain the RECs for wind production from the Siemens and Gamesa turbines because of their ownership structure and research agreements.) Wind production from the GE and CART turbines increased to 689 MWh in FY 2020, approximately double the production in FY 2019. Wind production from these turbines fluctuates from year to year based on research requirements.

In July 2020, the Flatirons Campus electrical service upgrade to a transmission interconnection was completed. As a result, the 10-MW limit on simultaneous connected generation capacity at the Flatirons Campus has been increased to 19.9 MW. Because the GE and CART turbines will no longer be subject to curtailment under the connected generation capacity limit, their use and associated production in future years is anticipated to increase.

Other sources of renewable energy include an ongoing annual 355-MWh clean power purchase (REC purchase) and ongoing operation of the RFHP (see Section 2, Energy Management). In addition to the 355-MWh clean power purchase, NREL also continued to purchase replacement RECs to reclaim environmental attributes that were associated with RECs sold from on-site solar

[1] Export of electricity generated at the STM Campus is prohibited under NREL's utility rate agreement. Inadvertent export would require NREL to disable all energy storage systems connected to the grid at the STM Campus, which would adversely affect research projects. Therefore, preventing electricity export is a higher priority than maximizing renewable energy production.

PV systems. (These replacement RECs allow NREL to claim all PV generation on the STM and Flatirons campuses as renewable.)

NREL continued to reduce overall Scope 1 and 2 emissions and only purchased renewable energy credits (RECs) to replace RECs that were sold on previously installed systems.

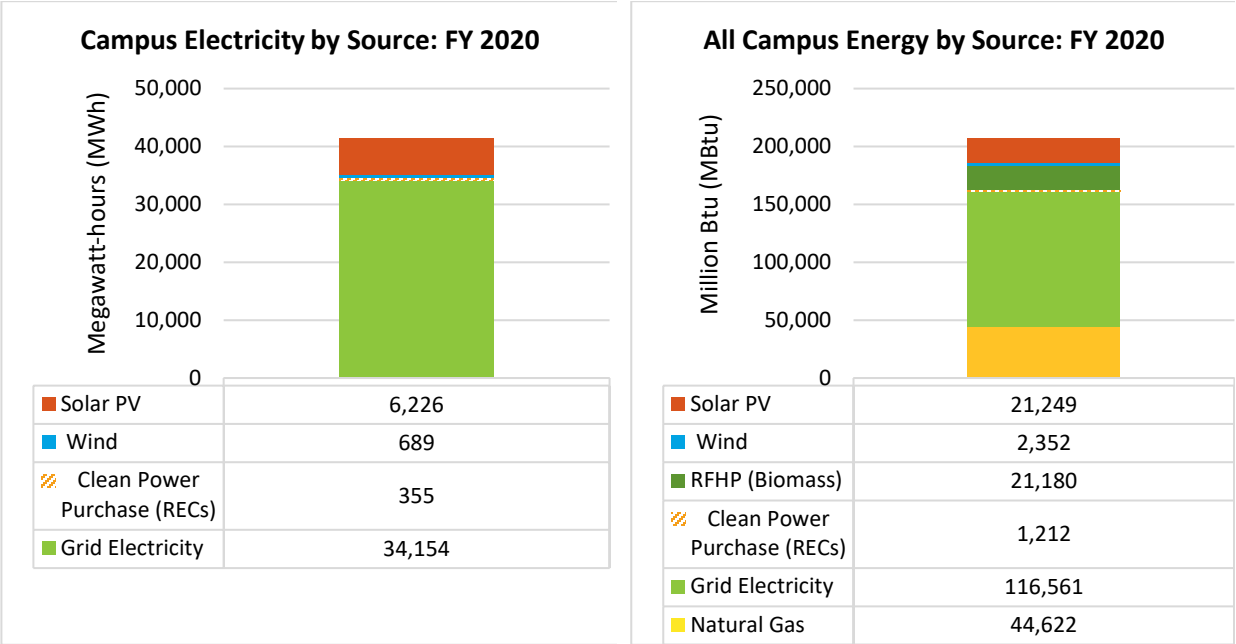


Figure 11. Total campus electricity and all energy by source, including on-site renewable energy production and clean power purchased

Figure 11 displays total campus electricity and all energy consumption by source.[2] Grid electricity is separated into clean power purchase and all other grid electricity. RECs other than clean power purchase are not shown in the chart.

Table 1 shows clean and renewable energy totals, retained (bonus) RECs, and replacement RECs purchased for PV generation. (Inclusion of replacement RECs and bonus RECs in the clean energy percentage calculation is for consistency with the calculation method used by DOE Sustainability Dashboard; the table should not be used for other purposes.)

[2] The solar PV and wind energy production totals include a small amount of renewable electricity at Flatirons Campus that was exported to the grid rather than self-consumed (i.e., consumed in Flatirons Campus buildings); therefore, the electricity and energy totals are slightly higher than the actual total energy consumption of the two NREL campuses. The error is estimated to be no more than 2% of the total. NREL is investigating metering options that will enable better accounting of exported versus self-consumed renewable energy at the Flatirons Campus.

Table 1. Renewable Energy and Electricity Use

	All Energy		Electricity	
Energy Source	**Mbtu**	**Clean Energy (%)**	**MWh**	**Clean Energy (%)**
Grid Electricity	116,561		34,154	
Natural Gas	44,622			
RFHP (biomass)	21,180	10.2		
Solar PV	21,249	10.3	6,226	15.0
Wind	2,352	1.1	689	1.7
Clean Power Purchase (RECs)[a]	1,212	0.6	355	0.9
Replacement RECs	*25,186*	*12.2*	*7,380*	*17.8*
Retained RECs (bonus)	*6,639*	*3.2*	*1,945*	*4.7*
TOTAL[b]	**207,176**	**37.6**	**41,425**	**40.1**

[a] Total purchased grid electricity includes Grid Electricity and Clean Power Purchase categories

[b] Energy total includes Grid Electricity, Natural Gas, RFHP, Solar PV, Wind, and Clean Power Purchase; excludes other RECs. However, for consistency with DOE Sustainability Dashboard, clean energy percentage calculation *includes* other RECs.

The RFHP provided 21,180 Mbtu of district heating energy in the FY 2020 heating season. NREL STM Campus facilities consumed approximately 42,600 Mbtu of district heating energy during the same period (September 2019 to May 2020); therefore, the RFHP provided just under 50% of the heating energy for the season. During the RFHP off season, waste heat from ESIF is utilized to provide morning boiler warm-up, reducing natural gas consumption.

Plans and Projected Performance

Renewable Energy Strategies

NREL continues to implement procedural and operational changes to the RFHP to increase its use during the heating season. NREL will move up the readiness and verification process with the energy service performance contract vendor and optimize the campus heating system and set points. NREL expects continued reductions in natural gas use on the STM Campus in FY 2021 from these efforts.

NREL will continue to pursue options to procure on-site renewable energy when financially feasible. NREL will also continue to purchase RECs to replace RECs sold for on-site renewable energy installations. This ensures NREL can accurately account for renewable energy production for on-site systems.

In FY 2021, NREL continues to conduct the feasibility of a small microgrid installation at the SSEB, a small-scale facility. This pilot is intended to enhance understanding of system components and advanced control for the operability and scalability of a larger microgrid projects in support of resilience. This project will incorporate energy storage and renewable generation as the main energy resources.

NREL will continue to upgrade electrical service at the Flatirons Campus over the next 3 to 5 years and investigate electrification from renewables for facility heating in lieu of natural gas.

NREL will continue to refine master planning for the eastern expansion of the STM Campus, investigating a distributed energy approach with assistance from its research community. When new facilities are being planned, NREL will set required energy performance targets defined in the Guiding Principles. The energy targets drive energy efficiency and, in many cases, the use of renewable energy systems. Even if a new facility can meet the energy performance targets without the installation of renewable energy systems, design requirements are specified that enable the installation of future renewable energy systems. For example, NREL requires roofing systems to be "PV capable," i.e., designed and installed to accommodate the weight and attachment of a rooftop solar PV system, even if that system is not provided as part of the initial construction of the project. Additional examples would be in the metering of facilities and design of the electrical distribution to allow future deployment of solar PV.

7 Sustainable Buildings

Performance Status

Guiding Principles

In FY 2020, COVID-19 impacted NREL's ability to conduct Guiding Principles evaluations. The current compliant facilities are represented in the table below. In FY 2021, NREL plans to evaluate nine more facilities in the assessment cycle. Funding and resources are barriers for NREL's current facilities that do not meet the Guiding Principles' sustainable building requirements. Achieving goals for the remaining buildings at NREL will require significant capital expenses and could impact research.

In spite of this, NREL has developed its "Guidelines to Meet NREL Sustainability Requirements for New Construction" and corresponding checklist based on the "Guiding Principles for Sustainable Federal Buildings." Along with ensuring compliance with federal mandates and providing stepped goals to encourage innovation, these support the laboratory's goal to demonstrate energy efficient buildings with lower impact on the natural environment. Labs will be designed for sustainability via low energy designs by following the best practices for risk management, optimal equipment performance, and energy reduction costs as identified by the International Institute of Sustainable Labs (I2SL) strategies.

Table 2. Summary of Facilities Compliant with Guiding Principles

Guiding Principle Compliant Facilities		
Facility	**Assessment**	**Guiding Principles**
Café	LEED Platinum FY 2013	2008 version
Energy Systems Integration Facility (ESIF)	LEED Platinum FY 2014	2008 version
Integrated Biorefinery Facility (IBRF)	LEED Gold FY 2011	2008 version
Research Support Facility (RSF)	LEED Platinum FY 2011/FY 2012	2008 version
Science and Technology Facility (STF)	LEED Platinum FY 2006	2008 version
South Site Entrance Building (SSEB)	LEED Platinum FY 2013	2008 version

New Building Design

In FY 2020, several VIPs, including Secretary of Energy Dan Brouillette and U.S. Senator for Colorado Cory Gardner, joined the NREL Leadership Team in a groundbreaking for the anticipated construction of the Research and Innovation Laboratory (RAIL) Facility at the STM Campus. The RAIL Facility mission is to provide much-needed laboratory space and capitalize on emerging hybrid research opportunities. Laboratory space will be flexible and designed to accommodate evolving interdisciplinary research, while integrating science and applied research disciplines to develop and validate the performance of hybrid energy technologies and processes for producing materials, chemicals, and fuels. Throughout FY 2020, NREL subject matter experts developed RAIL's design and construction requirements to address mission-critical needs. NREL seeks to create a living laboratory environment by using campus facilities as

instruments to further energy efficiency, renewable energy, and sustainability research. To that end, RAIL is required to incorporate innovation in energy technologies, environmental performance, and advanced controls using a "whole building" integrated design approach. NREL anticipates that the construction of the RAIL facility will be completed in late calendar year 2022.

In FY 2020, NREL completed the construction of the Power Generation Upgrade Project at the Flatirons Campus. The new interconnection agreement allows the power generators at the Flatirons Campus substation to put up double the nameplate capacity of renewable-generated power onto the grid. This expanded interconnection agreement eliminates the previous need to curtail generation when the site produces more than 10 MW, allowing the site to support larger-scale research projects and reducing competition against other renewables for prioritization testing. The substation also enhances research capabilities for the microgrid at the Flatirons Campus by providing a connection point for multiple generation technologies to the transmission system. Also completed at the Flatirons Campus in FY 2020 was the Grid Integrated Research Pads Upgrade and Expansion Project. This new asset allows batteries and other storage and generation technologies to connect to other technologies and the Flatirons Campus microgrid. Both projects support the Advanced Research on Integrated Energy Systems initiative to perform research on integrating diverse energy systems.

In early September 2020, the Flatirons Campus experienced a sitewide power outage due to a transformer explosion at the new substation. This unexpected outage fortuitously enabled researchers to test black start capabilities at the site by using renewable energy assets to power the campus without an outside utility connection, as explained in more detail in the article "An Unexpected Debut: ARIES Microgrid Infrastructure Powers NREL Campus Through Outage."

To broaden the capabilities of the Mechanical and Thermal Engineering Sciences directorate, NREL entered a lease with the Cold Climate Housing Research Center (CCHRC) in Fairbanks, Alaska, in FY 2020. Through this partnership, NREL welcomed CCHRC researchers and staff as employees. As laboratory employees, the CCHRC team will continue to research cost-effective building technologies for people living in circumpolar regions around the world, studying materials and techniques needed to build energy efficient, durable, and hearty housing for extreme weather conditions. CCHRC operates as a living laboratory and has the distinction of being the farthest-north LEED Platinum building. NREL does not include the CCHRC within its LEED portfolio, since it is a leased facility and not within the operational boundary of NREL.

Plans and Projected Performance

Guiding Principles

In FY 2021, NREL will evaluate nine facilities for their compliance with the 2016 Guiding Principles. Based on these evaluations, NREL will determine the possibility of and current estimated costs for bringing these facilities into compliance with the 2016 Guiding Principles. NREL will continue to meet the 2008 Guiding Principles goals at the compliant facilities without additional funding requirements beyond typical operational expenses.

New Building Design

For future facilities in the near and long term, NREL will continue efforts to build facilities that meet federal building efficiency standards. Future facilities will meet or exceed design standards at 30% more energy efficient than the baseline ANSI/ASHRAE/IESNA Standard 90.1. In addition, NREL is integrating the Smart Labs and the 2016 Guiding Principles into its design guidelines and performance criteria for new buildings to ensure that it continues to develop safe and energy efficient cutting-edge laboratories.

The design for the Control Center Facility (CCF) will commence in the first quarter of 2021. The CCF will be the cornerstone for the future expansion of the ARIES initiative by providing additional collaboration, office, and lab space at the Flatirons Campus.

As part of ongoing Intelligent Campus efforts, NREL will continue to use campus buildings as active tools to inform energy usage research. A shift from gas-fired to electric HVAC equipment and power is anticipated to provide assets for research utilizing the existing renewables-centric grid in use at campus buildings powered by solar arrays, battery energy storage, and wind turbines. Additionally, in conjunction with its sustainability design guidelines, NREL will evaluate other alternative power sources such as ground-source heat pumps, air-source heat pumps, and other electric HVAC technologies to not only provide opportunities to develop and monitor buildings as both research projects and operations assets, but also bolster NREL campus security and build resilience.

8 Acquisition and Procurement

Performance Status

Sustainable Acquisition Strategies

In FY 2020, NREL's Acquisition Services continued modernization of its and the laboratory's systems and processes with enhancements that will continue through FY 2021. These enhancements will include improvements to data collection and revised processes to adequately address sustainable acquisition requirements and initiatives. The Acquisition Services group plans to assign Sustainable Acquisition program responsibility to a newly formed Policies, Programs & Compliance team, within which a new position will be partly focused on improving the process by which NREL collects sustainability data from vendors.

Acquisition Services management continued work on the implementation of a fully automated and paperless cloud-based eProcurement system known as Oracle Procurement Cloud and kicked off the second and third phases of the implementation process of the paperless system.

All subcontracts and purchase orders valued at greater than the simplified acquisition threshold were awarded by NREL using NREL's terms and conditions. Federal Acquisition Regulation clauses that used to be incorporated by reference in NREL's version of DEAR 970.5223-07 are now incorporated in their entirety as of a March 1, 2020, update of NREL's standard terms and conditions.

These clauses require the use of products that have bio-based content, are energy efficient, or have recycled content. This includes the procurement of ENERGY STAR, FEMP-designated, WaterSense, U.S. Department of Agriculture BioPreferred, EPEAT-registered, Supplemental Nutrition Assistance Program, Safer Choice, and SmartWay-designated products, where cost-effective.

The March 1, 2020, version of NREL's subcontract terms and conditions include derivations of the following clauses related to sustainable acquisition.

Table 3. Clauses Related to Sustainable Acquisition

Sustainable Acquisition Clauses	
Clause Derivation	**Clause Title**
970.5223-7	Sustainable Acquisition Program
970.5223-7	Sustainable Acquisition Program - Construction
52.223-2	Affirm Procurement of Biobased Products under Service and Construction Contracts
52.223-10	Waste Reduction Program
52.223-11	Ozone-Depleting Substances and High Global Warming Potential Hydrofluorocarbons
52.223-12	Maintenance, Service, Repair, or Disposal of Refrigeration Equipment and Air Conditioners
52.223-15	Energy Efficiency in Energy-Consuming Products
52.223-17	Affirm Procurement of EPA-designated Items in Service and Construction Contracts

Laboratory Level Procedure *PROC 1000-2 Purchase Requests*, accessible by all laboratory staff, was updated in August 2020 to update and modernize the Sustainable Acquisitions/Green Purchasing guidance. It now includes the requirement for procurement actions to be conducted in compliance with federal green procurement requirements for purchasing certain products unless they do not meet mission needs or are cost prohibitive. The issued guidance includes lists of types of products for the major product categories, compliance requirements, and links to additional guidance/resources, for example:

- AFVs and alternative fuels required by the Energy Policy Act of 2005 at http://www.afdc.energy.gov/afdc
- Biobased products designated by the U.S. Department of Agriculture in the BioPreferred program at https://www.biopreferred.gov/BioPreferred/faces/catalog/Catalog.xhtml
- ENERGY STAR products identified by DOE and Environmental Protection Agency (EPA), and Federal Energy Management Program (FEMP)-designated energy efficient products at http://energystar.gov/ and https://energy.gov/eere/femp/find-product-categories-covered-efficiency-programs
- Environmentally preferable products and services, including EPEAT-registered electronic products at http://www.epeat.net/
- Non-ozone-depleting substances, as identified in EPA's Significant New Alternatives Program at http://www.epa.gov/ozone/snap/index.html
- Recycled content products designated in EPA's Comprehensive Procurement Guidelines at https://www.epa.gov/smm/comprehensive-procurement-guideline-cpg-program
- Water efficient products, including those meeting EPA's Water-Sense standards at http://www.epa.gov/watersense/
- Nontoxic or less toxic alternative products that meet EPA Safer Product standards at https://www.epa.gov/saferchoice.

Table 4. Sustainable Acquisition Progress in FY 2020

FY 2020 Sustainable Acquisition Progress	
Metric	**Total**
Number of Eligible Contract Actions	150
Number of Contract Actions w/ SA Clauses	150
Percent of Contract Actions w/ SA Clauses	**100%**
Total Eligible Contract Dollars ($)	$65.4 M
Total Contract Dollars ($) w/ SA Clauses	$65.4 M
Percent of Contract Dollars w/ SA Clauses	**100%**

The total number of eligible contracts and contract dollars includes all purchase orders greater than the simplified acquisition threshold. This includes about 5% of purchase orders awarded through GSA and the DOE Integrated Contractor Purchasing Team, which do not use NREL's terms and conditions. NREL assumes these contracts include sustainable purchasing requirements per federal guidance.

Table 5. Biobased Product Purchase and Targets Based on the Number of Contract Actions

Biobased Product Purchase and Targets (# of actions)	
FY 2020	**FY 2021**
1	1

NREL has never had the ability to report on biobased product actions. The custodial contract has always contained, and will continue to contain, requirements to use biobased products. The office supply contract at NREL does enable identification of biobased purchases, but these are not part of a contract-specific action.

NREL encourages staff to use less toxic/hazardous materials in their processes whenever possible to reduce the quantity of chemicals acquired to the minimum amount necessary to complete the work.

The Sustainable Acquisition strategies described above are all designed to help improve NREL's supply chain GHG emissions.

In FY 2020, sustainable acquisition contracts and biobased products reporting by contractors was reported in the Excel workbooks provided by Sustainability Performance Division instead of Microsoft Word/Adobe PDF tables in the SSP narrative.

Plans and Projected Performance

Sustainable Acquisition Strategies

NREL will complete the remaining phases of the Oracle Procurement Cloud paperless cloud-based eProcurement system in FY 2021. These new features are expected to make it easier for staff to identify and purchase sustainable products. Features planned for implementation include:

- ASIQ Self-Service Portal—to implement and integrate internal customer interface
- Collaboration tools—for internal approval and internal customer service
- Supplier Portal—to house supplier and subcontractor registration and facilitate documentation exchange.

In FY 2021 and beyond, NREL will increase use of web-based resources to promote sources for sustainable goods and services, increase efficiency in cradle-to-grave acquisition, and improve sustainable reporting methodology and resulting data so they can be leveraged in the future.

9 Measures, Funding, and Training

Performance Status

Efficiency and Conservation Measures

All efficiency and conservation measures are identified in the Energy Independence and Security Act audits conducted annually. A full EISA audit report is given to facility managers and chief operators upon completion of the audits. Facility managers will decide whether any projects should be incorporated into the building project schedule. During the EISA audit process, energy and water conservation measures that are simple programmatic or controller changes are implemented, and these are included in the reports to facility managers and chief operators. Although NREL restricted access to campus facilities during COVID-19, the laboratory hired an outside consulting group to perform mandated EISA audits in the last quarter of FY 2020. These were completed in four facilities at the STM Campus:

- Cafeteria: 11,635 ft^2
- Research Support Facility: 442,910 ft^2
- Solar Energy Research Facility: 120,2661 ft^2
- South Site Entrance Building: 1,580 ft^2.

Due to the COVID-19 pandemic, the audits were delayed relative to the normal cycle; walk-throughs were completed in the summer and audit reports finalized in the early fall.

From the completed audits, NREL identified 46 energy- and water-saving measures for these four facilities, representing 10,055/year Mbtu of energy savings and 11,200/year gallons of water savings (water-saving measures only). However, implementation of all identified energy conservation measures would result in a net *increase* in water consumption of 77,800/year gallons due to increased use of evaporative cooling (89,000 additional gallons of water consumed for evaporative cooling minus 11,200 gallons of water saved). The total identified energy cost savings across all measures was $128,085/year, offset slightly by a net water cost increase of $545/year.

Of the 46 identified measures, 24 were zero-cost or low-cost measures. These consist primarily of correcting control problems in existing systems. The 24 low-cost measures represent 4,832 Mbtu/year of energy savings opportunity and $48,824/year of energy cost savings. NREL will pursue these measures with internal resources. The remaining 22 measures represent 5,223 Mbtu/year of energy savings and $79,261/year in cost savings but have a collective estimated implementation cost of approximately $1.7 million. These projects will be considered for future implementation by facility managers and prioritized within available budgets. NREL uses simple payback period and total cost to prioritize ECMs for implementation; however, research needs are typically given higher priority. In addition, NREL is investigating options for financing and implementing these projects using energy-savings performance contracts (ESPCs).

NREL does not conduct comprehensive M&V for most implemented energy conservation measures (ECMs). Most identified ECMs, especially control-related ECMs, are estimated to result in small financial savings, which would be offset by the cost of installing additional metering to perform the M&V.

One of the key challenges NREL faces is low utility costs. NREL's electricity-blended electricity charge is approximately $0.07/kWh for the STM Campus. The low cost of electricity makes it difficult to justify the implementation of ECMs based solely on energy savings and requires life-cycle cost analysis for energy conservation projects.

Performance Contracts

In FY 2020, NREL prepared an assessment for the DOE Golden Field Office (GFO) to consider the financial mechanism of an ESPC to implement an extensive list of backlogged ECMs. NREL's team found that, through the installation of approximately 80–100 identified ECMs across both the STM and Flatirons campuses, it was possible to achieve cost savings and implement cybersecurity and reliance measures, in parallel, to pilot a renewable energy generator. NREL and the GFO worked collaboratively to produce a notice of opportunity (NOO) for an energy services company (ESCO), with the intention of awarding an ESPC if the selected ESCO's preliminary assessment of the identified ECMs indicates that they are financially feasible. It is expected the NOO will be publicly released in the first quarter of FY 2021.

Appropriations/Direct Obligations

Applicable NREL projects consider water- and energy-savings opportunities as part of the design process**.**

Training and Education

In FY 2020, NREL Intelligent Campus and energy management staff have completed training on a variety of topics, including SkySpark, facility management systems, energy efficiency, and rule-based fault detection and diagnostics. NREL currently has two certified energy managers on staff in Site Operations.

Plans and Projected Performance

Efficiency and Conservation Measures

NREL will continue to implement energy and water conservation measures when cost-effective. The Intelligent Campus platform will be upgraded in the next few years to allow NREL to better monitor and capture savings for ECMs on an ongoing and continuous basis.

DOE encourages M&V of all ECMs, and NREL is therefore pursuing the installation of more general metering and submetering that will enable M&V in the future. In addition, NREL will develop processes to evaluate M&V pathways for every identified ECM. This could include metering, nonmetering sensors that allow for tracking, sampling, and indirect estimation methods from measurement after the implementation of the measure.

Performance Contracts

In FY 2021, the GFO will select an ESCO to perform a preliminary assessment to investigate the financial feasibility of 80–100 ECMs. If the measures prove feasible, the GFO will award an ESPC to implement these improvements.

Appropriations/Direct Obligations

NREL does not allocate specific funds to energy- and water-conservation measures. In FY 2021, NREL will hire a subcontractor to complete EISA energy and water audits. This will ensure that NREL has identified all cost-effective opportunities for facilities and can use these findings to help further inform the project prioritization process.

Training and Education

For FY 2021, NREL energy managers and Intelligent Campus staff will continue to complete training in a remote capacity due to COVID-19. Learning topics will include demand management analytics using PV arrays and battery systems, microgrid technologies, ESPC procurement contracts, optimization-based simulation, and energy efficiency technologies.

10 Travel and Commute

Performance Status

Business Travel Strategies

The number of NREL business trips in FY 2020 decreased 53.03% from FY 2019. This decrease was significantly due to the halt in business travel because of the COVID-19 pandemic. In mid-March alone, more than 600 previously approved business trips were cancelled. Restrictions remain in place. Due to this decrease in business travel, GHG emissions from air and ground travel decreased 56%.

These unprecedented times have uniquely changed conference attendance. Prior to COVID-19, NREL travel did not track virtual conferences because virtual attendance formats were typically not offered as an option for conference attendance. However, since the pandemic began, the number of virtual events has been astonishing. From April through September of FY 2020, the NREL travel department processed more than 800 virtual conference attendance requests.

Commute Strategies

NREL continued to promote staff alternative commuting through the telework policy, vanpool vouchers, and the Regional Transportation District (RTD) EcoPass. The telework policy allows all NREL staff to work remotely if their manager determines it is appropriate for their job duties, reducing the overall GHG impact of staff commuting. The GFO also offers a liberal telework policy for its staff. These policies were shown to be effective in FY 2020 as the COVID-19 pandemic impacted staff levels on campus. More than 2,000 employees were successfully working remotely by late March/early April. It is expected that a higher percentage of NREL employees will elect to telework more frequently than they did prior to the pandemic, even once site access returns to normal. NREL management is actively developing a new teleworking policy to support remote work in FY 2021.

NREL and the GFO reimburse staff for participating in official vanpools, further reducing GHG emissions. NREL payrolled staff, regular full- and part-time staff, limited-term staff, and interns can now receive the RTD EcoPass, which provides free and unlimited bus and light rail rides, airport rides, and a call-n-ride service throughout the region. The GFO also offers the RTD EcoPass to its staff.

In FY 2020, NREL's shuttle service subcontractor started working with TripShot, a mobility management software system, to electronically track passenger ridership by time of day and boarding/alighting stop location. In May 2020, NREL piloted a new system with TripShot that enables employees to request an NREL on-demand shuttle using an app downloaded to their mobile device rather than calling the driver to request a ride. When a ride is requested, the user is notified that the shuttle is on the way and can track the shuttle on the map. Moving forward, NREL intends to manage all shuttle requests via an on-demand shuttle system such as TripShot

to optimize shuttle operations by seamlessly pooling requests, reducing redundant trips and empty shuttles, and communicating with riders.

COVID-19 had a major impact on transit ridership in FY 2020. As a result, RTD modified its service plan for the foreseeable future. Under the new service plan, RTD no longer offers two bus routes that previously had stops at the STM Campus: Route 125 between Ward Road and Federal Center and Route 20. Additionally, RTD plans to discontinue service of the GS route (between Boulder and NREL) in January 2021 and replace it with Uber/Lyft vouchers. The reduced transit options for NREL staff may increase single-occupancy vehicle (SOV) commute trips to NREL in the future.

NREL participates in regional transportation planning efforts to support NREL commuters and the surrounding community by reducing SOV travel and minimizing environmental impacts. Through established relationships with local and regional transportation service providers (e.g., RTD and the Colorado Department of Transportation [CDOT]) and local governments (e.g., City of Lakewood, Jefferson County, and City of Golden), NREL partners with local entities to strengthen commuting and travel options near NREL facilities.

In FY 2020, NREL facilitated the installation of wayfinding signs to help area cyclists navigate a tricky bypass around the NREL STM Campus between two different regional bikeway trails. The trail connection runs from west to east along the southern fence line for the STM Campus and is difficult to identify. NREL engaged with the GFO, City of Lakewood, Jefferson County, and Bike Jeffco (local bicycle advocacy group) to create and install the wayfinding signage to direct cyclists wanting to travel between the City of Lakewood trails to the east and Jefferson County trails to the west.

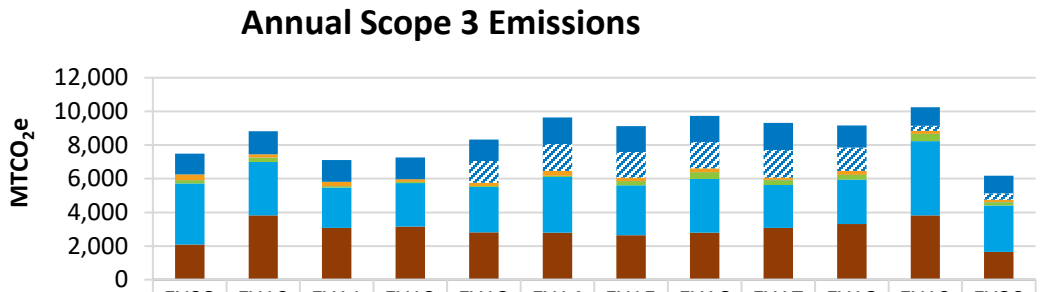
Also in FY 2020, NREL participated as a member of the Employer-based Trip Reduction Program working group that is coordinated by the Regional Air Quality Council. The group is working to develop programs and regulations for employers in the Denver Metro area to reduce SOV travel to work and the associated GHG emissions. NREL also hosted a booth at the Sustainable Denver Summit, an event that brings together more than 1,000 leaders from across Denver's business, nonprofit, and civic communities to educate, inspire, and drive action.

NREL planned to conduct a commuter survey in FY 2020. However, because COVID-19 prohibited staff from coming on-site and required social distancing that could impact staff commuting decisions, NREL elected to hold off on conducting a survey until the return to normal operating conditions, optimistically in FY 2021. The results of the most recent commuter survey from FY 2017, along with estimated staff levels from March through September 2020, were used to estimate the FY 2020 commuter data submittals.

In addition to the commuter survey, NREL intended to host and attend several events throughout FY 2020 to promote alternative commuting and sustainability. Due to COVID-19, many of these events were canceled, including Colorado Bike to Work Day. In October 2019, NREL participated in the Go-Tober Challenge, a month-long commuting challenge that encourages

commuters to try different modes of getting to and from work. NREL partnered with the GFO to build a team that placed in the top 10 in its class.

Overall, GHG emissions counted in the Scope 3 inventory decreased by 4,223 MT CO_2e, or 44%, from FY 2019 to FY 2020, as seen in Figure 10. This is largely due to the drastic reduction in business travel and employee commuting discussed in this section—over 96% of this change was driven by these COVID-19 travel impacts. Figure 10 illustrates the trends in Scope 3 GHG emissions that result from NREL operations.



	FY08	FY10	FY11	FY12	FY13	FY14	FY15	FY16	FY17	FY18	FY19	FY20
T&D Losses	1,230	1,364	1,293	1,283	1,289	1,591	1,527	1,556	1,624	1,316	1,102	1,038
T&D Losses w/ RECs					1,289	1,591	1,527	1,556	1,624	1,383	301	376
Solid Waste	340	195	274	160	186	293	211	236	143	232	176	148
Wastewater Treatment	5	6	8	6	6	7	6	6	7	7	8	11
Ground Travel	200	255	64	65	62	62	241	398	289	279	433	186
Commuting	3,623	3,163	2,398	2,594	2,691	3,308	2,962	3,192	2,544	2,640	4,406	2,763
Air Travel	2,093	3,829	3,079	3,151	2,814	2,795	2,645	2,789	3,087	3,311	3,823	1,653

Figure 12. Annual Scope 3 emissions broken down by emission type

Plans and Projected Performance

Business Travel Strategies

Current domestic business travel restrictions allow for *essential* travel only. Travel deemed "essential" will require additional approval from management, including the GFO. Foreign travel is still prohibited at NREL and will remain so until further notice.

Given the unparalleled challenges of COVID-19, the forecast for travel is uncertain. According to travel industry experts, it may take 5 years before travel is back to where it was prior to COVID-19. The uncertainty of travel makes it impossible to accurately project travel goals in the coming years.

Commute Strategies

NREL will continue to promote alternative commuting with staff through several venues in FY 2021 (if permissible due to COVID-19 impacts) and into the future, including:

- Staff an NREL Benefits Fair Booth to promote all commuting options available to staff

- Participate annually in Way to Go's Go-Tober Challenge and Colorado Bike to Work Day
- Continue to promote and provide teleworking, alternative work schedules, and other alternative commute options that reduce the number of SOV trips and associated GHG impacts, and maintain program participation
- Explore the feasibility of innovative and emerging mobility solutions that expand the use of alternative transportation
- Conduct a commuter survey in FY 2021 if NREL returns to normal operating conditions.

NREL will continue to collaborate with regional partners to promote alternative commuting and explore the feasibility of a joint autonomous-vehicle (or other advanced-mobility) demonstration project with surrounding municipal partners, including the RTD and the CDOT, over the next 2–5 years.

When NREL returns to normal operating conditions, NREL's Campus Mobility Specialist plans to perform a feasibility study to evaluate two new alternative commuting programs:

1) An updated carpool program that will make it easier for NREL employees to connect and carpool to/from the office together

2) A bike share program to promote alternative commuting options on campus.

GHG Emissions Accounting Strategies

With the shift to many NREL employees working remotely due to the COVID-19 pandemic, along with the expected implementation of an updated teleworking policy, NREL will need to consider revising its strategy for Scope 3 GHG emissions accounting.

As a result of the shift to remote work, FY 2020 saw reduced GHG emissions from Facility Energy Use (Scopes 1 and 2), as well as from Employee Commuting (Scope 3). These emissions are offset by increased GHG emissions occurring due to employees working remotely (e.g., from their homes), which are currently not counted in NREL's GHG emissions inventory. Since these emissions related to teleworking are indirectly related to NREL's operation, they would be categorized as Scope 3. However, quantifying these emissions would be difficult, and a method for estimating the work-related portion of an employee's home energy use—and associated GHG emissions—would need to be developed.

11 Fugitives and Refrigerants

Performance Status

Fugitive and Refrigerant Strategies

Fugitive emissions of greenhouse gases at NREL are small in scale and result from the following activities:

- Research that involves the use of these gases and resulting small emissions from normal activities or maintenance of research equipment
- Maintenance of infrastructure cooling equipment, such as comfort cooling chillers
- The occasional leak or failure.

These activities are subject to NREL's Ozone-Depleting Substances Management Procedure and Colorado and EPA regulations that require maintenance of equipment to minimize leaks, Colorado permitting of certain equipment, and the prohibition of release of refrigerants under EPA regulations. Certain gases, such as SF_6, are not used as refrigerants and may not be subject to Colorado and EPA regulation; however, they are subject to NREL's "best practices," which require the recovery and reuse of these gases during maintenance activities to minimize emissions. Note that use of refrigerants and other greenhouse gases does not equate to fugitive emissions of such gases because of the above management practices.

Most gas is contained in sealed devices with no emissions. Refrigeration devices and electrical equipment may function for many years without leaks. High-voltage devices, such as particle accelerators and electron microscopes, use SF_6 as an insulating gas and may require periodic service to remove the gas prior to service. A pump is used to remove gas from refrigeration and research devices to the lowest possible safe pressure. Removed gas is stored in a clean cylinder until the gas is reintroduced into the device following repair or maintenance. A small amount of the gas often remains behind at the end of gas recovery and is released into the air when the device is opened for service. There is no alternative method available to control these small releases of refrigerants or SF_6. NREL accounts for such releases, which do not violate any rule, regulation, or permit.

In FY 2020, a refrigerant leak was detected in a newly installed chiller at the TTF. In August, approximately 44 pounds of R-410a refrigerant were replaced to bring the chiller back to a full charge of approximately 181 pounds (indicating 44 pounds of refrigerant were emitted during this event). Refrigerant that had remained in the appliance during the leak was recovered and reused following the repair. Leak testing prior to recharge confirmed that the chiller was properly repaired.

Some research requires the use of CO_2 gas as a process feedstock or SF_6 as a tracer gas for detection of gas leaks or other purposes. The use of such gases is usually in small quantities for short periods of time. CO_2 is often used in sealed systems, and the CO_2 may be used in chemical reactions in which the CO_2 is destroyed and converted into other compounds. The fugitive emission of such gases is required as part of the research work, cannot be reasonably controlled or reduced, and is typically small, as evidenced by the infrequent purchase of CO_2 and SF_6 gases.

SF_6 is used as an arc quenching agent in high-power switches and circuit breakers. These electrical devices are sealed and do not emit SF_6 but infrequently can fail and lose their SF_6 charge. Failed devices are replaced, and there is no reasonable method for controlling such emissions. No such electrical failures were reported in FY 2020.

The management of fugitives and refrigerants during FY 2020 included:

- Updating the detailed refrigerant inventory at NREL facilities
- Updating the SF_6 inventory
- Quantifying the R-410a leak that occurred in August.

Bulk refrigerants are accounted for on an ongoing basis throughout the year to document use in FY 2020. NREL captures and recycles refrigerants.

Plans and Projected Performance

Fugitive and Refrigerant Strategies

NREL will continue to monitor proposed changes in refrigerants and gas emissions to mitigate any increases in refrigerant or research gas emissions. In FY 2021, NREL will implement and comply with any changes to the EPA regulations.

The plans and projected performance for FY 2021 include the following:

- Continue to update the SF_6 and refrigerant inventories and obtain additional data for equipment identified in FY 2021
- Train personnel who own or operate refrigeration appliances that are subject to the EPA regulation, and evaluate the need for additional guidance
- Continue to participate in the DOE Clean Air Working Group and Fugitive Emission Working Group to learn from the refrigerant and SF_6 experiences of other DOE laboratories
- Closely track any changes in Colorado or EPA refrigerant and/or GHG regulatory changes and assess for impact to NREL operations and research activities.

NREL will also continue to assess methodologies for tracking SF_6 and refrigerant inventories to inform best operational practices for the management of these substances.

12 Electronic Stewardship

Performance Status

Acquisition Strategies

In FY 2020, NREL received the 2020 Five-Star EPEAT Purchaser Award for its exceptional commitment in support of the laboratory's mission to ensure that purchases meet established EPEAT and ENERGY STAR ratings wherever possible. NREL also updated purchasing requirements to include EPEAT standards for mobile phones and servers.

Operations Strategies

In FY 2020, NREL enabled power-management settings on all eligible personal computers, laptops, and monitors before being deployed to staff or installed on any NREL site. Devices are set to turn off the display after 10 minutes of inactivity and put the hard drive into standby mode after 15 minutes 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.

In FY 2020, NREL replaced five problematic multi-function devices (MFDs) with more efficient machines. With the majority of NREL staff working remotely due to COVID-19, the load on MFDs has been significantly reduced. NREL anticipates needing to replace few MFDs in FY 2021. Additionally, due to the remote work of NREL staff, energy consumption for MFDs fell to an all-time low because each device is in "sleep mode" when not in use.

All eligible MFDs are set to automatic duplexing, with 141 out of 154 devices being eligible for such functionality.

End of Life Strategies

The Site Operations and Environment, Safety, Health & Quality (ESH&Q) offices work together to ensure responsible stewardship of electronics designated as having reached their end of life at NREL and designated as electronic waste (e-waste). The management of e-waste incorporates procedures and best practices that first involve Property Management, which performs due diligence to verify whether items can be legitimately dispositioned through reuse by outside qualified entities. In FY 2020, approximately 1,200 lbs of reactor vessels were diverted from landfills and donated to a university. An additional nominal amount of e-waste was provided for reuse through the GSA Computers for Learning program.

Subsequently, when reuse is not an option, items are managed as "universal waste," where accumulation time limits and storage requirements prescribed by state and federal waste regulations are followed prior to the material being shipped off-site for recycling through NREL's Responsible Recycling (R2)-certified local vendor. The vendor also has e-Stewards, ISO 9001, ISO 14001, and OHSAS 18001 certifications. In FY 2020, approximately 26,384 lbs of e-waste were recycled through certified recyclers.

FY 2020 activities comprised the routine handling of equipment relinquished to Property Management as excess (e.g., computers, peripherals, tablets, cellular phones) as well as the management of research equipment containing electronic components from various NREL

spaces being prepared for laboratory renovation projects. In FY 2020, Information Technology Services (ITS) expanded efforts to reclaim underutilized computers around the laboratory, reducing security vulnerabilities associated with unmanaged/unpatched computers and maximizing the value of existing IT assets. These efforts have resulted in building a pool of approximately 400 reutilized computers, which are centrally managed by ITS and made available for use as loaner and surplus systems labwide.

As a result of today's hardware configurations that make disassembly, battery removal, and data destruction increasingly labor-intensive, FY 2020 activities included focused discussions among NREL Property Management, Cyber Security, and ESH&Q to address safety and efficiency when handling laptop computers, tablets, and cellular phones. The agreed-upon policy is the increased utilization of purchased information technology equipment at NREL and the recycling of all such equipment at the end of life.

Data Center Strategies

NREL's HPCDC continues to be a showcase facility for sustainable and energy efficient data centers. Featuring compressor-free, component-level warm-water liquid cooling and waste heat capture and reuse, this data center achieved an average PUE of 1.03 in FY 2020. This extreme energy efficiency is complemented by water efficiency. In August 2016 NREL installed a prototype thermosyphon hybrid cooling system in the data center to reduce on-site water usage. The thermosyphon, supplemented with existing cooling towers, has saved 5 million gallons of water over the last 4 years.

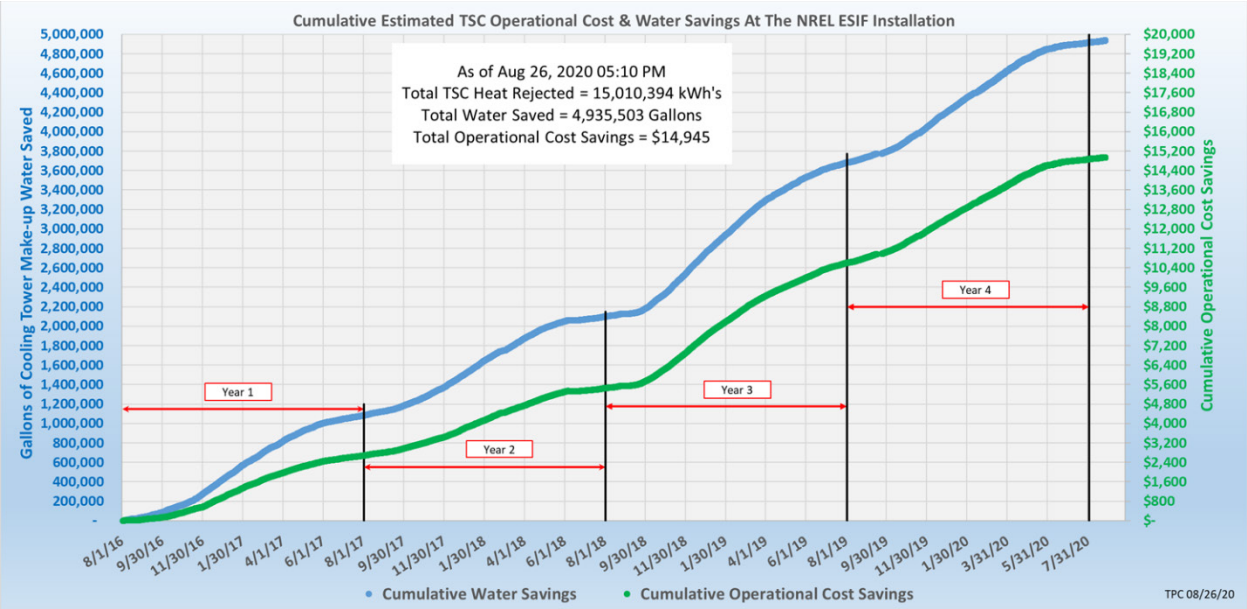


Figure 13. Estimated total cumulative water consumption and savings over 4 years for the HPCDC system based on average water costs per gallon at the STM Campus

On the HPC system side, NREL's flagship system, Eagle, underwent an expansion in FY 2020 to support growing computing needs. Eagle went into production in FY 2019 in support of the DOE Office of Energy Efficiency and Renewable Energy's mission.

Plans and Projected Performance

Acquisition Strategies

In FY 2020 and beyond, NREL will continue to strive to purchase EPEAT-rated devices and work with manufacturers and EPEAT to add necessary hardware to EPEAT.

Operations Strategies

In the near term, ITS will redefine which systems are eligible for power management to improve processes and more accurately determine potential for further power management across NREL's campuses.

With this improved oversight, ITS will continue to refine its policies and procedures to enhance guidance to end users, as well as its processes and definitions concerning power management, and exceptions to power management settings.

These power management initiatives are expected to develop in scope over the next 2–3 years as older, as obsolete equipment is replaced and a greater percentage of the laboratory's hardware inventory becomes centrally managed.

End of Life Strategies

As the reutilization program continues to expand in coming years, ITS will revamp how computers are purchased and provided to employees. Reutilized computers will be provided in lieu of new computers where appropriate. This strategy will reduce the number of computers purchased annually as well as the number of computers in the laboratory's inventory overall.

In FY 2021 and beyond, NREL will continue its safe, compliant, and responsible management of electronic waste on both campuses. Although destruction and recycling of electronics is always the last management option for unneeded electronics (following the prospects of reduction in purchasing and reuse), NREL will continue to source authorized vendors who provide disposition/recycling services in accordance with all applicable DOE, environmental, and state management requirements.

Data Center Strategies

In FY 2021, NREL plans to begin an HPCDC facility upgrade project to support the next HPC flagship system that will arrive in 2022. This incremental expansion will look to upgrade the facility to 7.5 MVA (transformer capacity) with a targeted 6 MW usable for IT equipment. Future expansion of the HPCDC is expected to continue until it reaches 10 MVA (transformer capacity), with a projected 8 MW usable for IT equipment. NREL will continue to maintain and operate the HPCDC with an annualized average PUE of 1.05 or lower. A multidisciplinary team will continue to meet as needed to discuss logistics for future expansion projects and to ensure energy and water efficiency in NREL's data centers. NREL will continue to maintain and operate a data center facility with an annualized average PUE of 1.20 or lower.

13 Resilience

Performance Status

Resilience Strategies

NREL completed its first resilience (vulnerability) assessment in June 2015 and has taken initial steps to implement specific individual projects at the STM and Flatirons campuses.

At the STM site, NREL continues to investigate microgrid feasibility that would improve STM Campus resilience by assessing needs and determining controller requirements. The long-term goal is to implement the autonomous operation (islanding) of the SSEB that results in disconnecting from the utility electrical grid. Enabling this capability at SSEB will allow it to function as a backup command facility to conduct continuous operations during an emergency response. In FY 2020, NREL drafted an NOO to be issued in October 2020 to select an ESCO and award an ESPC. The award will allow implementation of energy/cyber security and operational resilience measures to transform the SSEB into a microgrid interconnected grid-interactive efficient building, supporting the goal of achieving continuity of operations in an emergency.

At the Flatirons Campus, NREL began conceptual design and scoping for a project to connect the campus to the local water supply, reducing NREL's reliance on trucked-in water to meet on-site potable and firewater needs. This vulnerability was identified as a resilience risk to NREL in its 2015 resilience assessment. The scoping process included working with Consolidated Mutual Water Company to understand requirements for purchasing water shares, determining the on-site water cleaning and filtering needs, and estimating on-site storage for potable and firewater use. This first step sets the stage for hiring a design firm and constructing the new infrastructure planned for FY 2022/2023.

A couple of events in FY 2020 presented unique opportunities to test NREL's resilience posture:

- In September 2020, a substation equipment malfunction at the Flatirons Campus led to a total loss of campus power and subsequently demonstrated successful deployment of on-site research renewable energy assets, including solar arrays, battery energy storage, and wind turbines, minimizing the need for diesel generators and reducing the duration and impact of the outage. Within a week of the event, teams working together across the lab had repowered the campus from black start using these NREL's own ARIES assets.[3] Overall, the recovery brought out the best in NREL collaboration. Every morning following the outage, multiple teams spanning Site Operations, ESH&Q, Electrical Safety Officers, research staff, and GFO staff coordinated the laboratory's response. Collectively, the group decided on a phased approach that would cautiously shift megawatts of wind, solar, and battery power from purely research capabilities, to primary

[3] NREL, "An Unexpected Debut: ARIES Microgrid Infrastructure Powers NREL Campus Through Outage," November 18, 2020, https://www.nrel.gov/news/features/2020/an-unexpected-debut-aries-microgrid-infrastructure-powers-nrel-campus-through-outage.html.

power sources for the campus.[4] This experience highlighted the value of renewable assets for future consideration in campus planning and capital infrastructure activities.

- While the full impacts from COVID-19 are still developing, the pandemic has also illustrated NREL's resilience capabilities, and there are early indicators that highlight NREL's adaptability in dramatically changing conditions. In response to local conditions and in alignment with the Colorado Department of Public Health and Environment and the U.S. Centers for Disease Control and Prevention, NREL quickly established a pandemic response team that met daily to discuss issues and develop plans of action that were communicated regularly with staff. Some of those actions included:
    - Developing protocols for on-site social distancing, travel, hosting visitors, etc.
    - Deploying a contact tracing program
    - Planning to safely ramp down to idle mode and ramp up to full on-site operations in metrics-driven phases
    - Shifting as many staff as possible to remote working
    - Establishing timekeeping and leave protocols for those experiencing COVID-19 impacts, including as caregivers
    - Providing regular updates to staff from leadership team
    - Providing regular briefings to managers about how to support staff during these trying times.

Taken together, these actions have enabled NREL to maintain a safe and secure workforce and work site while continuing to deliver quality work product and meet project milestones. This highlights NREL's previously untested operational capabilities. For example, the volume of remote internet access that could be sustained for an extended period was unknown and nearly impossible to test prior to COVID-19. However, during the spring and summer of 2020, NREL proved the robustness of its IT infrastructure with more than 90% of NREL staff working online remotely with no major network impacts or downtime.

Plans and Projected Performance

Resilience Strategies

NREL looks toward the following strategies to be implemented in coming years:

- NREL has volunteered to be a pilot site to test the FEMP Technical Resilience Navigator (TRN), a water and energy resilience planning tool being developed for government sites. NREL researchers are supporting FEMP in development of the TRN and are proposing to use NREL as a pilot site. It is estimated that this activity will take place in FY 2021.
- In FY 2021, NREL will contract with a firm to finalize the design for the local water supply connection infrastructure at the Flatirons Campus, which will also include

[4] Connor O'Neil, *NREL Headlines* (internal publication), "Device Failure Forces Microgrid Recovery at Flatirons—Flatirons Team Powers Site Using ARIES Assets," October 14, 2020.

improvements to existing on-site water distribution systems. Funding has been identified and construction of the local water line infrastructure is anticipated to begin in FY 2022.

- NREL is discussing how to modify its campus master planning process to include resilience-focused elements. NREL believes robust resilience planning requires broad stakeholder participation for developing institutional knowledge and building a resilience mindset. However, staff time for participation is limited. Therefore, NREL is exploring how best to incorporate resilience components into its master planning process to be efficient with staff time and identify areas of synergy between the master plan and resilience planning.
- NREL is investigating how to expand its asset management system (Workspace) to create an aggregated view of different software applications for infrastructure systems. As a first step in FY 2021, NREL plans to conduct a diagnostic assessment to understand the network architectural platform requirements so various applications can be integrated for better system synergies, optimal performance, and resilience information.
- In preparation for the return-to-office phase of the COVID-19 plan, the NREL Leadership Team is evaluating what has been learned about working remotely because of COVID-19 and establishing a more flexible, efficient, and effective workplace. NREL management is also rethinking its space planning approach and exploring how to enable laboratory growth and create work environments that better foster collaboration through thoughtful design of spaces on campus.

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